Integrated Water and Waste Management Plan

Application for Environmental Authorisation, Waste Management Licence and Water Use Licence

Ilima Coal Company, Kranspan Project, Carolina, Mpumalanga

May 2019

ABS Africa
Sustainability Advisors

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LIST OF ACRONYMS AND ABBREVIATIONS

ADT	Articulated Dump Truck
CALLM	Chief Albert Luthuli Local Municipality
DMR	Department of Mineral Resources
DWS	Department of Water and Sanitation
EA	Environmental Authorisation
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EMPr	Environmental Management Programme
I&APs	Interested and Affected Parties
IUCMA	Inkomati Usuthu Catchment Management Agency
IWULA	Integrated Water Use Licence Application
IWWMP	Integrated Water and Waste Management Plan
LOM	Life of Mine
mm	Millimetre
MPRDA	Minerals and Petroleum Resources Development Act
MR	Mining Right
MRA	Mining Right Application
NEMA	National Environmental Management Act
PES	Present Ecological State
SDF	Spatial Development Framework
WML	Waste Management Licence

1 INTRODUCTION

Ilima Coal Company (Pty) Ltd. (hereafter referred to as "the Applicant") is seeking to establish mining operations on various portions of the farm Kranspan 49 IT in Mpumalanga, whereby coal from the E Seam of the Ermelo Coalfields will be mined via open-cast and underground mining techniques.

This Integrated Water and Waste Management Plan (IWWMP) has been compiled in support of an application for an Integrated Water Use Licence (IWUL) and is intended to provide a management plan for the water uses relating to the proposed mining and associated activities of proposed Kranspan project.

The approach to compiling and the content of the IWWMP has been informed by the following:

- Requirements of Government Notice R. 267, promulgated in terms of Section 26(1)(k) and 41(5) of the National Water Act, 1998 (Act 36 of 1998). The IWWMP is structured in accordance with this regulation;
- Department of Water and Sanitation (DWS) Operational guideline: Integrated Water and Waste Management (2010);
- DWS Best practice guidelines; and
- The Scoping and Environmental Impact Reporting (S&EIR) process undertaken in support of the Mining Right Application (MRA), Environmental Authorisation (EA), Waste Management Licence (WML), and Water Use Licence (WUL). The IWWMP has been developed from several reports and studies completed as part of the S&EIR Process. The Environmental Impact Report (EIR), Environmental Management Programme (EMPr) and specialist studies compiled in support thereof, especially the hydrology study, hydrogeology study and surface water ecosystems study have been referenced throughout the IWWMP[1]. .

Consistent with the Operational Guideline: Integrated Water and Waste Management (DWS, 2010), the IWWMP has been compiled with the understanding that the document must be updated throughout the Life of Mine (LoM) in response to the ongoing assessment and management of the risks and impacts of the proposed mine activities.

1.1 CONTACT DETAILS

TABLE 1-1: PROPONENT DETAILS

PROJECT APPLICANT:	Ilima Coal Company (Pty) Ltd.		
REGISTRATION NO (IF ANY):	2002/017821/07		
TRADING NAME (IF ANY):	None		
RESPONSIBLE PERSON, (E.G. DIRECTOR, CEO, ETC).:	Director		
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[1] The specialist study reports are appended to the EIR

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1.2 REGIONAL SETTING AND LOCATION OF ACTIVITY

Ilima Coal Company (Pty) Ltd. is applying for a mining right over nine (9) portions of the Farm Kranspan 49IT. The farm Kranspan is situated approximately 13 km South-West of Carolina and approximately 12 km North of Breyten in the Gert Sibande District of the Mpumalanga Province. The farm falls within the authority of the Chief Albert Luthuli Local Municipality (Appendix 1, Map 1).

1.3 PROPERTY DESCRIPTION

The farm Kranspan 49 IT is approximately 3 382 ha in size. Historically the area has been utilised for intensive commercial cultivation of annual crops and grazing of livestock with significant coal mining in close proximity (within 5 km. The site has largely been transformed by the intensive farming activities.

The R36 traverses the property from the North - Eastern border of the Kranspan Farm to the South – Eastern border. The surface topography is undulating, with gradual rises and falls over the area with the highest elevations towards the central portion of the Project area.

The vegetation of the general area and the proposed site consists of Eastern Highveld Grassland (Mucina & Rutherford 2006). Two large pans occur in the area that would have been focal points in antiquity.

TABLE 1- 1: DESCRIPTION OF THE PROPERTIES

FARM NAMES:	Kranspan 49 IT
APPLICATION AREA (HA):	Approximately 3 382 ha
MAGISTERIAL DISTRICT:	Gert Sibande
MUNICIPALITY:	Chief Albert Luthuli Local Municipality
DISTANCE AND DIRECTION TO NEAREST TOWNS:	Carolina is situated approximately 13 km north-east of the proposed mining right area. And Breyten is situated approximately 13 km South of the proposed mining right area.

TABLE 1- 2: DIGIT SURVEYOR-GENERAL CODE FOR EACH FARM PORTION

FARM NAME	PORTION	TITLE DEED	21 DIGIT SURVEY OR GENERAL CODE FOR EACH FARM PORTION
Kranspan 49 IT	RE	T1717/2013	T0IT00000000004900000
Kranspan 49 IT	1	T38919/1972	T0IT00000000004900001
Kranspan 49 IT	2	T97271/2004	T0IT00000000004900002
Kranspan 49 IT	3	T2076/2012	T0IT00000000004900003
Kranspan 49 IT	4	T16244/1996	T0IT00000000004900004
Kranspan 49 IT	5	T97271/2004	T0IT00000000004900005
Kranspan 49 IT	6	T16243/1996	T0IT00000000004900006
Kranspan 49 IT	7	T175671/2003	T0IT00000000004900007
Kranspan 49 IT	8	T1717/2013	T0IT00000000004900008

 General Site Conditions	 Mining Operations Adjacent to the Study Area
 Existing Cultivation in The Study Area	 Existing Cultivation in The Study Area

1.4 PURPOSE OF IWWMP

The IWWMP has the following objectives:

- To provide the technical supporting documentation for the IWULA;
- To ensure that water and wastewater management at the site complies with legislation as well as relevant good practice standards for the mining sector;
- To provide management controls for preventing and protecting soil, surface water and ground water contamination by mine activities, including the use of hazardous substances;
- To provide management controls for protection of flora, fauna and people from indirect impacts associated with contaminated soil and water;
- To assign responsibility for implementing the plan;
- To describe mitigation measures to minimize the risk associated with waste generated by the mining activities;
- To ensure water is sustainably managed during the life of the mine; and

- To ensure that appropriate water monitoring is undertaken.

2 CONCEPTUALISATION OF ACTIVITY

2.1 DESCRIPTION OF THE ACTIVITIES TO BE UNDERTAKEN[2]

2.1.1 MINING OVERVIEW

All the required mine infrastructure for the Project Area will be established within the proposed mining right area. The E Seam will initially be mined through opencast mining methodologies followed in time by underground (bord and pillar) mining.

The mine support and administration block will be situated towards the central-eastern interior of the Kranspan Farm (Portions 3 and 5).

The mine infrastructure will consist of the following:

- A mine contractors camp;
- Overhead powerlines and related electrical infrastructure from the nearest Eskom take-off position;
- Back-up power supply (generators);
- Bunded fuel storage area;
- Potable water supply infrastructure;
- Mine haul roads and associated stormwater control structures;
- Explosives storage area;
- Mine offices, parking area, first aid station, stores, laboratory, workshop, change house and lamp room (pre-fabricated structures);
- Wash plant;
- Surface discard stockpile facility (if there is insufficient capacity for in-pit disposal of discard);
- Product stockpiles and loading area;
- Weighbridges;
- Brake test ramps;
- Crushing and screening plant;
- Underground mine access shaft and associated equipment;
- Upcast ventilation shaft and fans (underground mine), and
- Wastewater (sewage) treatment infrastructure for the contractor's camp and mine office block area.

The mine will operate on a 2-shift system 6 days per week and the coal preparation plant operates on a 3-shift system 7 days per week. Coal is out-loaded to rail 7 days per week. The raw coal handling, stockpiling, processing, and out-loading facilities are designed to cater for the differences between mining, coal preparation, and product handling operations.

2 The information in this section has primarily been summarised from the Kranspan Mining Works Programme (Ilima, 2018)

A summary of selected key parameters defining the proposed mining activity is provided in Table 2-1.

TABLE 2-1: SELECTED KEY MINE OVERVIEW PARAMETERS

PARAMETER	UNIT	VALUE*
Life of Mine	Years	12
Total ROM Tonnage	Mt	24.8
Mine Tonnage (Surface Mining)	Mt	14.1
Mine Tonnage (Underground Mining)	Mt	10.7
Average Stripping Ratio	Ratio	8.7:1
Total Overburden Material Stockpile Volume	Mm^3	120.5
Total Topsoil Stockpile Volume	Mm^3	2.6
Maximum Depth of Surface Mining	m	40

** Source: Ilima Mine Works Programme (2018)*

2.1.2 OPENCAST MINING

A conventional strip mining (roll-over) method will be employed for each of the opencast pits. Material from the boxcut phase will be stored per overburden classification, with the bulk of the material placed in a position alongside the final strip, to facilitate filling of the final void (Figure 2-1).

Each of the steps in the open cast mining method is summarised below:

2.1.2.1 Topsoil

Topsoil will be removed two strips in advance of the current working strip and will be either stockpiled separately or placed directly on the rehabilitated area behind the advancing strip. Topsoil will be removed using excavators and hauled with Articulated Dump Trucks (ADTs).

The average depth of topsoil at Kranspan is 0.5 m.

2.1.2.2 Softs Removal

Soft subsoil will be removed one strip in advance of the current working strip and will be either stockpiled separately or placed directly on the rehabilitated area behind the advancing strip. Softs will be removed using excavators and hauled with Articulated Dump Trucks (ADTs).

Softs are generally the weathered material within the soil profile. At Kranspan, this material has an average thickness of approximately 6.65 m.

2.1.2.3 Overburden Drill and Blast

Drilling of the overburden will be done using a mobile drill rig drilling a 110 mm diameter hole and with a planned burden and spacing of 4 m x 5 m. This may be adjusted once mining has commenced.

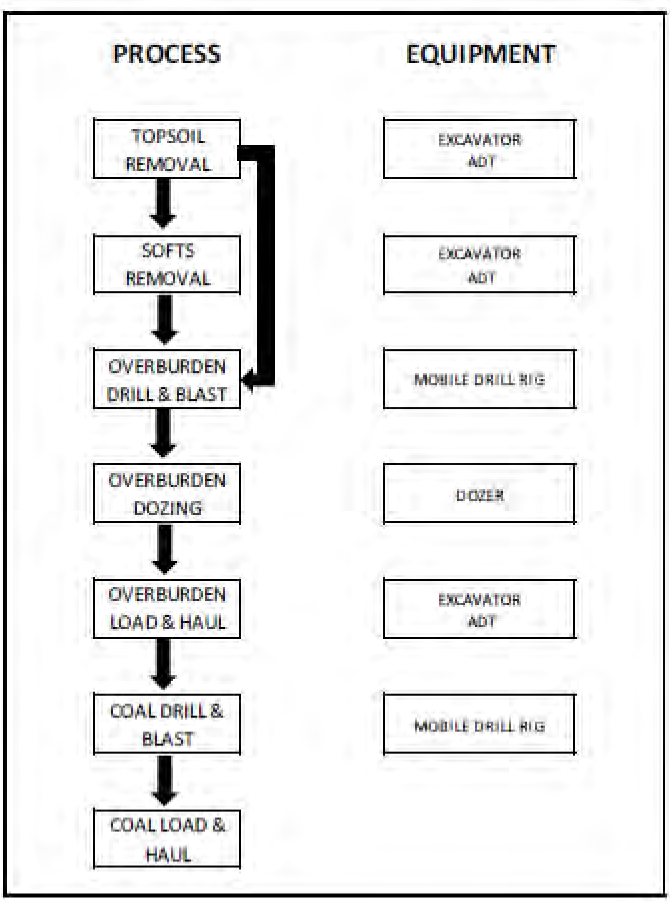

FIGURE 2-1: MINING METHOD

Hards overburden material typically comprises of unweathered sandstone. At Kranspan, the average thickness of the hards material is 12 m.

2.1.2.4 Overburden Dozing

The first overburden removal process will be to doze overburden material to the spoil side. For modelling purposes, it is assumed that 30% of the overburden can be dozed. The assumption is based on current mining practice at similar sites.

2.1.2.5 Overburden Load and Haul

After dozing, remaining overburden will be loaded and hauled and dumped on the spoil side of the current strip. The load and haul will be conducted using excavators and ADTs.

2.1.2.6 Coal Drill and Blast

Drilling of the coal will be done using a mobile drill rig drilling a 110 mm diameter hole and with a planned burden and spacing of 7 m x 8 m. This may be adjusted once mining has commenced.

2.1.2.7 Coal Load and Haul

Permanent haul roads will be constructed in line with relevant safety requirements. The coal be loaded and hauled to the Run of Mine (ROM) Stockpiles using excavators and ADTs.

2.1.2.8 *Rehabilitation*

Rehabilitation of the open pits will be done concurrently with the opencast mining using the recognised roll over method of mining and the stated mining sequence.

Materials are placed back into the void in the former stratigraphic sequence i.e. topsoil on the surface, subsoil directly below the topsoil, while all hard material (sandstone and shale) is deposited in the bottom of the void. It is envisaged that the final reinstated surface level will be approximately 0.52 m above the original surface level. However, the existing surface drainage pattern will remain unchanged and the total disturbed area will be free draining. On completion of surface reinstatement, the area will be re-vegetated with suitable pasture grass species.

2.1.3 UNDERGROUND MINING

The underground mining method will be a conventional bord and pillar mining operation deploying continuous miners with shuttle cars, supported by roof bolters for roof support and load haul dumpers for sweeping. The mine will be designed for the maximum extraction on the advance with no pillar extraction on retreat. The safety factors applied for main developments is 2.0 and for secondary production panels 1.6.

It is planned to establish three continuous miner production sections producing between 120,000 and 130,000 tpm. A stone development section will be established for developing through dykes and faults. This will ensure that the continuous miner sections focus on coal production only.

The mine design will allow for the introduction of additional production sections, if required in the future.

2.1.3.1 *Underground Material Handling Systems*

Broken ore will be transported from the production faces by means of an LHD and tipped into underground dump trucks for transporting to the underground crushing circuit.

Ore will be tipped directly onto a grizzly. The undersize will pass through the grizzly screen onto an apron feeder and vibrating grizzly, which will convey the ore to the underground crusher. Oversize will undergo secondary breakage using a hydraulic rock breaker.

Ore will be transferred via the underground conveyor to the adit entrance and loaded onto a stockpile where it will be transported to the plant via tipper trucks.

2.1.4 DRY CRUSHING AND SCREENING PLANT

Certain areas will be mined to produce a high Ash, medium Volatile, thermal coal product for power station consumption by screening and crushing the run of mine (ROM) coal. The crushing and screening plant will be situated at the plant area. A typical crushing and screening plant is shown in Figure 2-2.

At the crushing and screening plant, the raw coal is fed into the crushing plant by a FEL (Front End Loader). The coal is crushed mechanically in the plant by jaw crushers. This reduces the size of the raw coal so that it can be more easily handled. The crushed coal then moves into the screening plant where vibrating screens separate the crushed coal into different sizes or grades of coal.

This coal product is then loaded onto trucks for delivery to the Eskom market.

FIGURE 2-2: COAL PROCESSING PLANT

2.1.5 Overburden Stockpiles

Several overburden stockpiles will be established during the LOM. These overburden stockpiles comprise of the hards and softs sub-soil material removed in order to gain access to the coal seam. The stockpiles have been placed as close to the pits as possible but outside of areas identified as environmentally sensitive. The proposed location of the stockpiles is shown in Appendix 1.

Topsoil is stored separately to the overburden stockpiles.

The location and capacity of the PCDs is summarised in the table below and shown in Appendix 1.

TABLE 2-2: SUMMARY LIST OF PLANNED OVERBURDEN STOCKPILES

LABEL	LENGTH	WIDTH	HEIGHT	AREA (M2)	VOLUME (M3)
H1	345	90	10	32 254	246 736
H2	400	95	10	38 532	318 838
S1	252	126	10	32 153	271 333
T1	180	36	5	8 258	24 732
H3	151	75	10	11 409	86 518
H4	150	70	10	15 511	79 608
H5	275	40	10	10 854	70 000
H6	301	40	10	6 938	78 949

S2	150	103	10	11 941	124 313
S3	206	50	10	12 450	72 429
T2	130	78	5	11 961	52 699
H26	232	87	10	21 466	156 600
H27	256	100	10	31 012	204 000
S21	250	100	10	27 720	199 100
H7	337	223	10	90 253	682 028
S4	355	196	10	71 707	627 470
T3	294	70	5	25 106	91 845
H8	540	72	10	39 814	312 663
H9	289	100	10	31 711	241 405
S5	480	105	10	50 112	431 319
T3A	400	45	5	24 356	76 035
S6	266	154	10	41 289	358 078
H10	458	106	10	47 686	415 486
H11	791	142	10	114 547	1 005 997
H12	576	129	10	101 869	628 800
S7	238	125	10	108 714	243 103
H13	280	158	10	45 703	384 028
S8	238	125	10	29 835	243 103
T4	221	101	5	20 578	101 576
S9	238	117	10	34 303	235 217
H14	278	123	10	39 149	292 809
S10	309	150	10	47 648	406 946
T5	339	45	5	15 424	64 262
H15	180	123	10	22 830	184 813
S11	126	126	10	16 921	128 701
H28	370	120	10	45 654	368 138
S22	441	75	10	31 472	256 224
H18	765	75	10	58 679	465 430
S13	765	75	10	51 556	465 430
T6	665	30	5	21 133	77 785
H19	371	100	10	34 217	312 910
H20	283	100	10	28 753	236 173
H21	270	90	10	24 962	199 117
H22	270	95	10	26 761	211 977
H23	270	99	10	25 969	222 265
H24	270	90	10	24 072	199 117
H25	140	95	10	13 290	105 117
S14	409	123	10	59 953	437 172
S15	270	80	10	21 600	173 397
S16	489	97	10	53 876	401 521

S17	270	80	10	21 600	173 397
S18	270	80	10	21 600	173 397
S19	270	80	10	21 586	173 397
S20	141	100	10	14 068	112 349
T7	270	50	5	13 500	57 535
T8	270	50	5	13 500	57 535
T9	270	50	5	13 500	57 535
T10	270	50	5	13 500	57 535
T11	141	80	5	11 280	49 603

The stockpiles are temporary in that they are only on surface for as long as it takes to extract the coal from the relevant pit. After the coal has been removed, the overburden material is placed back into the pit in the same order as it was removed, typically hards, softs and then topsoil. Whilst on surface, the overburden stockpiles are managed as part of the dirty water management area. Runoff from the stockpile areas thus drains and is contained in the PCDs.

2.1.6 ROM Stockpiles and Product Stockpile

Several ROM stockpiles will be established at the open cast mine areas. Raw coal extracted from the pits is temporarily stockpiled at these locations before being transported to the coal processing area either for dry crushing and screening or washing.

Following processing, the coal is placed on the product stockpile. The latter is situated adjacent to the processing plant. From here, the product is transported to the customer. The product stockpile will be in place for the LOM.

The ROM and product stockpile areas are managed as part of the dirty water management system. Runoff from the stockpile areas thus drains and is contained in the PCDs.

2.1.7 Dense Medium Beneficiation (Coal Washing) Plant

Washing of the raw coal is required for the approximately 70% of the coal product over the LOM. The purpose of washing is primarily to reduce the ash content of the coal so that it meets the quality requirements of the export market (Table 2-3).

TABLE 2-3: COAL QUALITY COMPARISON

PARAMETER	PRODUCT		
	KRANSPAN COAL	EXPORT – RB2 GRADE	ESKOM
Total Product tonnes per annum	2 160 000	1 162 296	498 127
Proportion of Total	100%	70%	30%
Gross Calorific Value (MJ/kg)	19.72 – 25.50	>25.30	19 - 24
Ash (%)	18.00 – 31. 65	<20	24 - 33
Volatile Matter (%)	20.07 – 23.77	>21	>20
Total Sulphur (%)	0.70 – 1.11	<1.20	<1.50
Abrasion Index (Mg Fe/kg)	280 - 420	n/a	<450

Source: Mine Works Programme (Ilima, 2019)

The raw coal handling facilities, coal preparation plant (wash plant) and product out-loading facilities are designed to receive and process coal from both opencast and underground mining operations and to produce 3.0 Mt/a of saleable product at 5,500 kcal/kg net as received which is to be out-loaded on rail for delivery to the RBCT. A typical coal washing plant is shown in Figure 2-3.

The coal preparation plant design capacity and product out-loading systems are calculated on the following basis:

Raw coal feed	4.24 Mt/a AD
Sales	3.00 Mt/a AD
Operating time	6360 h/a
Theoretical Yield	80.8%
Plant Efficiency	87.6%
Plant Yield	70.8% (+10% maximum -15% minimum)
Average plant capacity	670 t/h AD
Design plant capacity	+10%-740t/h AD

The coal preparation plant is designed on a modular basis to allow for a phased build-up in coal production.

The washing plant design comprises of the following modules: -

- Dense medium (DM) cyclone modules each inclusive of de-sliming screen clean coal drain and rinse screen, 2 x 600 dense medium cyclones and associated tanks and pumps;
- Discard modules comprising 1 drain and rinse screen fed from 2 dense medium cyclone modules;
- Fines treatment plants fed from 2 dense medium cyclone modules each module inclusive of de-sliming cyclones, spirals, spiral clean coal dewatering cyclones and screens, spiral discard dewatering cyclones and water clarification system;
- Clean coal dewatering module fed from the 4 dense medium cyclone modules by a common conveyor feeding 2 clean coal centrifuges; and
- Plant services for magnetite addition, compressed air, and high-pressure water.

The modules are sized to handle the design tonnage plus 10% and the expected variations in yield and size consist as set down in the design criteria.

The 40 mm x 0 raw coal is fed onto fixed sieve panels followed by de-sliming screens where water is added and the 1mm x fines are removed. The 40 x 1 mm de-slimed raw coal is then mixed in a magnetite in water suspension and laundered to a dense medium cyclone feed tank from where it is pumped to 2 x 600 mm dense medium cyclones.

The cyclones are sized to handle the feed tonnage and particle top size. The 1 mm x 0 fines gravitate to a de-sliming tank and are pumped to the fines treatment for further processing.

The dense medium cyclones separate the coal by density into clean coal and discard fractions. Clean coal gravitates over a fixed sieve to a horizontal vibrating drain and rinse screen where medium is drained from the coal and the coal is then rinsed with water to remove any adhering medium. Discard from the cyclones similarly gravitates to a horizontal vibrating drain and rinse screen where medium is again drained from the coal and the coal is again rinsed with water to remove any adhering medium.

Correct medium from the fixed sieve and drainage section of the drain and rinse screens gravitates to a correct medium tank and is then pumped to a head-box from where it is distributed to the pump tank and bleed-off to dilute medium to remove excess water entering the circuit with the raw coal.

Dilute medium from the drainage section of the drain and rinse screens gravitates to a dilute medium tank from where it is pumped to a magnetic separator for recovery of the magnetite. Magnetic separator effluent is used as primary rinse water on the drain and rinse screens or flood box water on the de-sliming screen. Over dense magnetite from the magnetic separator gravitates to the correct medium tank.

An automatic nucleonic density controller measures the density of the correct medium and controls the addition of clarified water into the correct medium tank to maintain the correct density in the circuit.

Fresh magnetite slurry is periodically added at the required density to the correct medium tank from the magnetite mixing plant if the density of the medium or the tank level drops.

Clean coal from the drain and rinse screens is discharged onto a common collection conveyor and fed to clean coal centrifuges for further dewatering of the coal. Effluent from the centrifuges is pumped back via flood-box onto the drainage section of the clean coal drain and rinse screens.

Discard from the drain and rinse screens is collected on a common discard conveyor and conveyed to the discard bin. Floor clean-up sumps and pumps are provided in each module.

FIGURE 2-3: EXAMPLE OF A TYPICAL WASH PLANT

2.1.8 SLURRY AND DISCARD

Washing of the coal in the coal preparation plant will result in the generation of two coal waste streams, namely a coal slurry and a coal discard. The former comprises of fine coal particle material with a high moisture content as well as clay and shale. The presence of contaminants like clay and shale in the coal, and more especially the high moisture content thereof, present complications in the handling and use of the slurry. The Calorific Value of the slurry is however still adequate for application in markets like the cement industry.

2.1.9 Discard Management

Coal discard generated at the wash plant generally comprises of larger coal particle sizes and less moisture. Discard from the coal preparation plant is planned to be deposited back into the open pits, after extraction of the target coal seam has been completed. In accordance with the recommendations from the geochemical characterisation testwork, geochemical modelling and groundwater study, only Pit 5 is proposed to be used for the in-pit disposal of the discard material.

The volume of discard material which will be generated over the LOM is dependent on several factors including the tonnage of coal processed through the wash plant. This, in turn, is dependant on the quality of the coal seams and the difference in the export versus Eskom price of the coal per tonne. Both of these factors cannot be predicted with absolute certainty at the mine planning stage and are expected to fluctuate over the LOM.

Two discard management alternatives were assessed as part of the S&EIR Process, namely surface and in-pit discard disposal. These are discussed in the relevant specialist studies, summarised in Section 17 of the EIR. The alternatives analysis is presented in Section 6 of the EIR.

Based on the mine planning undertaken to date and informed by the findings of the geochemical modelling, approximately 5 384 455 m^3 of discard material is proposed to be backfilled in Pit 5 as part of the rehabilitation of this pit. This comprises of a surface area of approximately 143 ha and is based on backfilling of the discard into the mined pit up to the average height of the roof of the coal seam. Should additional discard disposal capacity be required and the material be backfilled to above the pre-mining coal seam depth, geochemical and groundwater modelling will be undertaken to estimate this impact prior to the implementation of this management option.

This will limit the extent to which carbonaceous material is placed back in the pit at a different height to that which occurred naturally in the pre-mining profile. The height of the coal seam increases towards the north and north-west of Pit 5 and decreases towards the south. The backfilling height will follow the same gradient as the coal seam with greater height of discard material backfilled in the north and north-west of the pit. Plans showing the proposed area for the in-pit disposal of discard are shown in Appendix 4.

Current forecasts indicate that there will be enough capacity in Pit 5 for the in-pit disposal of all discard material that will be generated over the LOM. Should this change, Ilima will establish an engineered surface discard stockpile. This stockpile will be situated in proximity to the coal preparation plant (Appendix 1) and will be designed in compliance with the Regulations regarding the Planning and Management of Residue Stockpiles and Residue Deposits, 2015 (as amended)[3].

2.1.10 Conveyor

Based on current mine plans, provisions has been made for the construction of underground conveyor which will convey coal to the surface stockpile. The underground shaft conveyor will be elevated to ~15 m, which allows for a 7,000-tonnes ROM coal stockpile on surface.

An overland conveyor was considered as part of the Mine Works Programme. Based on the current mine plans, the overland conveyor was considered less viable. However, the use of overland conveyor might be considered in future.

[3] Government Notice No. R. 632 of 24 July 2015, promulgated in terms of the National Environmental Management: Waste Act 59 of 2008

2.1.11 POWER

Based on the planned mining operation, surface plant, and product handling information planned for the Kranspan Project, the calculated Total Power Demand is 7.0 megavolt amperes (MVA). The Maximum Demand is dependent on correct operation of a Power Factor Correction (PFC) system to keep the Power Factor above 0.96. Should the PFC system fail, the Maximum Demand can substantially increase to 9.3 MVA.

Calculation of the Maximum Demand is based on:

- Underground power requirements
  - Three continuous miner sections;
  - Conveyor systems; and
  - Auxiliaries installations such as water reticulation systems.
- Surface power requirements
  - Office complexes;
  - Change house facilities;
  - Ventilation fans;
  - Incline conveyors;
  - Surface stockpile conveyors;
  - Crushing and screening plant;
  - Modular Coal Processing Plant;
  - Water purification and sewer plants; and
  - Workshops.

In order to mitigate risks to underground operations and to comply with legislation, an alternate power supply to the ventilation fans has been recommended and other critical infrastructure is mitigated by installing standby diesel generators for the purposes of fulfilling the alternate power supply.

The Surface Consumer Substation for Kranspan will typically consist of the following:

- Two 22 kV pole-mounted Ganged Isolators with surge arrestors.
- Two 22 kV / 11 kV 10 MVA DY11 skid-mounted Oil Natural Air-cooled transformers fitted with:
  - Automatic 16-step tap switch changer
  - Primary circuit breaker
  - Secondary circuit breaker
  - 25-Amp dry-type continuously rated Neutral Earthing Resistor
  - Primary, secondary, transformer, and neutral earthing resistor protection
  - Controllers
  - Automatic tap switch changer
  - 22 kV voltage transformer
- One skid-mounted breaker skid with:

- Two incoming breakers
- One lighting transformer
- Bus section breaker
- Two reactor capacitor inductive system feeders
- Two underground feeders
- Four surface feeders

- Earthing system as per SANS requirements.
- Two PFC systems.

A 22kV overhead power line, approximately 2.7 km in length will be required. The route of this power line is proposed to be established from a connection on Portion 1 from where it will cross the R36 and then broadly follow the alignment of the main mine access road to the mine offices.

2.1.12 Explosives Magazine

Explosives for blasting of overburden and coal will be stored at selected areas across the site. Storage areas will comply with all relevant legislation.

2.1.13 Pollution Control Dams

Six PCDs will be established on the mine site to collect and retain dirty water for reuse. The proposed location of the PCDs has been informed by the surface topography of the site in relation to the proposed mining areas (Appendix 1). The location of the PCDs also avoids areas identified as environmentally sensitive. .

The capacity of the PCDs is based on a 1:50 year storm event[4].

The location and capacity of the PCDs is summarised in the table below.

PCD	CAPACITY	LOCATION (FARM PORTION)
PCD 1	49 000m3	Kranspan 49IT Portion 1
PCD 2	49 000m3	Kranspan 49IT Portion 1
PCD 3	49 000m3	Kranspan 49IT Portion 2
PCD 4	49 000m3	Kranspan 49IT Portion 3
PCD 5	49 000m3	Kranspan 49IT Portion 5
PCD 6	49 000m3	Kranspan 49IT Portion 7

2.1.14 Water Supply

Water requirements for use by the mine staff is calculated at 100 litres (L) per person per day. The total number of employees and subcontractors are estimated to be between 350 and 400 and the water supply capacity has therefore been calculated at 40 kilolitres (kL) per day.

Boreholes will be established to supply water for staff requirements. A small water treatment plant will be built at the mine to produce potable water from the borehole water.

Industrial water requirements include:

- Beneficiation Plant (Dense medium);

[4] A stormwater management plan has been compiled by JB Umwelttechnik (2019) and is attached as Appendix 2.

- Dust suppression (Surface and Underground);
- Cooling (Underground)

The processing plant water consumption has been estimated to be between 10,000 and 20,000 m^3 per month.

Two sources for the supply of water, especially to the beneficiation plant, have been identified, namely:

- Water from ground or surface water resources; and
- Water from dirty water containment facilities.

2.1.15 Sewage

New facilities for sewage will be constructed within the footprint of the process plant. The technology is likely to be a modular sewage package plant with a design throughout capacity suitable for the expected mine labour.

Chemical toilets will be used for the underground mining. These will be serviced at the required frequency by a contractor.

2.1.16 Water Management

All dirty rainfall run-off will be separated from clean water through cut-off drains. The polluted run-off water collected will be stored in high-density polyethylene-lined (HDPE) pollution control dams (PCDs). The latter will be located adjacent to the screening and crushing plant and in proximity to the open pits. The water from the PCDs will be used for dust suppression around the plants and the ROM and product stockpiles.

Water management across the site will be in compliance with all requirements of Government Notice 704, promulgated in terms of the National Water Act, Act 36 of 1998, specifically in respect of the following:

- Collection of the water arising within any dirty area, including water seeping from mining operations, outcrops or any other activity, into a dirty water system;
- Design, construction, maintenance and operation of the clean water and dirty water management systems so that it is not likely for either system to spill into the other more than once in 50 years;
- Design, construction, maintenance and operation of any dam that forms part of a dirty water system to have a minimum freeboard of 0.8 m above full supply level, unless otherwise specified in terms of Chapter 12 of the Act;
- Design, construction, and maintenance of all water systems in such a manner as to guarantee the serviceability of such conveyances, for flows up to and including those arising as a result of the maximum flood, with an average period of recurrence of once in 50 years; and
- Prevention of erosion or leaching of materials from any residue deposit or stockpile from any area and containment of material or substances so eroded or leached in such area by providing suitable barrier dams, evaporation dams or any other effective measures to prevent this material or substance from entering and polluting any water resources.

2.1.17 Non-Mineral Waste Management

No solid waste disposal facilities are to be constructed as part of the mine development. All waste will be managed in accordance with the waste management hierarchy as required by the National Environmental Management: Waste Management Act 59 of 2008.

Waste will be segregated into general and hazardous waste and contractors will be appointed to remove the waste to licensed waste disposal facilities.

Recyclable waste like glass, wood and plastic will similarly be segregated on site and removed by licensed waste transporters. An oil recycling company will also be appointed to remove waste oil generated by the mining activities. Medical waste arising from the on-site clinic will also be removed from site by a contractor.

The on-site waste storage area is proposed to be located within the process plant footprint.

2.1.18 Main Mine Access Road and Internal Haul Roads

The Project Area will be directly accessed from the R36 Provincial Road, which runs in a north to south direction from Carolina to Breyten. The administrative offices, main store, main workshop, and the wash plant infrastructure will be constructed approximately 2 km from the proposed junction of the main mine access road with the R36. This is an existing junction with the R36, used by current landowners and site occupiers. A weighbridge will be installed on the main mine access road.

The main access road would consist of a 10-15m wide gravel road with softs material berms along both sides of the roads. These roads will be equipped with all the required storm water systems and structures to prevent any possible flooding. Dust from these roads will be controlled by applying road binders and regular watering with water tankers.

Stormwater runoff from the roads within the mining right area will be regarded as dirty water and managed through the mine's dirty water management system.

2.1.19 Rail

No new rail infrastructure is proposed to be constructed as part of the Kranspan Project. Product destined for the export market will be transported via truck to an existing rail siding. The rail route links to the RBCT mainline at Ermelo and onto the export facility at Richards Bay.

The rail haul route from the Project Area to Majuba Power Station goes south to Ermelo, and then onto the newly constructed rail line that links the export rail line at Ermelo with the Majuba Power Station.

2.1.20 Offices, Workshops and Change Houses

Based on the anticipated management structure at the Kranspan Project, office and ablution facilities have been designed to accommodate all on-site personnel. The office design contains the reception area, eight offices, boardroom, male and female ablution facilities, kitchen, and change house and laundry facility. The office design will, as far as possible, make use be made of existing buildings (farmhouses).

The processing wash plant offices will be incorporated into the main office complex that is situated close to the plant.

An office complex, including offices, a small boardroom, a change house, stores, lamp room, and workshops will also be established at the underground adit area.

2.2 EXTENT OF ACTIVITY

Based on the mine planning available at present, it is expected that the mine and all associated infrastructure and structures will have a maximum surface area footprint of approximately 1210 hectares.

The underground mining area will take up approximately 392 ha. A summary of the surface area extent of the most significant structures associated with the Project are provided in Table 2-4.

TABLE 2-4: EXTENT OF PROPOSED ACTIVITIES

NAME OF ACTIVITY (ALL ACTIVITIES INCLUDING ACTIVITIES NOT LISTED) (E.G. EXCAVATIONS, BLASTING, STOCKPILES, DISCARD DUMPS OR DAMS, LOADING, HAULING AND TRANSPORT, WATER SUPPLY DAMS AND BOREHOLES, ACCOMMODATION, OFFICES, ABLUTION, STORES, WORKSHOPS, PROCESSING PLANT, STORM WATER CONTROL, BERMS, ROADS, PIPELINES, POWER LINES, CONVEYORS, ETC…ETC…ETC.)	AERIAL EXTENT OF THE ACTIVITY HA OR M^2
Mine Contractors Camp	2 ha
Open Pit Mine Areas	777 ha
Overburden Stockpiles	181 ha
Topsoil Stockpiles	19 ha
Surface Discard Stockpile (alternative to in-pit discard disposal)	15.6 ha
Pollution Control Dams	6 ha
Fuel Storage Area and Back-Up Power Generation (generator sets)	0.04 ha
Explosives Storage Area (Rapid reload area 100m*50m) (Magazine 70m x 45m)	0.8ha
Mine Haul Road and Internal Roads – Main Roads (7km @15m wide)	10.5 ha
Mine Haul Road and Internal Roads – Pit Roads (3km @ 15m wide)	4.5 ha
Mine Haul Road and Internal Roads – Roads for Final Rehabilitation (2km @10m wide)	2.0 ha
ROM Stockpiles (Located near opencast pits)	6.4 ha
ROM Stockpile (Located near plant)	2.6 ha
Coal Processing Plant (Dry Crushing and Screening and Wash Plant)	1.7 ha
In-Pit Discard Disposal (Pit 5)	143 ha
Mine Support and Administration Block (Sewage treatment facility, workshops, offices, ablutions, change houses, lamp room, first aid station, stores, weighbridges, solid waste handling area, vehicle parking area, and vehicle wash bay, water supply boreholes)	1.7 ha
Mine Access Shaft and Ventilation Shaft	5.4 ha
Underground Mining Area	264 ha

2.3 KEY ACTIVITY RELATED PROCESSES AND PRODUCTS

The key activities applicable to this IWWMP are open pit and underground mining and coal processing. The mining method and infrastructure required to support the mining are described in Section 2.1.

2.4 ACTIVITY LIFE DESCRIPTION

In terms of the MPRDA, the maximum period a mining right may be issued for is 30 years, with the option to renew for another 30 years. Current LOM planning indicates that the resource will be mined within 30 years.

2.5 ACTIVITY INFRASTRUCTURE DESCRIPTION

The key structures and infrastructure associated with the proposed mine development are described in Section 2.1 and summarised in Table 2-4.

2.6 KEY WATER USES AND WASTE STREAMS

2.6.1 WATER USES

Water requirements for use by the mine staff is calculated at 100 litres (L) per person per day. The total number of employees and subcontractors are estimated to be between 350 and 400 and the water supply capacity has therefore been calculated at 40 kilolitres (kL) per day.

Boreholes will be established to supply water for staff requirements. A small water treatment plant will be built at the mine to produce potable water from the borehole water.

Industrial (process) water requirements include:

- Beneficiation Plant (Dense medium);
- Dust suppression (Surface and underground); and
- Cooling (Underground).

The processing plant water consumption has been estimated to be between 10 000 and 20 000 m^3 per month.

Two sources for the supply of water, especially to the beneficiation plant, have been identified, namely:

- Water from ground or surface water resources; and
- Water from dirty water containment facilities (PCDs).

2.6.1.1 Section 21 Water Uses

Various water uses are required for the proposed project in terms of the National Water Act 36 of 1998. These are listed below and summarised in Table 2 2 - Table 2-8 and visually represented in Map 6-8:

Section 21a and 21j Water Uses

- Boreholes to supply water for office requirements.
- Taking of water / dewatering (rainfall and seepage) which may collect in the open pit void and which will need to be removed to allow for mining.
- Taking of water from / dewatering the underground mine workings.

TABLE 2-5: SECTION 21A WATER USES IDENTIFIED FOR THE PROPOSED PROJECT

ACTIVITY	INFRASTRUCTURE	PROPERTY DESCRIPTION	FARM PORTIONS	ID	X	Y
Taking of water	Abstraction BH	Kranspan 49IT	3/49	A1	30,00835638	-26,15664796
Taking of water / dewatering (rainfall and seepage) which may collect in the open pit void and which will need to be removed to allow for safe continuation of mining	Opencast Mining - Pit 1	Kranspan 49IT	3/49	A2	30,007434	-26,16406475
	Opencast Mining - Pit 2	Kranspan 49IT	2/49	A3	29,99483077	-26,16627896
	Opencast Mining - Pit 3	Kranspan 49IT	5/49	A4	30,01852011	-26,17888912
	Opencast Mining - Pit 4	Kranspan 49IT	2/49	A5	29,98494387	-26,17019918
	Opencast Mining - Pit 5	Kranspan 49IT	3/49	A6	30,02222809	-26,15443867
	Opencast Mining - Pit 6	Kranspan 49IT	7/49	A7	30,01767151	-26,14385913
	Opencast Mining - Pit 7	Kranspan 49IT	7/49	A8	30,00732421	-26,14544498
	Opencast Mining - Pit 8	Kranspan 49IT	4/49	A9	29,99804175	-26,14706459

	Opencast Mining - Pit 9	Kranspan 49IT	RE/49	A10	30,02235896	-26,18363556
	Opencast Mining - Pit 10	Kranspan 49IT	1/49	A11	30,03910793	-26,17528335
	Opencast Mining - Pit 11	Kranspan 49IT	1/49	A12	30,02934663	-26,16521763
	Underground Mining Area	Kranspan 49IT	4/49	A13	30,00083629	-26,15571197

TABLE 2-6: SECTION 21J WATER USES IDENTIFIED FOR THE PROPOSED PROJECT

ACTIVITY	INFRASTRUCTURE	PROPERTY DESCRIPTION	FARM PORTIONS	ID	X	Y
The dewatering process associated with the continuation of mining activities (surface)	Opencast Mining - Pit 1	Kranspan 49IT	3/49	J1	30,007434	-26,16406475
	Opencast Mining - Pit 10	Kranspan 49IT	2/49	J2	29,99483077	-26,16627896
	Opencast Mining - Pit 11	Kranspan 49IT	5/49	J3	30,01852011	-26,17888912
	Opencast Mining - Pit 2	Kranspan 49IT	2/49	J4	29,98494387	-26,17019918
	Opencast Mining - Pit 3	Kranspan 49IT	3/49	J5	30,02222809	-26,15443867
	Opencast Mining - Pit 4	Kranspan 49IT	7/49	J6	30,01767151	-26,14385913
	Opencast Mining - Pit 5	Kranspan 49IT	7/49	J7	30,00732421	-26,14544498
	Opencast Mining - Pit 6	Kranspan 49IT	4/49	J8	29,99804175	-26,14706459
	Opencast Mining - Pit 7	Kranspan 49IT	RE/49	J9	30,02235896	-26,18363556
	Opencast Mining - Pit 8	Kranspan 49IT	1/49	J10	30,03910793	-26,17528335
	Opencast Mining - Pit 9	Kranspan 49IT	1/49	J11	30,02934663	-26,16521763
The dewatering process associated with the continuation of mining activities (underground)	Underground Mining Area	Kranspan 49IT	4/49	J12	30,00083629	-26,15571197

Section 21c&i Water Uses

- Parts of the proposed pits and some mine infrastructure, including roads and stockpiles, will be located within 500 m of a wetland.
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TABLE 2-7: SECTION 21C&I WATER USES IDENTIFIED FOR THE PROPOSED PROJECT

ACTIVITY	INFRASTRUCTURE	PROPERTY DESCRIPTION	FARM PORTIONS	ID	X	Y
Placement of adit within 500 m of a wetland.	Adit	Kranspan 49IT	4/49	C1	30,00046808	-26,16040701
Placement of discard facility within 500 m of a wetland.	Alternative Surface Discard Disposal Site	Kranspan 49IT	3/49	C2	30,01333745	-26,15748497
Placement of haul road within 500 m of a wetland.	Haul Road 1 End	Kranspan 49IT	7/49	C3	30,00161573	-26,14486408
	Haul Road 1 Start	Kranspan 49IT	4/49	C4	29,99343293	-26,15374656
	Haul Road 2 End	Kranspan 49IT	3/49	C5	30,00963947	-26,15515197

	Haul Road 2 Start	Kranspan 49IT	4/49	C6	29,99458481	-26,15046558
	Haul Road 3 End	Kranspan 49IT	7/49	C7	30,01951228	-26,15019587
	Haul Road 3 Start	Kranspan 49IT	2/49	C8	29,9870334	-26,17094173
	Haul Road 4 End	Kranspan 49IT	5/49	C9	30,02683246	-26,16568214
	Haul Road 4 Start	Kranspan 49IT	3/49	C10	30,00984317	-26,15784479
	Haul Road 5 End	Kranspan 49IT	1/49	C11	30,0286485	-26,16725609
	Haul Road 5 Start	Kranspan 49IT	RE/49	C12	30,02007222	-26,18889068
	Haul Road 6 End	Kranspan 49IT	1/49	C13	30,03529499	-26,17684826
	Haul Road 6 Start	Kranspan 49IT	1/49	C14	30,02667483	-26,17163283
	Haul Road 7 End	Kranspan 49IT	1/49	C15	30,04479164	-26,16591338
	Haul Road 7 Start	Kranspan 49IT	1/49	C16	30,03428588	-26,17603181
Placement of infrastructure within 500 m of a wetland.	Mine Offices and Workshop	Kranspan 49IT	3/49	C17	30,00751226	-26,15770541
Proposed surface mining area (open pits) within 500 m of a wetland	Opencast Mining - Pit 1	Kranspan 49IT	3/49	C18	30,007434	-26,16406475
	Opencast Mining - Pit 10	Kranspan 49IT	1/49	C19	30,03910793	-26,17528335
	Opencast Mining - Pit 11	Kranspan 49IT	1/49	C20	30,02934663	-26,16521763
	Opencast Mining - Pit 2	Kranspan 49IT	2/49	C21	29,99483077	-26,16627896
	Opencast Mining - Pit 3	Kranspan 49IT	5/49	C22	30,01852011	-26,17888912
	Opencast Mining - Pit 4	Kranspan 49IT	2/49	C23	29,98494387	-26,17019918
	Opencast Mining - Pit 5	Kranspan 49IT	3/49	C24	30,02222809	-26,15443867
	Opencast Mining - Pit 6	Kranspan 49IT	7/49	C25	30,01767151	-26,14385913
	Opencast Mining - Pit 7	Kranspan 49IT	7/49	C26	30,00732421	-26,14544498
	Opencast Mining - Pit 8	Kranspan 49IT	4/49	C27	29,99804175	-26,14706459
	Opencast Mining - Pit 9	Kranspan 49IT	RE/49	C28	30,02235896	-26,18363556
Pollution Control Dam within 500 m of a wetland.	PCD	Kranspan 49IT	1/49	C29	30,03524375	-26,17186132
	PCD	Kranspan 49IT	1/49	C30	30,02734467	-26,1712652
	PCD	Kranspan 49IT	2/49	C31	29,98831735	-26,17014295
	PCD	Kranspan 49IT	3/49	C32	30,01509313	-26,15965221
	PCD	Kranspan 49IT	5/49	C33	30,00935258	-26,17031489
	PCD	Kranspan 49IT	7/49	C34	30,00622194	-26,13648573
Proposed plant within 500 m of a wetland.	Plant	Kranspan 49IT	3/49	C35	30,00861969	-26,15692297
Product stockpiles will be placed within 500 m of a wetland.	Product Stockpile	Kranspan 49IT	3/49	C36	30,0093435	-26,15715241
Proposed ROM stockpile within 500 m of a wetland.	ROM	Kranspan 49IT	RE/49	C37	30,02571467	-26,17208905
	ROM	Kranspan 49IT	1/49	C38	30,03406252	-26,17527595
	ROM	Kranspan 49IT	2/49	C39	29,99908949	-26,16168274
	ROM	Kranspan 49IT	2/49	C40	29,98662829	-26,1670566
	ROM	Kranspan 49IT	3/49	C41	30,01021084	-26,15566657
	ROM	Kranspan 49IT	7/49	C42	30,01560396	-26,15099611

Proposed Sewage treatment plant within 500 m of a wetland.	Sewage Treatment Plant	Kranspan 49IT	3/49	C43	30,00847363	-26,15656123
Proposed topsoil & overburden facilities are within 500 m of a wetland.	Topsoil & Overburden Facilities	Kranspan 49IT	RE/49	C44	30,01951483	-26,19070874
	Topsoil & Overburden Facilities	Kranspan 49IT	RE/49	C45	30,02456885	-26,17395238
	Topsoil & Overburden Facilities	Kranspan 49IT	1/49	C46	30,0307159	-26,16197611
	Topsoil & Overburden Facilities	Kranspan 49IT	1/49	C47	30,04089335	-26,17107419
	Topsoil & Overburden Facilities	Kranspan 49IT	2/49	C48	29,99266387	-26,16404166
	Topsoil & Overburden Facilities	Kranspan 49IT	2/49	C49	29,98758005	-26,16840849
	Topsoil & Overburden Facilities	Kranspan 49IT	2/49	C50	30,00321924	-26,16597393
	Topsoil & Overburden Facilities	Kranspan 49IT	3/49	C51	30,01613226	-26,15246537
	Topsoil & Overburden Facilities	Kranspan 49IT	3/49	C52	30,02913287	-26,15868274
	Topsoil & Overburden Facilities	Kranspan 49IT	4/49	C53	29,99336782	-26,15725037
	Topsoil & Overburden Facilities	Kranspan 49IT	4/49	C54	30,00557312	-26,15736747
	Topsoil & Overburden Facilities	Kranspan 49IT	5/49	C55	30,01218217	-26,1661309
	Topsoil & Overburden Facilities	Kranspan 49IT	7/49	C56	30,01205982	-26,14453059
	Topsoil & Overburden Facilities	Kranspan 49IT	7/49	C57	30,01488469	-26,1492671
Underground mining within 500 m of a wetland.	Underground Mining Area	Kranspan 49IT	4/49	C58	30,00083629	-26,15571197
Weighbridge will be placed within 500 m of a wetland.	Weighbridge / Security	Kranspan 49IT	3/49	C59	30,01322092	-26,16026013
Slurry Curing Facility will be placed within 500 m of a wetland.	Slurry Curing Facility	Kranspan 49IT	3/49	C60	30,00865283	-26,15645649

Section 21g Water Uses

- Establishment of six PCDs, located across the Kranspan Farm and used to contain the dirty stormwater runoff from the process plant area, roads, topsoil and overburden material stockpiles.
- Temporary stockpiles for topsoil and overburden material. During rehabilitation, these stockpiles are placed back into the pit in the same sequence as they were removed;
- Offices and other buildings needed in support of the mining activity;
- Coal wash plant;
- ROM stockpiles;
- In-pit disposal of slurry and discard from the wash plant; ;

- If there is insufficient capacity for in-pit disposal of discard material, establishment of an engineered surface discard stockpile in proximity to the coal wash plant.
- New facilities for sewage will be constructed within the footprint of the process plant. The technology is likely to be a modular sewage package plant with a design throughout capacity suitable for the expected mine labour;and
- Dust suppression activities on stockpiles and haul roads (surface and underground) will be undertaken using water from the PCDs.

TABLE 2-8: SECTION 21G WATER USES IDENTIFIED FOR THE PROPOSED PROJECT

INFRASTRUCTURE	PROPERTY DESCRIPTION	FARM PORTIONS	ID	X	Y
Adit	Kranspan 49IT	4/49	G1	30,00046808	-26,16040701
Alternative Surface Discard Disposal Site	Kranspan 49IT	3/49	G2	30,01333745	-26,15748497
Haul Road 1 End	Kranspan 49IT	7/49	G3	30,00161573	-26,14486408
Haul Road 1 Start	Kranspan 49IT	4/49	G4	29,99343293	-26,15374656
Haul Road 2 End	Kranspan 49IT	3/49	G5	30,00963947	-26,15515197
Haul Road 2 Start	Kranspan 49IT	4/49	G6	29,99458481	-26,15046558
Haul Road 3 End	Kranspan 49IT	7/49	G7	30,01951228	-26,15019587
Haul Road 3 Start	Kranspan 49IT	2/49	G8	29,9870334	-26,17094173
Haul Road 4 End	Kranspan 49IT	5/49	G9	30,02683246	-26,16568214
Haul Road 4 Start	Kranspan 49IT	3/49	G10	30,00984317	-26,15784479
Haul Road 5 End	Kranspan 49IT	1/49	G11	30,0286485	-26,16725609
Haul Road 5 Start	Kranspan 49IT	RE/49	G12	30,02007222	-26,18889068
Haul Road 6 End	Kranspan 49IT	1/49	G13	30,03529499	-26,17684826
Haul Road 6 Start	Kranspan 49IT	1/49	G14	30,02667483	-26,17163283
Haul Road 7 End	Kranspan 49IT	1/49	G15	30,04479164	-26,16591338
Haul Road 7 Start	Kranspan 49IT	1/49	G16	30,03428588	-26,17603181
Mine Offices and Workshop	Kranspan 49IT	3/49	G17	30,00751226	-26,15770541
PCD	Kranspan 49IT	1/49	G18	30,03524375	-26,17186132
In Pit Discard - Pit 5	Kranspan 49IT	3/49	G19	30,02451386	-26,15338803
PCD	Kranspan 49IT	1/49	G20	30,02734467	-26,1712652
PCD	Kranspan 49IT	2/49	G21	29,98831735	-26,17014295
PCD	Kranspan 49IT	3/49	G22	30,01509313	-26,15965221
PCD	Kranspan 49IT	5/49	G23	30,00935258	-26,17031489
PCD	Kranspan 49IT	7/49	G24	30,00622194	-26,13648573
Plant	Kranspan 49IT	3/49	G25	30,00861969	-26,15692297
Raw Coal Stockpike	Kranspan 49IT	3/49	G26	30,00775185	-26,15707972
Product Stockpile	Kranspan 49IT	3/49	G27	30,0093435	-26,15715241
ROM	Kranspan 49IT	RE/49	G28	30,02571467	-26,17208905
Slurry Curing Facility	Kranspan 49IT	3/49	G29	30,00865283	-26,15645649
ROM	Kranspan 49IT	1/49	G30	30,03406252	-26,17527595
ROM	Kranspan 49IT	2/49	G31	29,99908949	-26,16168274
ROM	Kranspan 49IT	2/49	G32	29,98662829	-26,1670566

ROM	Kranspan 49IT	3/49	G33	30,01021084	-26,15566657
ROM	Kranspan 49IT	7/49	G34	30,01560396	-26,15099611
Sewage Treatment Plant	Kranspan 49IT	3/49	G35	30,00847363	-26,15656123
Topsoil & Overburden Facilities	Kranspan 49IT	RE/49	G36	30,01951483	-26,19070874
Topsoil & Overburden Facilities	Kranspan 49IT	RE/49	G37	30,02456885	-26,17395238
Topsoil & Overburden Facilities	Kranspan 49IT	1/49	G38	30,0307159	-26,16197611
Topsoil & Overburden Facilities	Kranspan 49IT	1/49	G39	30,04089335	-26,17107419
Topsoil & Overburden Facilities	Kranspan 49IT	2/49	G40	29,99266387	-26,16404166
Topsoil & Overburden Facilities	Kranspan 49IT	2/49	G41	29,98758005	-26,16840849
Topsoil & Overburden Facilities	Kranspan 49IT	2/49	G42	30,00321924	-26,16597393
Topsoil & Overburden Facilities	Kranspan 49IT	3/49	G43	30,01613226	-26,15246537
Topsoil & Overburden Facilities	Kranspan 49IT	3/49	G44	30,02913287	-26,15868274
Topsoil & Overburden Facilities	Kranspan 49IT	4/49	G45	29,99336782	-26,15725037
Topsoil & Overburden Facilities	Kranspan 49IT	4/49	G46	30,00557312	-26,15736747
Topsoil & Overburden Facilities	Kranspan 49IT	5/49	G47	30,01218217	-26,1661309
Topsoil & Overburden Facilities	Kranspan 49IT	7/49	G48	30,01205982	-26,14453059
Topsoil & Overburden Facilities	Kranspan 49IT	7/49	G49	30,01488469	-26,1492671
Site dust Suppression	Kranspan 49IT	5/49	G50	30,00833637	-26,16648941
Underground Mining Area	Kranspan 49IT	4/49	G51	30,00083629	-26,15571197
Weighbridge / Security	Kranspan 49IT	3/49	G52	30,01322092	-26,16026013

2.6.2 Waste Streams

The following waste streams are likely to be generated by the site activities and are discussed in detail in Section 6 of this report:

- Domestic waste;
- Hazardous waste;
- Sewage; and
- Effluent/wastewater.

2.6.3 Company Structure

The business model adopted by Ilima Coal Company is based on a contractor operated and owner-managed mine. Ilima Coal Company will provide sufficient financial and human resources to ensure that:

- The mine maintains its license to operate;
- Business objectives are met; and

- Facilities and services that fall between or across contracts are provided.

The company organisational structure is shown in Figure 2-4

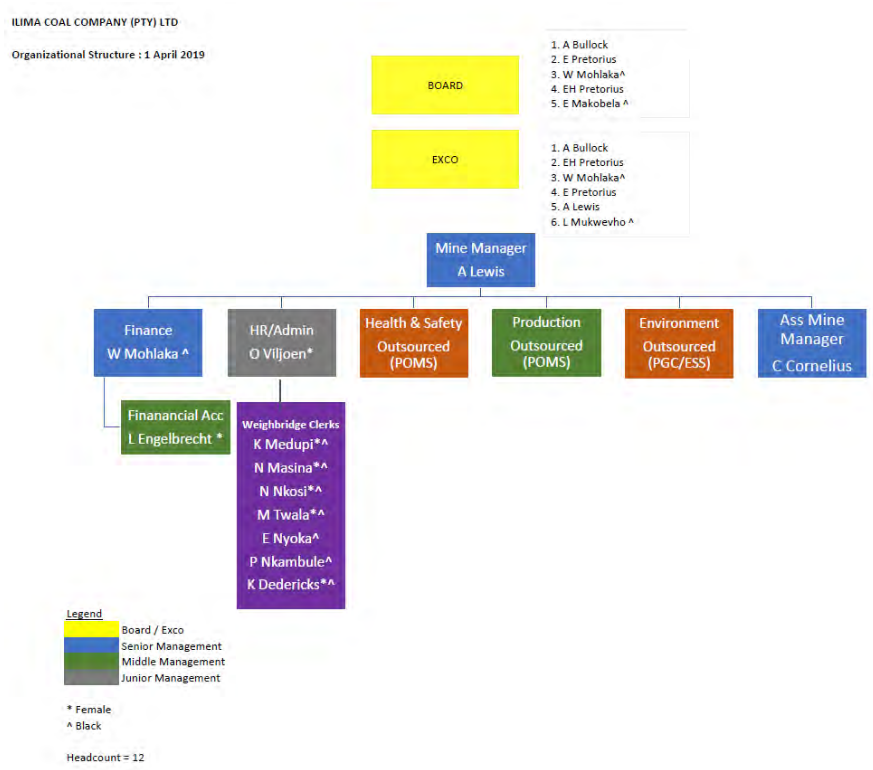


FIGURE 2-4: COMPANY ORGANISATIONAL STRUCTURE

2.7 BUSINESS AND CORPORATE POLICIES

The Ilima Coal Company operates the Ilima Colliery, situated near Carolina. The company is thus an operating mine with policies, systems, processes and procedures in place for the management of its activities. A summary of the company's Safety, Health and Environment (SHE) commitments is provided below:

2.7.1 SAFETY COMMITMENT

Ilima recognises that the key to a safe workplace is through the development of a safety culture where our people show a genuine desire to protect not only their own safety but also the safety of fellow workers. The SHE Management system has been documented and implemented and shall be maintained.

Our commitments towards compliances is as follows -

- The safety of our people is a value which is not compromised;
- All incidents and accidents can be prevented;
- We are aware of the hazards and risks in the workplace and act accordingly;
- We understand that we are responsible for our own safety and the safety of other;
- Compliance with standard operating procedures (SOP's) is absolute;
- At risk behaviour is not accepted and will be addressed when observed;
- Effective skills to lead and work safely are developed through ongoing training and mentoring;

- Where risks are identified, plans will be developed and implemented to manage the risks;
- The Company complies with all the applicable legal and other requirements.

2.7.2 HEALTH AND HYGIENE COMMITMENT

- Health stressors will be continuously identified, evaluated and controlled in all areas across the Company;
- The workplace will be continuously re-engineered to reduce health stressors;
- Where this is not possible, appropriate personal protective equipment (PPE) will be provided, maintained and enforced;
- We are committed to prevent injuries and ill health.

2.7.3 ENVIRONMENTAL COMPLIANCE COMMITMENT

- Statutory and management control measures will be maintained and optimised to ensure the effective prevention of environmental pollution;
- We are aware of the environmental risks and we will act in a manner which best prevents these risks.

2.7.4 RISK MANAGEMENT COMMITMENT

- Hazards will be identified, risks will be assessed, and risk control measures will be implemented, monitored and controlled before any work is to commence;
- Effective skills to work safely are developed through ongoing hazard identification and risk assessment training and mentoring.

3 REGULATORY WATER AND WASTE MANAGEMENT FRAMEWORK

3.1 SUMMARY OF ALL WATER USES

Existing water uses across the proposed mining right area are limited to those associated with the agricultural activities in practice, including boreholes for irrigation and personal use. The hydrocensus completed as part of the geohydrological study provides further details on these uses.

The new water uses required for the proposed mining activities are presented in Section 2.6.

3.2 EXISTING LAWFUL WATER USES

No ELU applies to the proposed Kranspan Project. There are no water uses which pre-date the National Water Act No. 36 of 1998.

3.3 RELEVANT EXEMPTIONS

No exemptions with respect to the use of water are known to have been granted over the properties relevant to the application for the IWUL.

Some of the water uses associated with the proposed mining activities require exemption in terms of Regulation 4 of GN 704[5].

The motivation for exemption from certain regulations in GN704 for these activities is provided in TABLE 3-1.

[5] Government Notice 704 promulgated in terms of Section 26 of the National Water Act 36 of 1998

TABLE 3-1: GN704 EXEMPTION MOTIVATION

GN704 REGULATION	APPLICABILITY TO IWULA	MOTIVATION
4 (a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground, or on ground likely to become water-logged, undermined, unstable or cracked	➲ The PCD will be constructed within a horizontal distance of 100m of a wetland. ➲ Topsoil and overburden facilities may be placed within 100m of a wetland. ➲ Haul road placed within 100m of a wetland. ➲ A section of the proposed location for the surface discard disposal (if it is needed) may be placed within 100m of a wetland.	➲ Several alternatives and layout options were considered to place infrastructure outside of buffer zones for sensitive areas. ➲ Mitigation measures have been proposed to reduce impacts to water resources. ➲ The specialist assessments indicated that with mitigation measures adequately implemented the impact to water resources will be reduced. ➲ All wetlands associated with the project area were assessed to have a PES of C – moderately modified. ➲ A wetland offset mitigation plan will be developed where required.
4 (b) except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary, whichever is the greatest;	➲ Opencast and underground mining will take place within 100m from a wetland.	➲ Several options were considered to avoid mining within the buffer zone. The specialist assessments indicated that with mitigation measures adequately implemented the impact will be reduced to an acceptable level. ➲ The footprint area has been minimised as far as Possible. ➲ A wetland offset mitigation plan will be developed where required.
4 (c) No person in control of a mine or activity may place or dispose of any residue or substance which causes or is likely to cause pollution of a water resource, in the workings of any underground or opencast mine excavation, prospecting diggings, pit or any other excavation	➲ Discard will be placed back in to the pit (pit 5 only) as part of mining operations.	➲ Placing the discard material back into the pit is consistent with the waste management hierarchy in that it will reduce the extent to which this material will need to be stockpiled on surface. ➲ In-pit discard disposal in Pit 5 has been modelled in the geohydrological report to be an acceptable option. ➲ The cost and environmental impacts associated with land sterilisation and managing clean and dirty water management around a surface discard stockpile will be reduced.

3.4 GENERALLY AUTHORISED WATER USES

No general authorisations are known to be applicable to the proposed mining right area.

3.5 NEW WATER USES TO BE LICENCED

The new water uses required for the proposed mining activities are presented in Section 2.6.

3.6 WASTE MANAGEMENT ACTIVITY (NEMWA)

The Kranspan Project will require a WML for the required PCDs, discard disposal and overburden stockpiles. Mine residue stockpiles are included in the definition of hazardous waste in NEMWA. In addition, all mineral and non-mineral waste generated by the mine activities will need to be managed in accordance with the provisions of NEMWA and its associated regulations, norms and standards.

A summary of applicable waste related authorisations required for the Project is provided in Table 3- 1.

TABLE 3- 1: LISTED WASTE MANAGEMENT ACTIVITIES APPLICABLE TO THE PROJECT

REGULATION	ACTIVITY NUMBER	SUMMARY DESCRIPTION
GN R.921, 29 November 2013 Category A: Basic Assessment	1	The storage of general waste in lagoons. **The pollution control dams, needed for management of dirty stormwater, are regarded as evaporation dams, as per the definition of lagoon in GN R. 921.**
GN R.921, 29 November 2013 Category A: Basic Assessment	12	The construction of a facility for a waste management activity listed in Category A of this Schedule (not in isolation to associated waste management activity). **The construction of the pollution control dams will fall within the ambit of this activity.**
GN R.921, 29 November 2013 Category B: Scoping and EIA	1	The storage of hazardous waste in lagoons excluding storage of effluent, wastewater or sewage. **The pollution control dams, needed for management of dirty stormwater, are regarded as evaporation dams, as per the definition of lagoon in GN R. 921.**
GN R.921, 29 November 2013 Category B: Scoping and EIA	10	The construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity). **The construction of the pollution control dams and residue stockpiles will fall within the ambit of this activity.**
GN R.921, 29 November 2013 Category B: Scoping and EIA	11	The establishment or reclamation of a residue stockpile or residue deposit resulting from activities which require a mining right, exploration right or production right in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002). **The material stockpiles (topsoil, overburden) and the discard disposal (in-pit and surface discard stockpile facility) fall within the definition of a residue stockpile.**

3.7 OTHER AUTHORISATION (ELAS, EMPS, RODS, REGULATIONS)

3.7.1 ENVIRONMENTAL AUTHORISATION

A Scoping and Environmental Impact Reporting (S&EIR) process is being undertaken in support of the Mining Right Application (MRA). The S&EIR informs the applications for Environmental Authorisation (EA), Waste Management Licence (WML), and IWUL required for the proposed mining and associated activities. The EMPr is part of the Environmental Impact Report (EIR).

4 BASELINE ENVIRONMENT

The following section summarises the baseline environmental conditions of the mining area. Further baseline information on the receiving environment is available in the EIR and the individual specialist studies compiled in support of the EIR.

4.1 CLIMATE

The rainfall characteristics of the study area are documented in the Surface Water Resources of South Africa 1990 Volume VI and within the X1A rainfall zone as per Map No 1.3 in the Book of Maps. The closest rainfall station to the study area is the South African Weather Station 0480267W – Kranspan which is located on the south-western boundary of the study area (Peens & Associates, 2019).

4.1.1 MEAN ANNUAL AND MONTHLY RAINFALL

The mean annual rainfall for South African Weather Station 0480267W – Kranspan is 698mm based on 44 years of data as indicated in the TR102 Southern African Storm Rainfall from PT Adamson. The mean monthly rainfall distributions as listed in the Surface Water Resources of South Africa 1990 Volume VI Appendix 2.2 were used to calculate the mean monthly rainfall and the annual standard deviation was used to estimate the typical wet and dry seasons(Peens & Associates, 2019).

The mean monthly rainfall distributions from Surface Water Resources of South Africa 1990 Volume VI Appendix 2.2 are listed in the table and shown in the figure below.

TABLE 4-1: MEAN MONTHLY RAINFALL DISTRIBUTIONS IN PERCENTAGE (%)

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MA	JUN	JUL	AUG	SEP
Distribution	10.8	17.4	16.1	17.1	12.5	10.5	5.9	2.2	1.2	1.0	1.2	4.1

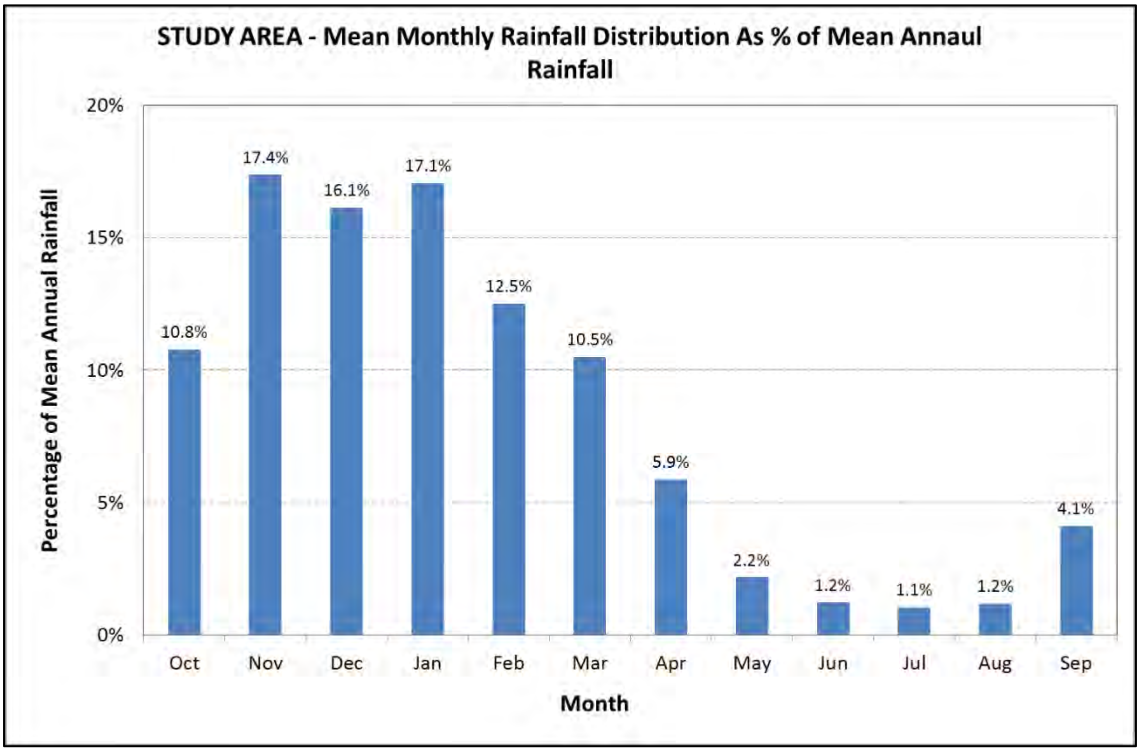


FIGURE 4-1: PERCENTAGE MEAN MONTHLY DISTRIBUTION OF MEAN ANNUAL RAINFALL (MAP)

The mean monthly and annual rainfall as well as that for typical wet and dry years is listed in the table below.

TABLE 4-2: MEAN MONTHLY AND ANNUAL RAINFALL (MM)

MONTH	OCT	NOV	DEC	JAN	FEB	MAR	APR	MA	JUN	JUL	AUG	SEP	ANNUAL
Wet	87	139	129	137	100	84	47	17	11	8	10	33	802
Mean	75	121	113	119	87	73	41	15	9	7	9	29	698
Dry	64	103	96	101	74	62	35	13	8	6	8	24	594

4.1.2 Surface Wind Field

The wind field for the study area is described with the use of wind roses. Wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period (Airshed, 2019).

The period wind field and diurnal variability in the wind field are shown in Figure 4-2. Seasonal variations in the wind field are provided in Figure 4-3.

The colours used in the wind roses reflect the different categories of wind speeds; the yellow area, for example, representing winds in between 4 and 5 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. Calm conditions are periods when the wind speed was below 1 m/s. These low values can be due to "meteorological" calm conditions when there is no air movement; or, when there may be wind, but it is below the anemometer starting threshold (Airshed, 2019).

The wind field was predominantly from the west-northwest and north-east. Calm conditions occurred 4.70% of the time. There is a great contrast between day-time and night-time wind fields. During the day, winds occurred more frequently from the north-westerly sector, with 4.75% calm conditions. Night-time airflow showed increased wind speeds which occurred most frequently from the north-easterly sector. The frequency of night-time calm conditions decreased to 4.65%. From Figure 4-3, autumn and winter show similar wind direction profiles to the period average, while summer shows more frequent winds from the east-northeast and a decrease in wind speeds from the north-west. There is an increased frequency of wind speeds of 3 m/s or more in spring.

According to the Beaufort wind force scale[6] wind speeds between 6-8 m/s equates to a moderate breeze, with wind speeds between 9-11 m/s referred to as a fresh breeze. Wind speeds between 11-14 m/s are described as a strong breeze with winds between 14-17 m/s near gale force winds and 17 - 21 m/s as gale force winds (Airshed, 2019).

Based on the three years of WRF data, wind speeds between 6 m/s and 8 m/s occurred 10.4% of the time; wind speeds between 9 m/s and 11 m/s occurred 5.4% of the time and wind speeds higher than11 m/s occurred 0.3% of the time (Airshed, 2019).

[6] https://www.metoffice.gov.uk/guide/weather/marine/beaufort-scale

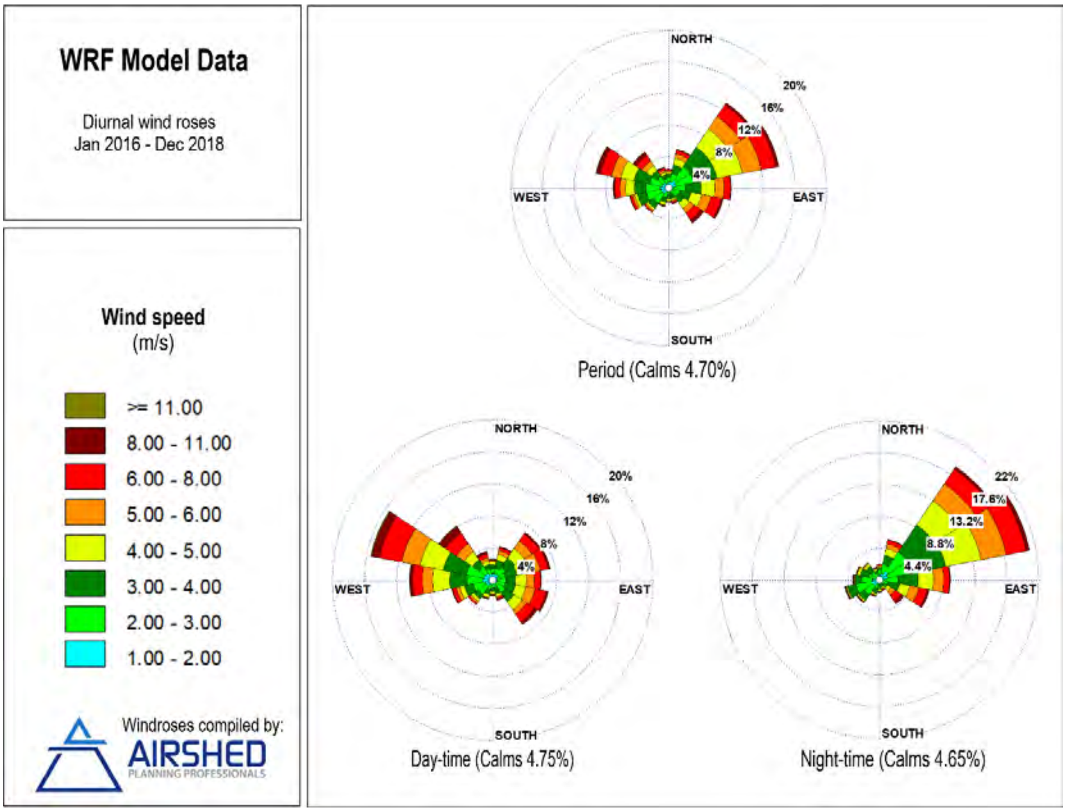


FIGURE 4-2: PERIOD, DAY- AND NIGHT-TIME WIND ROSES (WRF DATA; 2016-2018)

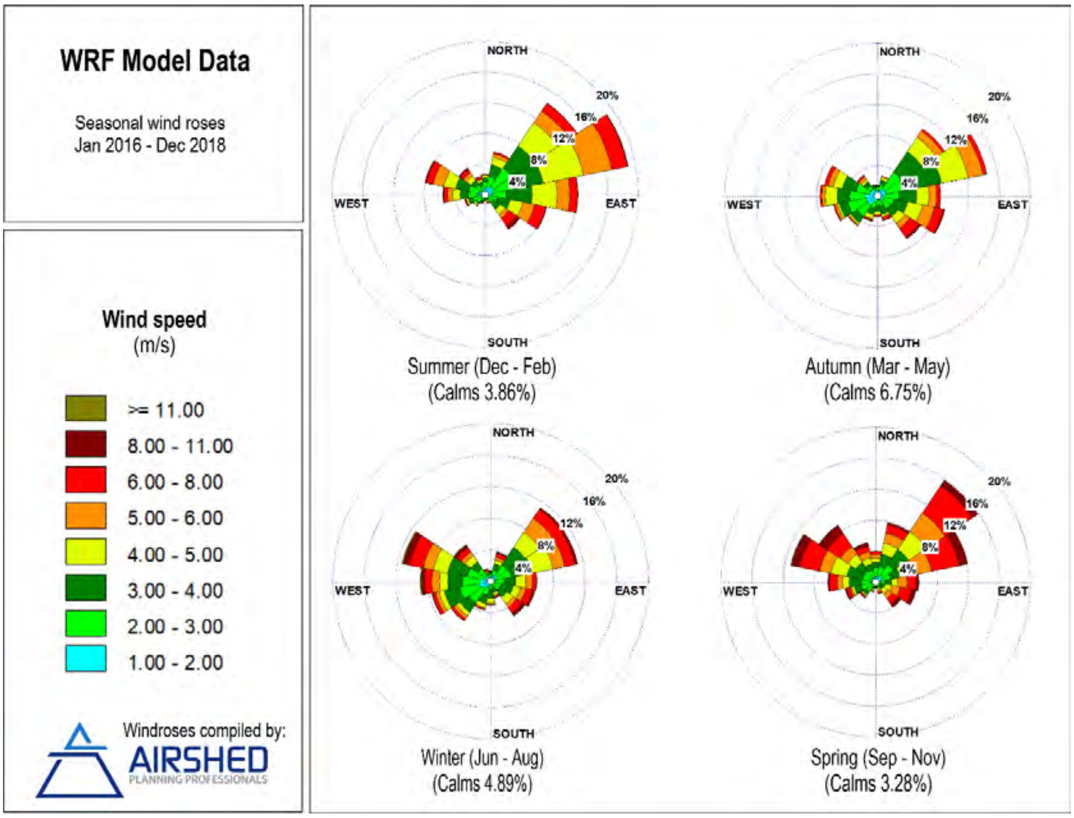


FIGURE 4-3: SEASONAL WIND ROSES (WRF DATA; 2016-2018)

4.1.3 TEMPERATURE

The monthly temperature pattern is shown in Figure 4-4. The area experienced mild temperatures during summer. Winter temperatures were relatively low especially in the month of July. Average maximum temperatures range from 33.3°C in December to 21.9°C in July, with minima ranging between -2.8°C in July and 7.8°C in December (Airshed, 2019).

The diurnal temperature profile for the site is given in Figure 4-5. During the day, temperatures increase to reach maximum at around 12:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 05:00 i.e. just before sunrise (Airshed, 2019).

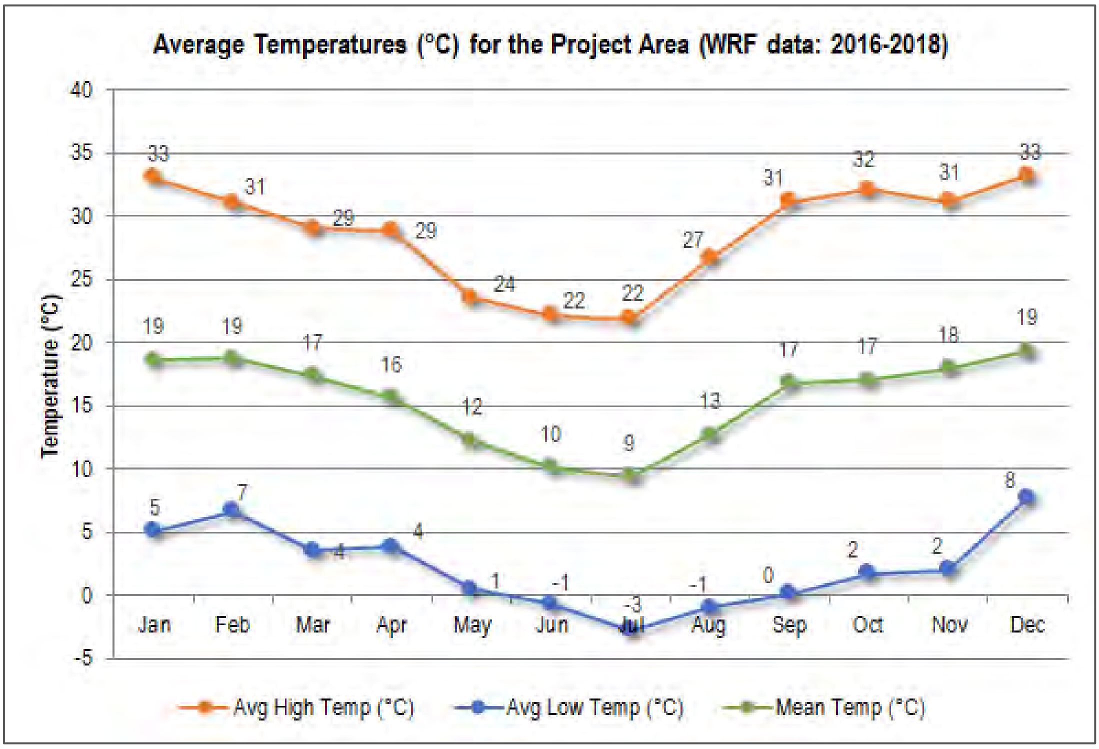


FIGURE 4-4: MONTHLY TEMPERATURE PROFILE (WRF DATA; 2016-2018)

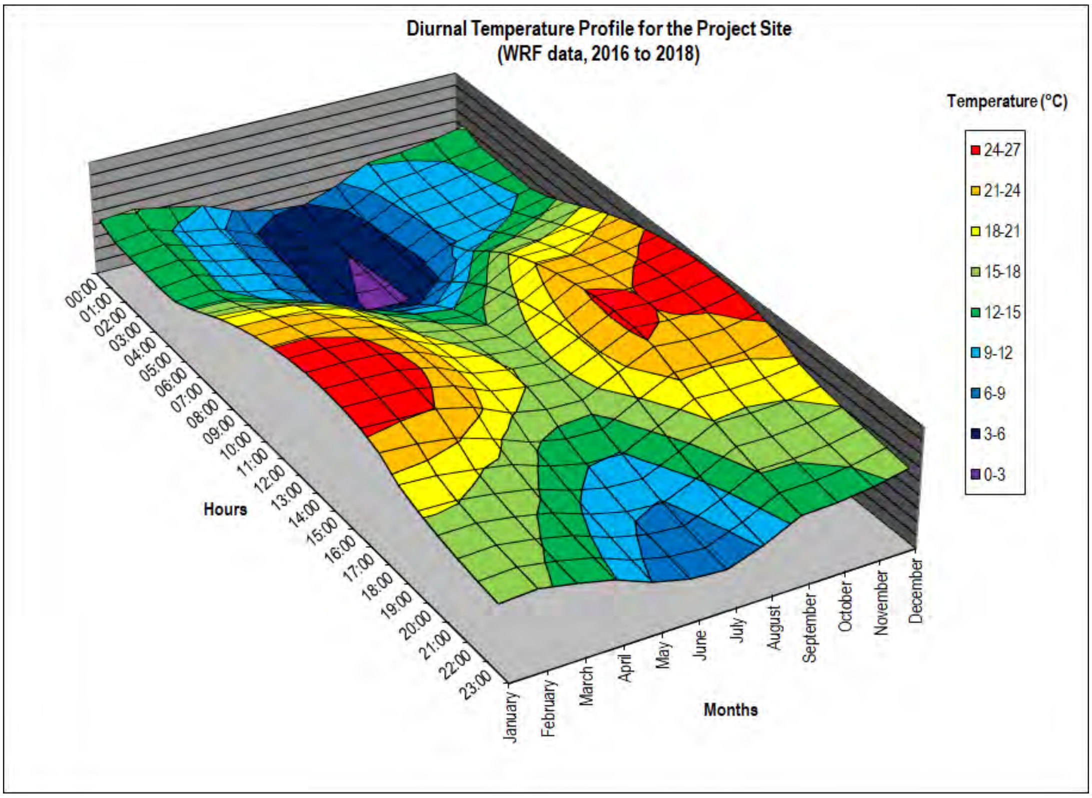


FIGURE 4-5: DIURNAL TEMPERATURE PROFILE (WRF DATA; 2016-2018)

4.2 SURFACE WATER[7]

4.2.1 CATCHMENT

The proposed mine right area falls within the Sabie/Crocodile/Komati (X) Primary catchment, the X1 Secondary catchment and the Inkomati/Usuthu (3) DWS Water Management Area.

The study area is situated in the X11B quaternary sub-catchment of the Komati River Drainage Region as per the Volume VI: Water Resources of South Africa 1990.

The Nooitgedacht Dam is the major water body of the X11B quaternary sub-catchment that might be impacted by the proposed mine. The Nooitgedacht Dam total catchment area, i.e. quaternary sub-catchments; X11A, X11B and X11C combined is 1 588 km^2.

Quaternary sub-catchment X11B under laying geology is basic or mafic and ultramafic intrusive lavas, which forms part of the igneous group. Igneous rocks are formed by volcanic activities and in moderate to wet regions it degrades to form clay. The overburden soils are moderate to deep sandy loam.

4.2.2 SITE SPECIFIC WATER RESOURCES

4.2.2.1 Major Rivers/ Watercourse through Study Area

The proposed mining right area is in the Boesmanspruit catchment area on the watershed between the Boesmanspruit and the Vaalwaterspruit catchments. Both the Boesmanspruit and the Vaalwaterspruit are tributaries of the Nooitgedacht Dam and the Komati River.

[7] Information in this section has been summarised from the hydrology (Peens &Associates, 2019) and surface water ecosystem (Enviross, 2019) reports attached in Appendix 3 of the IWWMP

Three pans are located within the proposed mining right area of which two have no outflow and their catchment areas can therefore be classified as endoreic areas that do not contribute to the runoff towards Nooitgedacht Dam.

The proposed mining right area is 33.8 km^2 in size of which 37.6% (12.7km^2) is endorheic areas; hence the portion of study area contribution to the Boesmanspruit runoff is 21.1 km^2. Thus the portion of the study area that contributes to runoff in the Boesmanspruit is 3.5% of the Boesmanspruit catchment, which has a total catchment of 597 km^2.

4.2.2.2 Minor Rivers / Watercourses in Study Area

The proposed mining right area consists both of endorheic areas and non- endorheic areas. Nodes S1 and S2 are accumulation points of such endorheic areas, node S3 acts as an attenuation system with only extreme flood events discharging into the catchment of node S4 (Appendix 1, Map 4).

However the discharge from S3 will never contribute to the flood peaks of S4 as the response times of the catchments will not synchronise with the same storm events. The locations for nodes S4 and S5 were selected to obtain the minimum catchment area of each stream that will be affected by the study area. The catchment areas mainly consist of grass lands and cultivated fields with predominantly flat slopes. The overburden soils are moderate to deep sandy loam and are classified as permeable soils.

TABLE 4-3: SUMMARY OF WATERCOURSES CATCHMENTS ON SITE

Node Name	Effective Catchment Area (km^2)	Stream Length (Km)	10-85 Method Avg. Slope (1:..)	Overland Flow Length (Km)	Overland Avg. Slope (1:..)
S1	15.490	3.62	49.35	-	-
S2	2.485	-	-	1.77	32.18
S3	2.222	-	-	3.37	134.77
S4	11.86	5.74	107.64	-	-
S5	16.49	4.62	86.66	-	-

4.2.2.3 Wetlands / Pans

The region is characterised by depression-type wetland units, supplemented by hillslope seep wetlands that are often interconnected by valley-bottom wetland types. Valleyhead seeps often are associated at the origin of the valley topographical feature that develops into a valley-bottom wetland feature. The proposed development site includes two watershed zones, with the bulk of the runoff water collecting the southern, central and eastern runoff water and draining it south-eastwards to drain along a watercourse (Boesmanspruit) that flows north-eastwards. Another watershed collects runoff from the central north-western portions and drains it northwards, with the watercourse (Vaalwaterspruit) draining north-eastwards. Figure 8 presents a digital elevation terrain model of the proposed development site, which is based on 1m contour data. It can be seen that the majority of Portion 4 and Portion 7 drain north-westwards, whereas the remaining portions tend to drain eastwards and northwards.

The site is located within the upper reaches of the catchment area and therefore valleyhead seep zones that develop into valley-bottom wetland units are common. Depression wetlands that are either ephemeral (short-lived/seasonal) or more perennial (persistent) in occurrence are common. Kranspan, being the largest wetland unit within the survey area is regarded as a typical ephemeral wetland unit. There are impoundments along the watercourses of the valley-bottom units that induce persistent surface waters. Although the wetland clusters and complexes are largely isolated in terms of surface water flow, overtopping of the wetland units and surface interconnection would happen following exceptional rainfall events. They are, however, also interconnected via subsurface flows and interchanges.

Although there is a relatively high degree of interlinking, the survey area includes three main drainage areas. These areas are subject to similar pressures and drivers of ecological change and all have similar catchment characteristics. There are numerous small impoundments located along all watercourses, cultivation is commonplace within the higher-lying areas and livestock graze generally throughout all of the grassland areas, which are all factors that have deleterious impacts on the overall functionality of the wetland features. Hydrological, vegetation and geomorphological features are therefore generally similar for all units. All of the individual wetland units within these three areas have therefore been grouped in order to evaluate their overall ecological status.

4.2.3 SURFACE WATER HYDROLOGY[8]

4.2.3.1 Design Storm

The closest rainfall gauging station to the study area is the 0480267W – Kranspan. The design rainfall events associated with this gauging station is documented in the TR 102 Southern African Storm Rainfall.

For storm Duration less than 6 hours the following relationship developed by Hershfield and later modified by Alexander is used to calculated point rainfall with:

$P_t,T = 1.13(0.41 + 0.64^* \ell n\ T)(-0.11 + 0.27^* \ell n\ t)(0.79M^{0.69}R^{0.20})$

* R = 60 days/year that thunder is seen.

TABLE 4-4: DESIGN 24 HOUR RAINFALL DATA

Station Number	Description	MAP (mm)	24-Hour Rainfall (mm)					
			1:2	1:5	1:10	1:20	1:50	1:100
0480267	Kranspan	698	62	82	97	112	135	153

4.2.3.2 Flood Peaks and Volumes

The flood peaks were calculated utilising the Rational Method. The flood volume was calculated using a triangular hydrograph with the time of concentration equal to a third of the storm duration.

The table below summaries the peak flows and flood volumes for the range recurrence intervals.

TABLE 4-5: FLOOD PEAKS AND VOLUMES FOR WATER COURSES IN STUDY AREA

Catchment Name		Recurrence Interval					
		1:2	1:5	1:10	1:20	1:50	1:100
S1	Flood Peak (m^3/s)	32.7	58.9	81.3	107.1	141.5	171.6
	Flood Volume (10^3 m^3)	141.6	255.0	351.9	463.6	612.6	742.9
S2	Flood Peak (m^3/s)	4.0	7.2	10.0	13.0	17.2	20.9
	Flood Volume (10^3 m^3)	25.1	45.1	62.6	81.4	107.7	130.9
S3	Flood Peak (m^3/s)	2.3	4.2	5.8	7.6	10.1	12.2
	Flood Volume (10^3 m^3)	27.1	49.4	68.3	89.5	118.9	143.6
S4	Flood Peak (m^3/s)	14.2	25.5	35.5	46.4	61.4	74.4
	Flood Volume (10^3 m^3)	118.1	212.1	295.2	385.9	510.6	618.7
S5	Flood Peak (m^3/s)	23.7	42.6	59.2	77.4	102.4	124.2
	Flood Volume (10^3 m^3)	153.6	276.0	383.6	501.6	663.6	804.8

[8] Information in this section has been summarised from the hydrology (Peens &Associates, 2019)

4.2.4 CLEAN WATER CATCHMENT

The stormwater management plan (Appendix 2) has been developed to ensure compliance with the requirements of GN704. Clean stormwater will be diverted around the mining area. This is explained in more detail in Section 5.1.4 of this report.

4.2.5 DIRTY WATER CATCHMENT

The stormwater management plan (Appendix 2) indicates that all water within the mining area will be managed as dirty water and directed via drains, trenches and other similar structures to the Pollution Control Dams. This is explained in more detail in Section 5.1.4 of this report

4.2.6 SURFACE WATER QUALITY[9]

Four water samples were collected during the field survey undertaken by Enviross as part of the surface water ecosystems specialist study and sent to an accredited laboratory for analysis. The results are presented in Table 4-6 and Table 4-7. Results in Table 4-6 show that site 4 has been subject to external contamination, with relatively higher values for those parameters tested than for other watercourses from within the same catchment area.

It is assumed that this is from runoff water emanating from sand winning and mining operations located to the nearby north of the site. The depression wetland from where the sample was taken showed obvious signs of pollution sources, with a high turbidity discoloured water and obvious odour.

TABLE 4-6: GENERAL WATER QUALITY PARAMETERS FOR THE FOUR SAMPLING SITES

Analyses in mg/ℓ (Unless specified otherwise)	**Method Identification**	**Sample Identification**			
		Site 1	**Site 2**	**Site 3**	**Site 4**
Sample Number (Lab ref)		55147	55148	55149	55150
pH – Value at 25°C	WLAB065	6.9	7.4	6.9	7.5
Electrical Conductivity in mS/m at 25°C	WLAB002	30.0	31.6	29.1	203
Total Dissolved Solids at 180°C	WLAB003	184	222	218	1 342
Suspended Solids at 105°C	WLAB004	12.2	6.7	126	1 714
Turbidity in N.T.U	WLAB005	5.5	4.8	38	1 092
Total Alkalinity as $CaCO_3$	WLAB007	24	52	40	556
Chloride as Cl	WLAB046	51	57	57	286
Sulphate as SO_4	WLAB046	26	3	7	147
Fluoride as F	WLAB014	0.4	0.3	0.3	1.0
Nitrate as N	WLAB046	0.1	<0.1	0.1	<0.1
Total Coliform Bacteria / 100 mℓ	WLAB021	58 000	980	1 600	6 200
Faecal Coliform Bacteria / 100 mℓ	WLAB021	0	0	0	340
E. coli / 100 mℓ	WLAB021	0	0	0	280
Free & Saline Ammonia as N	WLAB046	0.4	0.4	0.5	0.5
% Balancing *	---	94.8	92.4	96.8	98.9

Electrical conductivity and total dissolved and suspended solids are all high (as is reiterated by the high positive cation concentrations shown in Table 4-7). Increased sulphate values indicate that the source of pollution is probably from dewatering opencast pits associated with existing coal mines.

[9] Information in this section has been summarised from the surface water ecosystem (Enviross, 2019) report attached in Appendix 3 of the IWWMP

TABLE 4-7: RESULTS OF THE ELEMENT SCAN OF THE FOUR SAMPLES. OUTLYING CONCENTRATIONS

Element	Sample 1	Sample 2	Sample 3	Sample 4		Element	Sample 1	Sample 2	Sample 3	Sample 4
Ag	< 0.010	< 0.010	< 0.010	< 0.010		Na	34	36	39	428
Al	0.309	0.449	0.237	3.66		Nb	< 0.010	< 0.010	< 0.010	< 0.010
As	< 0.010	< 0.010	< 0.010	< 0.010		Nd	< 0.010	< 0.010	< 0.010	< 0.010
Au	< 0.010	< 0.010	< 0.010	< 0.010		Ni	< 0.010	< 0.010	< 0.010	< 0.010
B	0.011	< 0.010	0.021	0.029		Os	< 0.010	< 0.010	< 0.010	< 0.010
Ba	0.055	0.090	0.080	0.551		P	0.058	< 0.010	< 0.010	1.56
Be	< 0.010	< 0.010	< 0.010	< 0.010		Pb	< 0.010	< 0.010	< 0.010	0.012
Bi	< 0.010	< 0.010	< 0.010	< 0.010		Pd	< 0.010	< 0.010	< 0.010	< 0.010
Ca	8	9	6	21		Pr	< 0.010	< 0.010	< 0.010	< 0.010
Cd	< 0.010	< 0.010	< 0.010	< 0.010		Pt	< 0.010	< 0.010	< 0.010	< 0.010
Ce	< 0.010	< 0.010	< 0.010	0.014		Rb	0.010	0.011	< 0.010	< 0.010
Co	< 0.010	< 0.010	< 0.010	< 0.010		Rh	< 0.010	< 0.010	< 0.010	< 0.010
Cr	< 0.010	< 0.010	< 0.010	< 0.010		Ru	< 0.010	< 0.010	< 0.010	< 0.010
Cs	< 0.010	< 0.010	< 0.010	< 0.010		Sb	< 0.010	< 0.010	< 0.010	< 0.010
Cu	< 0.010	< 0.010	< 0.010	< 0.010		Sc	< 0.010	< 0.010	< 0.010	< 0.010
Dy	< 0.010	< 0.010	< 0.010	< 0.010		Se	< 0.010	< 0.010	< 0.010	< 0.010
Er	< 0.010	< 0.010	< 0.010	< 0.010		Si	0.7	0.7	2.5	18.5
Eu	< 0.010	< 0.010	< 0.010	< 0.010		Sm	< 0.010	< 0.010	< 0.010	< 0.010
Fe	1.59	1.25	0.859	2.41		Sn	< 0.010	< 0.010	< 0.010	< 0.010
Ga	< 0.010	< 0.010	< 0.010	0.012		Sr	0.039	0.049	0.035	0.090
Gd	< 0.010	< 0.010	< 0.010	< 0.010		Ta	< 0.010	< 0.010	< 0.010	< 0.010
Ge	< 0.010	< 0.010	< 0.010	< 0.010		Tb	< 0.010	< 0.010	< 0.010	< 0.010
Hf	< 0.010	< 0.010	< 0.010	< 0.010		Te	< 0.010	< 0.010	< 0.010	< 0.010
Hg	< 0.010	< 0.010	< 0.010	< 0.010		Th	< 0.010	< 0.010	< 0.010	< 0.010
Ho	< 0.010	< 0.010	< 0.010	< 0.010		Ti	< 0.010	< 0.010	< 0.010	0.095
In	< 0.010	< 0.010	< 0.010	< 0.010		Tl	< 0.010	< 0.010	< 0.010	< 0.010
Ir	< 0.010	< 0.010	< 0.010	< 0.010		Tm	< 0.010	< 0.010	< 0.010	< 0.010
K	11.3	11.9	12.3	43		U	< 0.010	< 0.010	< 0.010	< 0.010
La	< 0.010	< 0.010	< 0.010	< 0.010		V	< 0.010	< 0.010	< 0.010	0.010
Li	< 0.010	< 0.010	< 0.010	< 0.010		W	< 0.010	< 0.010	< 0.010	< 0.010
Lu	< 0.010	< 0.010	< 0.010	< 0.010		Y	< 0.010	< 0.010	< 0.010	< 0.010
Mg	7	10	5	12		Yb	< 0.010	< 0.010	< 0.010	< 0.010
Mn	0.061	0.042	0.050	0.281		Zn	0.028	0.016	0.017	0.010
Mo	< 0.010	< 0.010	< 0.010	< 0.010		Zr	< 0.010	< 0.010	< 0.010	< 0.010

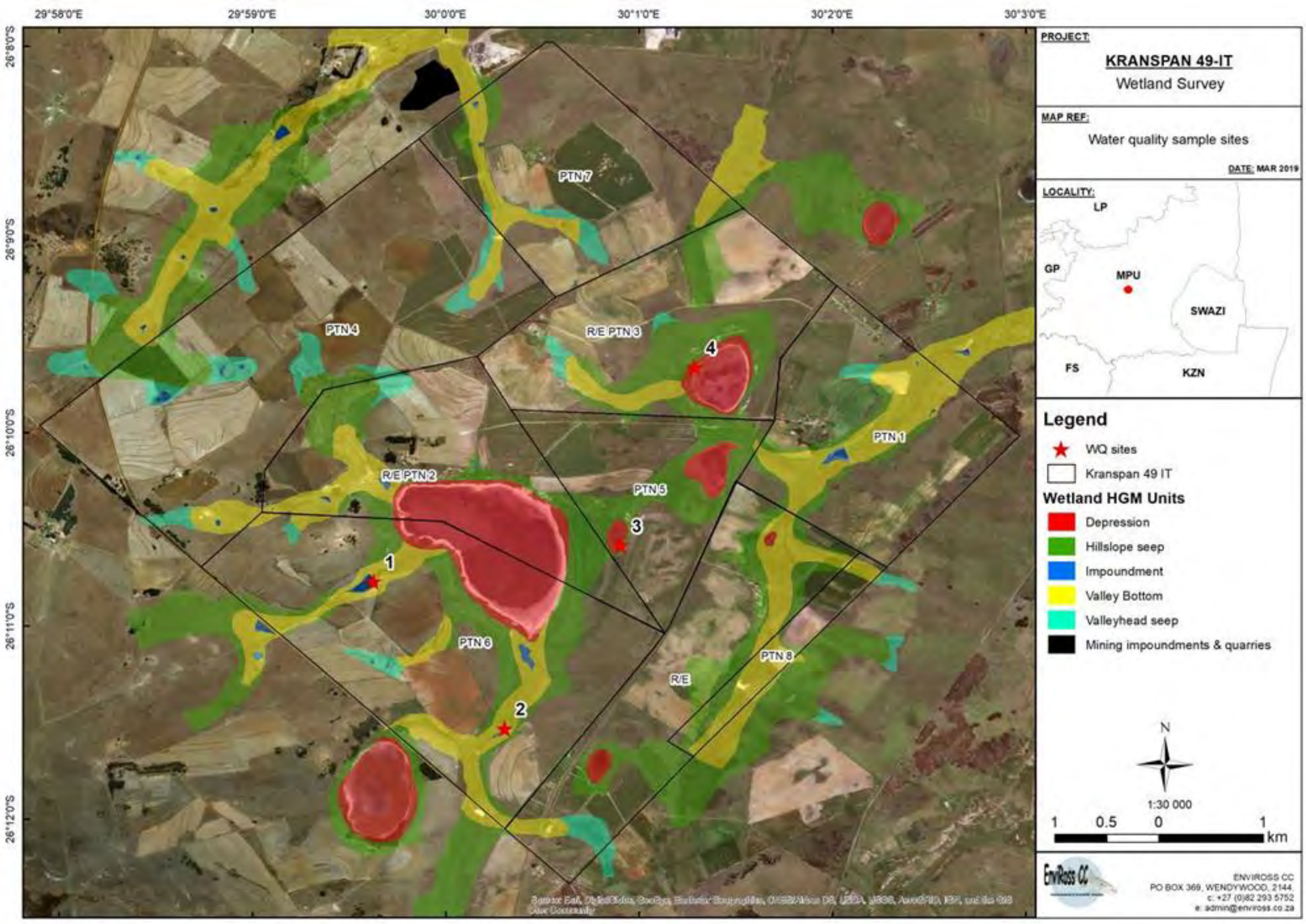


FIGURE 4-6: WATER QUALITY SURVEY SITES

4.2.7 MEAN ANNUAL RUNOFF[10]

There is no river flow gauging station in the Boesmanspruit in vicinity of the study area. No gauging station could be located with sufficient data that can be used as a representation of this catchment area. When a catchment has insufficient data, the Water Research Communion's "Surface Water Resources of South Africa 1990 Manual" Volume 1 provide recommended values that can be used.

4.2.7.1 Boesmanspruit

The catchment only falls within quaternary sub-catchment X11B. The calculated MAR for the Boemanspruit at the downstream end of the study area is ***26.2 million m³***.

TABLE 4-8: MEAN ANNUAL RUNOFF FOR THE BOESMANS[RUIT

Quaternary Sub – catchment Name	Net Area (km^2)	Net MAR (10^6 m^3/a)
X11B	597	26.2

[10] Information in this section has been summarised from the hydrology (Peens &Associates, 2019) and is attached in Appendix 3

4.2.7.2 Study Area

All the sub-catchments in the study area are situated in quaternary sub-catchment X11B. The mean annual rainfall for this site is 698 mm. The rainfall / runoff response number for this quaternary sub-catchment is 8, relating to a mean annual runoff (MAR) of 37 mm runoff depth. The catchment s are shown in Appendix 1, Map 4.

TABLE 4-9: MEAN ANNUAL RUNOFF OVER STUDY AREA

CATCHMENT NAME	CATCHMENT SIZE (KM^2)	MAR (M^3/A)	COMMENT
S1	15.490	573 130	Does not contribute to the mean annual runoff for the Boesmanspruit.
S2	2.485	91 945	
S3	2.222	82 214	
S4	11.86	438 820	Contributes to Boesmanspruit
S5	16.49	610 130	Contributes to Boesmanspruit
TOTAL	28.35	1 048 950	Total excludes S1, S2 and S3

4.2.8 Resources Class and River Health

The DWS released the proposed classes of water resources and water quality objectives for water resources. This was determined for all catchments of the Inkomati (DWS, 2016).

Integrated Units of Analysis (IUA) are used as the unit of assessment for the classification of water resources (DWS, 2016). The IUA are classified in terms of their extent of permissible utilisation and protection as either:

- Class I: indicating high environmental protection and minimal utilization; or
- Class II indicating moderate protection and moderate utilization; and
- Class III indicating sustainable minimal protection and high utilization.

The proposed management class for the catchment is currently considered to be a Class II with an overall ecological category of a B for the IUA.

Due to the largely homogenous land use throughout the catchment area and the similar pressures and drivers of ecological change experienced by the wetland units, there is little variation in scores and ratings within the units themselves. Overall, the wetland units fall within a C PES range. Variations do occur due to differences in vegetation cover, proximity to formal agriculture and mining (where the water quality would be more prone to deleterious effects of agrochemicals and other contaminants), erosion features and proximity to and number of impoundments.

All of the wetland units are considered to be classified as 'moderately modified' due to factors outlined above. The depression wetland unit located on R/E Ptn 3 suffers a higher level of water quality degradation that was not observed within the remaining units. The point source of this contamination was not ascertained during the field survey, but it is assumed to originate from the mining activities located to the nearby northern area, a large cattle presence and increased runoff from the immediate surrounding catchment area (formal agriculture and sand winning). In isolation, this wetland unit would be classified as a D/E PES rather, but, as a collective within the greater wetland unit/system, it does not proportionally contribute enough to change the PES of the overall unit. Water quality attributes are discussed in more detail under the relevant section.

Wetland sub unit 2.1 is considered a minor tributary and poorly-developed wetland feature that shows the retention of hydromorphic soil characteristics (reminiscent of historical wetland function) but has since been lost to cultivation and overall reduction of the extent of the source of water that feeds it. This unit, due to its use for cultivation, shows obvious reductions in scores in relation to the wetland unit as a whole. Water quality is shown to be rated higher than the whole wetland unit as potential sources of contamination are from only one source (one land use type) whereas, holistically, wetland unit 2 has a much wider potential source of water contamination.

Sub unit 2.8 includes a cultivated area that is regarded as a linkage between two depression-type wetland units. The PES of this unit calculated to 37.2% due to a diversity of pressures and drivers of ecological change, mostly emanating from cultivation. As this is a linkage zone between two established wetland features, the significance of impact of losing this functionality, although it shows a relatively low PES, would be greater.

Wetland sub unit 2.10 includes a feeder seepage zone that develops into a valley-head seep and unchannelled valley bottom, which feeds into sub unit 2.11, which is a depression wetland with permanent surface waters. The seep zones associated with this depression wetland within sub unit 2.10 were also considered when calculating the PES and evaluating the significance of the impacts. These units were separated due to differences in hydrogeomorphic types. The overall PES of sub unit 2.10 calculated to 44.5% (D), which is again largely due to cultivation through the unit that has led to altered vegetation structures, hydrology and geomorphological features. The PES of sub unit 2.11 calculated to 79.8% (B/C), with the main pressure and driver of ecological change being degraded water quality.

TABLE 4-10: RESULTS FROM THE WETLAND-IHI FOR THE WETLANDS ASSOCIATED WITH THE PROPOSED DEVELOPMENT AREA

WETLAND UNIT	SUB UNIT	VEGETATION	HYDROLOGY	GEOMORPHOLOGY	WATER QUALITY	OVERALL PES
Wetland unit 1	Holistically	72.8%	61.3%	52.7%	72.7%	65.5% (C)
Wetland unit 2	Holistically	87.8%	70.0%	56.4%	72.7%	75.2% (C)
	2.1	43.4%	29.6%	23.6%	85.3%	38.9% (D/E)
	2.8	43.4%	29.6%	23.6%	64.3%	37.2% (E)
	2.10	59.9%%	29.6%	23.6%	64.3%	44.5% (D)
	2.11	83.7%	86.4%	70.0%	62.7%	79.8% (B/C)
	2.12	43.4%	29.6%	23.6%	85.3%	38.9% (D/E)
Wetland unit 3	Holistically	80.4%	66.5%	75.0%	72.7%	75.0% (C)

4.2.9 ECOLOGICAL IMPORTANCE SENSITIVITY[11]

The Ecological Importance Sensitivity (EIS) was undertaken according to the methods outlined in WET-EcoServices (Kotze et al, 2007). The wetland units throughout the survey area are all subject to similar pressures and drivers of ecological change, and all of the units fall within a catchment area that shares a similar land use and are located on private land, so uses of the wetland resources by local inhabitants are limited. Impoundments are located along the vast majority of the watercourses, which is typical of an established agricultural area. The EIS of the wetland units are therefore all similar as they all share similar features. The generalised rating for the EIS is indicated in Table 4-11.

TABLE 4-11: THE RESULTS OF THE WET-ECOSERVICES INDEX TO DETERMINE THE EIS OF THE WETLAND UNITS.

Wetland functional feature	Unit 1	Unit 2	Unit 3
Flood attenuation	2.4	2.4	2.4
Stream flow regulation	2.7	2.7	2.7
Sediment trapping	2.1	1.9	2.3
Phosphate trapping	2.5	2.5	2.5
Nitrate removal	2.8	2.8	2.8
Toxicant removal	2.5	2.4	2.7

[11] Information in this section has been summarised from the surface water ecosystem (Enviross, 2019) report attached in Appendix 3of the IWWMP

Erosion control	2.1	2.1	2.1
Carbon storage	2.0	2.0	2.0
Maintenance of biodiversity	3.5	3.5	3.5
Water supply for human use	1.4	1.4	1.4
Natural resources	0.0	0.0	0.0
Cultivated foods	0.0	0.0	0.0
Cultural significance	0.0	0.0	0.0
Tourism and recreation	1.9	1.9	1.9
Education and research	0.8	0.8	0.8
Runoff intensity from the wetland unit's catchment	2.0	2.0	2.0
Alteration of sediment regime	3.0	1.0	3.0
Alteration of nutrient/toxicant regime	3.0	1.0	3.0
Level of threat	3.0	3.0	3.0
Levels of opportunity	3.0	3.0	3.0
Rating	2.04	1.82	2.06

These scores indicate that the wetlands supply a moderate to high ecological service. The threat level to the habitat units remain as relatively high (3 out of 4), with the levels of opportunity, which could be interpreted as the degree to which the wetland habitat units could perform these services, also scored relatively high as well (3 out of 4) (Table 4-11).

The various input features and how they scored for the wetland unit are presented in Figure 4-7. This shows which features (services) that are performed by the wetlands are currently scoring the highest, and which ones are ranked lower. It can be seen that the ecological services supplied by the wetlands are rated as the relative highest. The wetland functionality elements (flood attenuation, and water purification) are also ranked high. Tourism and recreation also ranks relatively high due to the opportunity for birding within these areas, but the area does not fall within a tourist-friendly area, which lowers the relevance of these factors. Low-scoring elements include the dependency of the rural sector on the resources offered by the wetland units (all located on private land) and cultural significance of the wetland units.

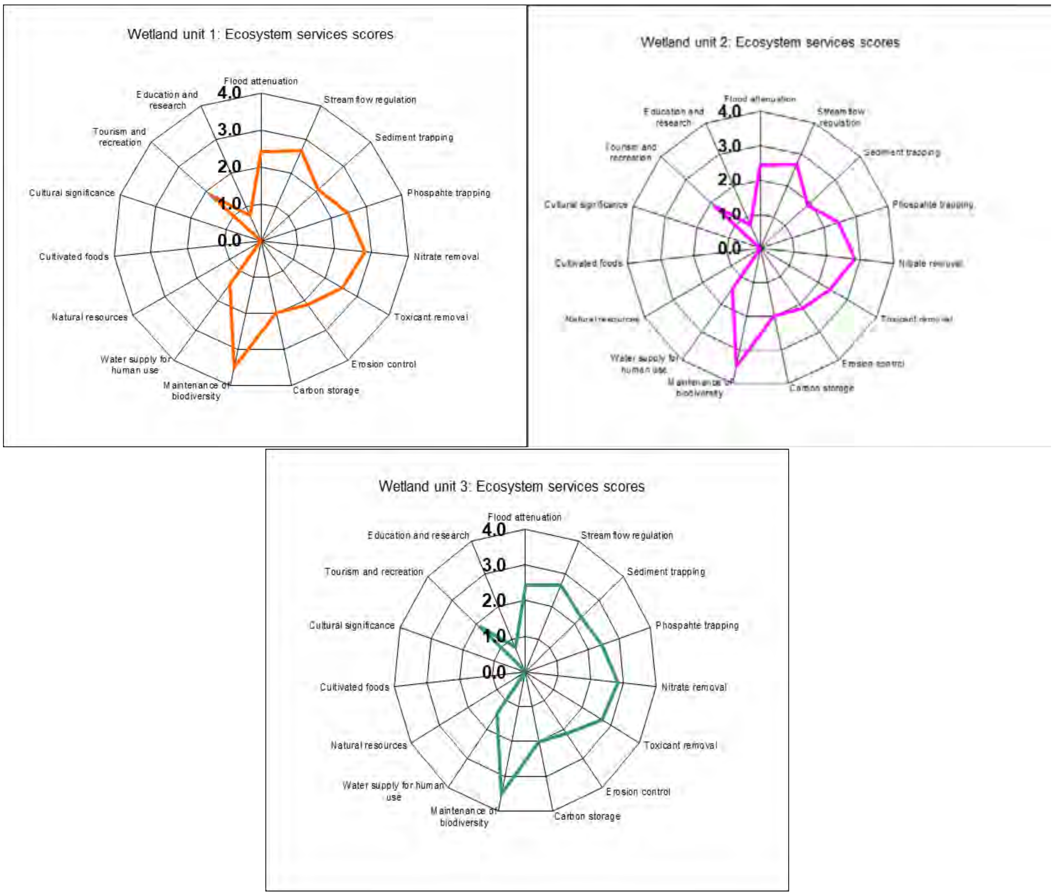


FIGURE 4-7: SCORING OF THE VARIOUS ASPECTS OF ECOLOGICAL SERVICES PROVIDED FOR BY THE WETLAND HABITAT UNITS PRESENT WITHIN THE SURVEY AREA.

Although the wetland units have scored average EIS and PES ratings, they remain ecologically sensitive habitat units, and they do offer value to protecting the water resource, maintenance of biodiversity, as well as provision of water to downstream ecosystems and water users, as well as provision of flood attenuation. The ecological value of such wetland units should therefore not be discounted.

4.2.10 Receiving Water Quality Objectives

Th Resource Quality Objectives (RQO) identified by the DWS (2014a) is summarised in Table 4-12 and Table 4-13.

TABLE 4-12: RQS OF THE KOMATI RIVER SYSTEM[12]

Rivers		
RUs	**SQ number**	**Water Quality RQOs**
IUA X1-1		
RU K2	*X11B-01370* *X11B-01361* *X11B-01370*	Ensure that nutrient levels are within Acceptable limits:50th percentile of the data must be less than 0.025 mg/L PO_4-P (aquatic ecosystems: driver). Ensure that electrical conductivity (salt) levels are within ideal limits: 95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver). Ensure pH levels stay within Acceptable limits: A small change from the ideal range is allowed, i.e. a 5th percentile of 5.9 – 6.5, and a 95th percentile of 8.0 – 8.8 (aquatic ecosystems: driver.) Ensure that toxics are within ideal limits or A categories or TWQR: 95th percentile of the data must be within the TWQR for toxics or the upper limit of the A category in DWAF (2008). Ensure that sulphate levels are within Acceptable limits: 95th percentile of the data must be less than 30 mg/L (industrial cat 3: drivers; DWA, 2012a). Meet faecal coliform and E. coli targets for recreational (full contact) use: Meet the TWQR of 0 -130 counts per 100 ml (DWAF, 1996)

Wetlands			
IUA X1-1			
RUs	**SQ number**	**TEC**	**Wetland RQO**
RU K2	*X11B-01272*	B/C	Improve to B/C by increasing buffer zones where wetlands are not artificial. Cessation of land use encroachment on non-artificial channelled valley bottom wetlands.

TABLE 4-13: KEY CAUSES AND SOURCES AND DERIVED COMPONENTS FOR WHICH RQOS WILL BE SET, THE WATER QUALITY USERS, AND WATER QUALITY VARIABLES:

RUs	SQ Number	River	RU priority rating	Comments	Biota and habitat component indicators	WQ Users	WQ Variables
IUA X1-1							
RU K2	X11B-01370 X11B-01361 X11B-01272	Boesmanspruit	3WQ	SERIOUS/ABUNDANT: Grazing (land-use). LARGE: Bed and channel disturbance. MODERATE: Agricultural fields, alien vegetation, overgrazing/trampling, sedimentation, vegetation removal.	1. Rip veg (2) 2. Instream Biota (2)	AMD, Carolina	Salts, sulphates, pH, nutrients, E coli, toxics.

[12] Department of Water and Sanitation, South Africa, December 2014. The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Resource Quality Objectives. Authored by Deacon AR, Kotze PJ, Louw MD, Mackenzie JA, Scherman P-A,. DWA Report, RDM/WMA05/00/CON/CLA/0414.
Link - http://www.dwa.gov.za/rdm/WRCS/doc/Inkomati%20RQOs%20Report_Draft.pdf visited 12 May 2019

4.2.11 SURFACE WATER USER SURVEY

In addition to the water use requirements for the ecological reserve, there are several in-stream farm dams over the Kranspan Farm which are understood to be used for agricultural activities by landowners. Abstraction volumes and patterns from surface water resources is not known. The hydrocensus conducted as part of the groundwater study indicated that groundwater is however the dominant source of water by water users. Sensitive Areas Survey

The placement of the mine surface infrastructure and open pits was informed by an environmental sensitivity plan which considered the location of all known sensitive physical, social and environmental features within the mining area. The layout included consideration of:

- Natural features, for example watercourses;
- Heritage features;
- The extent of the proposed orebody, as presently understood, to be mined over the Life of Mine was delineated; and
- Roads.

Buffer distances (minimum safe distances), determined primarily from legislation, including GN704 and the MHSA, were then applied (Table 4-14) and are shown in Map 5 of Appendix 1.

TABLE 4-14: ENVIRONMENTAL BUFFER ZONES

INFRASTRUCTURE	BUFFER (M)	LEGISLATION / COMMENT
Buildings	100	MHSA and Regulations
Roads		
Railways		
Tailings Storage Facility and Waste Rock Dump		
Structures		
Restricted areas	50	MHSA GN93
Watercourses	100	NWA GN704
Wetlands	500	NWA GN704 GN1199
Powerlines	25	A proposed buffer (either side of centre-line) for protection of powerline infrastructure

4.3 GROUNDWATER

The information presented below has been summarised from ILEH (2019). A copy of the report is provided in Appendix 3.

4.3.1 AQUIFER CHARACTERISATION

Two main aquifers are typically found in the Karoo sediments of the Ermelo Coal Field. These are a shallow weathered aquifer and a deeper fractured rock aquifer. These are discussed in more detail below.

4.3.1.1 Weathered aquifer

The shallow weathered aquifer forms within the limit of weathering (LOW). Information on the LOW available from exploration boreholes, National Groundwater Database (NGDB) boreholes and the newly drilled monitoring boreholes is summarised in Table 4-15.

TABLE 4-15: SUMMARY OF INFORMATION ON THE LIMIT OF WEATHERING IN THE PROJECT AREA

Source	Minimum depth (m)	Maximum depth (m)	Average depth (m)
NGDB boreholes	0,3	15,8	6,4
Exploration boreholes	1,3	14,9	5,7
Monitoring boreholes	3	50	15,5

It is shown that the average depth of the LOW varies between 5,7 and 15,5 from the three available sources. For the purpose of conceptualisation, it will be assumed that the average LOW is down to a depth of 9m.

Clay material was found in boreholes drilled around the largest of the two pans on site. This suggests that the pans are formed on clay lenses that do not facilitate vertical infiltration of surface water. The clay lenses are most probably associated with highly weathered dolerite sills that were identified during the exploration drilling phase of the project.

The permeability of weathered aquifer is variable, but groundwater occurrence is most often associated with the transition between weathered and fresh rock. In this area, the dolerite sill could form a barrier between the upper weathered and deeper fractured rock aquifers. At present, the permeability of the dolerite is not known, but based on experience in similar aquifer conditions, it is thought that the permeability of fresh and unfractured dolerite is low compared to the host rock and that it will therefore act as an aquitard or even an aquiclude, forming a barrier to the vertical flow of groundwater from the weathered to fractured rock aquifers.

In low-lying areas, the groundwater table is shallow. Springs develop in the weathered aquifer where groundwater seeps to surface along areas of lower permeability for example against a dolerite intrusion or a paleographic high or where the topography cuts into the water table. Six springs were identified during the hydrocensus.

The average depth to groundwater in the shallow boreholes drilled during the investigation is 4,37m, varying between 1,04 and 6,4m below surface.

This aquifer is not considered significant in terms of water supply due to its limited thickness. Information obtained from monitoring boreholes suggest that no water strikes occur in this aquifer. The exception is borehole Site8b, which yielded a blow yield of 5000 L/hr. but it does play an important role in terms of recharge to the underlying fractured rock aquifer and to the baseflow of streams, especially in the dry season.

Permeabilities could be calculated from two of the shallow monitoring boreholes drilled. The results indicate that the permeability of the weathered material varies between 0,1 and 0,3m/d.

4.3.1.2 Fractured rock aquifer

Underneath the shallow weathered aquifer, groundwater is associated with fractures, faults, bedding planes and contact zones with intrusions. The rock matrices are tight and do not transmit significant volumes of groundwater, as indicated from the results of the aquifer tests. Groundwater flow in the fractured rock aquifer therefore takes place along the identified preferential flow paths. These include the two major north NE-SW striking lineaments and the dolerite intrusions.

The two large lineaments delineated on the regional geological map were identified as aquifers and will therefore preferentially transmit groundwater. Monitoring boreholes 5-110, 6-220 and PM3 target these lineaments. Some of the private boreholes also target these lineaments, including KR11, KR19 and possibly KR7, KR8 and KR12.

The permeability of these aquifers are highly variable as it is dependent on the nature and extent of the secondary features mentioned. Results from the aquifer tests on these boreholes suggest that although the fractures carry groundwater, they are quickly dewatered when pumped due to the fact that inflows from the rock matrix are slow and cannot therefore sustain high volumes of groundwater abstraction. Transmissivities calculated from the aquifer tests for the lineaments vary between 19 and 26 m2/d. This is higher compared to transmissivities calculated for the unfractured rocks, where transmissivities vary between 0,3 – 7 m2/d. The wide range in transmissivities calculated from the available data is typical of the heterogeneous nature of fractured rock aquifers.

The aquifer testing data obtained during this study further indicates that vertical groundwater flow between the weathered and fractured rock aquifers is generally low, except along the strike of the NE-SW lineaments. Where present, zones of increased permeability allow groundwater flow through otherwise tight rock matrices. Measurements in borehole pairs that were drilled into the lineaments confirm that groundwater levels in the shallow boreholes react when the deeper boreholes are pumped.

Depth to groundwater in the deeper boreholes vary between 0,9 and 22,38m, based on data from the private and monitoring boreholes. Groundwater levels in the monitoring boreholes vary between 0,9 and 9,7m below surface, which is similar to that measured in the shallow boreholes. How well the seals were installed into the annulus of the deeper boreholes affects groundwater level measurements. For the purpose of this study, it will be assumed that the seals are in-tact and that groundwater level measurements in the deep monitoring boreholes indicate conditions in the fractured rock aquifer.

Based on the information obtained, the average depth to groundwater in the deeper boreholes based on all the data points is 9,4m, which is just below the average limit of weathering. The average depth to groundwater in the monitoring boreholes is 4,7m, which falls within the limit of weathering. Based on this information, the fractured rock aquifer seems to be confined to semi-confined, as groundwater levels rest above the depth of groundwater strikes in these. The dolerite sill could play a role in creating confined conditions in the fractured rock aquifer, where it is present.

4.3.2 HYDROCENSUS

A hydrocensus was completed in order to identify and characterise private groundwater use in the vicinity of the proposed Kranspan Mine.

During the hydrocensus 26 groundwater sites (boreholes and springs) were identified and included 19 boreholes and 7 springs. In terms of private groundwater use, the following information was obtained:

- 12 boreholes are in use:
  - 3 boreholes fitted with submersible pumps;
  - 8 boreholes fitted with wind pumps;
  - 1 borehole fitted with solar submersible pump;
- 2 boreholes are equipped, but not in use (old wind pumps); and
- 5 open boreholes are not currently in use.

The depth to groundwater level varied between a maximum depth of 22.38 m bgl (borehole KR7 (Appendix 1 of the Geohydrological report), and the surface elevation for the springs where the water table daylights. The average depth to groundwater in the hydrocensus boreholes is 14,7m, if the springs and seeps are excluded from the calculation.

Based on communication with the land owners, the springs in the area are seasonal, with the exception of KR-Spring3 and KR-Spring5 that flow throughout the year. The springs serve as water supply to livestock and wildlife in the area. KR-Spring3 is the most prominent spring identified during the hydrocensus (based on flow rate). During the hydrocensus the discharge rate was approximately 86m^3/d (3,600 L/h) and the water quality is good.

Detailed information in terms of borehole construction and yields are not available for the identified private boreholes. The information provided by the land owners indicated low borehole yields for most of the Kranspan project area.

Based on the geophysical survey results and an understanding of the local geology, Groundwater Abstract identified 8 suitable drilling positions for groundwater characterisation purposes. Data collected include the recording of geological formations at 1 metre intervals, water strike depths, the cumulative final blow yield and final rest water level. A summary of the results is presented in Table 2 of the specialist report.

The new Kranspan percussion boreholes produced blow yields between zero litres per hour (L/h) (thus dry) and 10,000 L/h, as detailed in Table 2. In general, borehole yields throughout the project area are low, indicating minor aquifer systems.

The base of the weathered zone yielded some water, but in very low quantities. Most water strikes produced low yields (1,000 to 2,000 L/h). The highest yielding water strike (>10,000 L/h) is associated with one of the north-south lineaments (borehole PM3). The water yielding zones can be classified as follow:

- Weathered sandstone – 1,000 to 2,000 L/h.
- Fractures in sandstone – 2,500 to 10,000 L/h.
- Dolerite top contact – 1,500 L/h.
- Dolerite bottom contact – 1,000 L/h.
- Sandstone shale contact 1,000 L/h.

Based on the percussion drilling results coal was found in borehole 1-130 only.

The depth of weathering varies between 3 and 50 m bgl; mostly around 7 to 9 metres below surface.

4.3.2.1 Monitoring Boreholes

In order to complete the geohydrological specialist study, eight pairs of shallow and deep monitoring boreholes were drilled and tested to obtain information to characterise the aquifer present. The borehole locations were determined with the aid of surface geophysical methods. Two northeast-southwest striking lineaments transect the proposed mining area. One of these lineaments is located underneath the largest pan present on site. The geophysical surface was used to pinpoint the locations of these, and monitoring boreholes were used to characterise aquifer conditions associated with the lineaments. The results indicate that the lineaments are have enhanced aquifer characteristics and will act as preferential flow paths to groundwater.

4.3.3 GROUNDWATER QUALITY

4.3.3.1 Hydrocensus Boreholes

Seven (7) groundwater samples were collected by Groundwater Abstract during the 2019 hydrocensus. The water samples were submitted to Waterlab, a South African National Accreditation System (SANAS) accredited laboratory, for analysis. Samples were collected from boreholes across the project area to ensure a good indication of ambient groundwater qualities.

Groundwater samples were also collected from the eight monitoring boreholes during the 2019 aquifer testing programme. The results are discussed below.

The results of the analyses are presented in Table 4-16. The information presented in Table 4-16 contains the main elements present in the water. It is noted that the results indicate that the concentrations of most of the trace elements are below laboratory detection limits

4.3.3.2 Monitoring Boreholes

Groundwater samples were also collected from the eight monitoring boreholes during the 2019 aquifer testing programme. The results of the analyses are presented in Table 4-17.

4.3.3.3 Summary of Groundwater Quality

The results of the chemical analyses presented in Table 4-16 and Table 4-17 show that the groundwater quality in the hydrocensus and monitoring boreholes generally comply with the SANS241:2015 Drinking Water Standards. The exceptions are hardness, iron, aluminium and fluoride. These are discussed in more detail below. Reference is made to DWAF (1996) in the interpretation of the result:

- Acute Health effects: Exceedances may pose an intermediate unacceptable health risk.
- Aesthetic effects: Exceedances may taint the water with respect to taste, odour or color, but does not pose an unacceptable health risk.
- Hardness: the groundwater is naturally hard. This is caused by high concentrations of calcium and magnesium salts. Temporary hardness is due to the presence of bicarbonates and can be removed by boiling the water. Permanent hardness is attributed to other salts (sulphates and chlorie salts), which cannot be removed by boiling. Excessive hardness can result in scaling in plumbing and household heating appliances and pose a nuisance to personal hygiene (the so-called "soap destroying" nature of water).
- Iron: elevated iron concentrations were recorded in one private borehole (KR3) and three monitoring boreholes (boreholes 1-130, Site8 and PM1). The elevated iron concentrations are considered natural and is probably associated with the rock formations present. It is unlikely that the surrounding mining activities could impact on groundwater quality at the Kranspan project. At concentrations exceeding 2 mg/l, a pronounced aesthetic effect (taste) and staining in plumbing is expected. Health effects are expected in young children and sensitive individuals. These are associated with hemochromatosis and tissue damage. Elevated iron concentrations in water also promote the proliferation of iron-oxidising bacteria, which manifests as slimy coatings in plumbing.
- Aluminium: The main effect of aluminium at the concentrations observed is relating to the discolouration in the presence of manganese. Concentrations below 0,5 mg/l are not expected to result in adverse health effects. Prolonged exposure to concentrations exceeding 0,5 mg/l may result in neurotoxic effects.
- Fluoride: One monitoring borehole (PM2) yielded elevated fluoride concentrations. If ingested, it is absorbed and retained in the skeleton and teeth. At the concentration recorded in the borehole, a small risk of dental mottling exists, but no skeletal fluorosis is expected. It is noted that fluorosis is less severe when the water is hard, since the occurrence of calcium limits fluoride toxicity..

TABLE 4-16: GROUNDWATER QUALITY – HYDROCENSUS JANUARY 2019

Parameter	SANS241 Drinking Water Standard		DWS Drinking Standards	Sample Numbers						
Unit: mg/l unless otherwise stated	Aesthitic Limit	Health Limit		KR3	KR11	KR12	KR14	KR18	KR19	KR Spring 3
pH – Value at 25°C	≥5 - ≤9.7			7.9	8.0	7.7	8.8	8.6	7.7	5.7
Electrical Conductivity in mS/m at 25°C	Aesthetic ≤170			31.0	48.5	41.9	25.2	26.3	31.2	4.8
Total Dissolved Solids at 180°C	Aesthetic ≤1200			216	375	365	255	177	285	21
Total Alkalinity as $CaCO_3$	NS	NS	NS	116	156	128	100	136	80	<5
P-Alkalinity as $CaCO_3$	NS	NS	NS	<5	<5	<5	10	10	<5	<5
Bicarbonate as HCO_3	NS	NS	NS	141	190	156	99	142	98	5
Total Hardness as $CaCO_3$	60–120 mg/l, moderately hard	120–180 mg/l, hard	more than 180 mg/l, very hard	47	139	27	42	71	94	7
Chloride as Cl	Aesthetic ≤300			16	58	35	14	3	2	7
Sulphate as SO_4	Aesthetic ≤250	Acute health ≤500		22	8	20	14	5	69	3
Fluoride as F		Chronic health ≤1.5		0.6	0.2	0.6	0.2	0.2	0.7	<0.2
Nitrate as N		Acute health ≤11		0.5	0.1	2.7	0.3	0.7	0.2	0.2
Nitrite as N		Acute health ≤0.9		<0.05	<0.05	<0.05	0.2	<0.05	<0.05	<0.05
Total Nitrogen as N	NS	NS	NS	0.8	0.9	3.2	1.6	1.4	1.4	0.5
Ortho Phosphate as P	NS	NS	NS	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
Kjeldahl Nitrogen	NS	NS	NS	<0.5	0.8	0.6	1.1	0.7	1.1	<0.5
Free & Saline Ammonia as N	Aesthetic ≤1.5			0.2	0.5	0.6	1.1	0.2	0.2	0.2
Calcium as Ca			No health. Scaling intensifies from 32mg/L	11	29	6	10	18	20	1
Potassium as K			No aesthetic or health effects below 50mg/L	3,1	4,1	5,2	3,2	4,2	7,6	1,9
Magnesium as Mg	Aesthetic ≤0.1	Chronic health ≤0.4		5	18	3	5	8	13	1
Sodium as Na	Aesthetic ≤200			46	38	73	32	27	20	4
Total Iron as Fe	Aesthetic ≤0.3	Chronic health ≤2		3,27	0,210	0,033	0,161	0,177	0,350	0,257
Total Manganese as Mn	Aesthetic ≤0.3	Chronic health ≤2		<0,025	0,084	<0.025	<0.025	<0.025	0.16	<0.025
Aluminium as Al	≤0.3			0,183	<0.100	<0.100	0,150	<0.100	<0.100	1,44

TABLE 4-17: GROUNDWATER QUALITY – MONITORING BOREHOLES

Parameter	SANS241 Drinking Water Standard		DWS Drinking Standards	Sample Numbers							
Unit: mg/l unless otherwise stated	Aesthitic Limit	Health Limit		2-50	1-130	Site8	5-110	6-220	PM1	PM2	PM3
pH – Value at 25°C	≥5 - ≤9.7			9.2	8.9	7.2	7.6	7.6	5.7	8.8	6.6
Electrical Conductivity in mS/m at 25°C	Aesthetic ≤170			53.4	25.0	28.4	29.3	26.3	25.0	74.9	32.5
Total Dissolved Solids at 180°C	Aesthetic ≤1200			425	215	200	180	120	113	453	300
Total Alkalinity as $CaCO_3$	NS	NS	NS	284	120	120	160	128	12	304	136
P-Alkalinity as $CaCO_3$	NS	NS	NS	52	15	<5	<5	<5	<5	48	<5
Bicarbonate as HCO_3	NS	NS	NS	219	109	146	195	156	15	253	166
Total Hardness as $CaCO_3$	60–120 mg/l, moderately hard	120–180 mg/l, hard	more than 180 mg/l, very hard	<5	75	95	105	20	53	27	55
Chloride as Cl	Aesthetic ≤300			9	5	8	5	12	44	68	22
Sulphate as SO_4	Aesthetic ≤250	Acute health ≤500		<2	9	19	3	<2	28	6	6
Fluoride as F		Chronic health ≤1.5		0.9	1.0	0.2	0.2	1.0	<0.2	1.7	0.4
Nitrate as N		Acute health ≤11		0.1	0.1	<0.1	<0.1	<0.1	2.5	<0.1	<0.1
Nitrite as N		Acute health ≤0.9		<0.05	<0.05	0.4	<0.05	<0.05	<0.05	0.6	<0.05
Total Nitrogen as N	NS	NS	NS	1.0	0.6	<0.5	<0.5	<0.5	2.5	0.6	<0.5
Ortho Phosphate as P	NS	NS	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Kjeldahl Nitrogen	NS	NS	NS	0.8	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Free & Saline Ammonia as N	Aesthetic ≤1.5			0.7	0.6	<0.1	<0.1	0.1	<0.1	<0.1	<0.1
Calcium as Ca			No health. Scaling intensifies from 32mg/L	1	15	22	28	5	9	6	12
Potassium as K			No aesthetic or health effects below 50mg/L	1.2	8.0	6,6	3,3	3,6	3,7	17,7	7,4
Magnesium as Mg			Diarrhoea and scaling issues from 70mg/L	<1	10	13	14	3	9	4	9
Sodium as Na	Aesthetic ≤200			127	17	13	13	45	18	144	40
Total Iron as Fe	Aesthetic ≤0.3	Chronic health ≤2		0,058	5,89	7,47	0,077	0,197	2,77	1,34	1,44
Manganese as Mn	Aesthetic ≤0.3	Chronic health ≤2	Diarrhoea and scaling issues from 70mg/L	<0,025	0,186	0,096	0,079	0,030	0,067	0,065	0,110
Aluminium as Al	≤0.3			0,115	0,895	0,171	<0.100	<0.100	0,124	0,350	<0.100

4.3.4 Potential Pollution Source Identification

The following areas are the main potential pollution sources on the site:

- Coal ROM stockpiles;
- PCDs;
- Spillage from coal trucks;
- Discard;
- Sewage infrastructure; and
- Hydrocarbon storage and handling areas.

The following receptors were identified:

- Existing private groundwater users.
- The pans present within the mining area.
- Rivers and streams down gradient of each mining area. Groundwater is expected to contribute to river and stream baseflow, specifically during the wet season when groundwater levels are expected to rise above the base of the streams as a result of the recharge of rainwater.

4.3.5 Groundwater Model

4.3.6 Conceptual Hydrogeological Model

ILEH (2019) developed a conceptual hydrogeological model that formed the basis of the numerical model for the Project. The complete report with the baseline information and impact assessment results is provided in the EIR. The information presented below has been summarised from ILEH (2019).

4.3.6.1 Seepage

During construction of the box cut and the adit to the underground workings from Pit 1, groundwater seepage to the mining areas will occur as the regional groundwater table will be intersected.

The volume of groundwater seepage to the first opencast strip and the construction of the adit in the underground workings is expected to be approximately 125 m3/d in total. As the aquifers are heterogenous, the volume may be lower (around 100 m3/d) or higher (up to 400m3/d), depending on whether water-bearing fractures are intersected. For the purpose of pollution control dam design, it is recommended that the dam size caters for around 100 m3/d of groundwater over and above direct rainfall and runoff, as not all the groundwater will be dewatered to surface. The seepage is expected to be most prominent during the wet season, which means that over a year, approximately 18 000m3 of groundwater may have to be contained during the construction phase to ensure safe and dry mining conditions.

The results of simulations to calculate the rate of groundwater seepage during the operational phase of mining are presented in Table 4-18. The seepage rates presented are cumulative (total) volumes as mining progresses.

The volumes presented indicate the expected average groundwater seepage rates and a progressive increase in the indicated percentage points to evaluate uncertainty in the permeability of the rocks that may be intercepted during mining. It is unlikely that permeabilities 200% above average conditions would prevail over extensive sections of the mining areas. The possibility however exists that these volumes may be encountered in discrete zones over short periods of time until the fractures are dewatered.

It is also possible that the rate of groundwater seepage may be lower than the expected average conditions. Calculations were made to cater for this eventuality, as shown in Table 4-18.

TABLE 4-18: ESTIMATED GROUNDWATER SEEPAGE RATES (UNIT: M^3/D)

Mining Schedule	Expected average	25% below average	25% above average	50% above average	100% above average	200% above average
Year 1	125	103	148	184	252	408
Year 2	114	97	134	158	212	318
Year 3	145	120	172	205	282	480
Year 4	186	148	221	265	367	624
Year 5	177	146	211	254	365	624
Year 6	154	130	181	215	293	483
Year 7	254	206	305	366	510	869
Year 8	277	223	332	398	554	931
Year 9	325	257	391	470	656	1099
Year 10	341	278	407	487	667	1028
Year 11	289	239	344	412	569	922
Year 12	278	216	343	407	552	840
Year 13	290	235	342	403	537	698
Year 14	278	225	337	393	522	578

The expected average volume of seepage that must be contained and managed during mining may vary between 100 and 340 m^3/d over the course of the operational phase. The volume of groundwater is expected to gradually increase during the operational phase and reach a maximum during Year 10. From Year 11, the volume is expected to decrease as underground mining reaches completion. At the end of life of mining, the total volume of groundwater that may seep to the mining areas is expected to be around 280 m^3/d on average. This volume may be as low as 225 m^3/d and as high as 578 m^3/d, depending on aquifer conditions. As the aquifers around the mining areas will be dewatered as mining progresses and mined out pits will be concurrently backfilled, it is unlikely that the higher groundwater seepage rates will be experienced during mining.

The groundwater may be contained in dedicated sumps in the pits and the underground workings, but it is expected that a portion of this water will have to be dewatered to surface from the mining areas to ensure safe mining conditions.

For the purpose of PCD design during the operational phase, it is recommended that provision is made for a total of 280 m^3/d of extraneous groundwater. This is equivalent to a total volume of 50 400 m^3/a at the end of the life of mine. The current surface layout plans cater for six PCDs across the operations. On average, each dam must therefore allow for the containment of around 8 400 m^3/a of groundwater seepage over and above direct rainfall and surface runoff.

4.3.6.2 Dewatering

The extent of the maximum anticipated cone of depression in the fractured rock aquifer is presented in Figure 16. As with the weathered aquifer, the most significant impact is expected in the central and northern parts of mining where the coal seam is deeper. Underground mining activities is also expected to have a more significant impact on groundwater levels due to the fact that it will be continually dewatered during the operational phase. In this area, groundwater levels may be lowered by up to 30m immediately above the underground workings. The extent to which this may impact on private boreholes will depend on the depth and construction of the borehole, details which are not currently available for the private boreholes.

The boreholes and springs that will be destroyed during opencast mining are listed in Table 4-19. Even though these boreholes will be destroyed, the assessment will address the impact of mining on each of these for comparative reasons.

TABLE 4-19: PRIVATE BOREHOLES AND SPRINGS THAT WILL BE DESTROYED DURING OPENCAST MINING

BH ID	Current use
KR5	Open hole not in use
KR6	Open hole not in use
KR7	Submersible pump (not operational): supply to house and animals
KR8	Wind pump not in use
KR_Spring5	Fenced in: supply to animals

The extent of the cones of depression around the opencast pits are less pronounced due to their comparatively short lives and the effect of concurrent rehabilitation. The cones of depression are steep around the mining areas and do not extend significantly beyond 200 m from the mining areas. This is due to the low average permeability of the matrix of the fractured rock aquifer.

As mentioned above, preferential drawdown is expected along the northern most lineament, which may result in a connection between the mining areas and the largest of the pans. Simulations suggest that a drawdown of up to 2 m may occur along the lineament in the vicinity of the pan.

The impact of mine dewatering on the private boreholes are summarised in Table 4-20. It is shown that groundwater levels may be lowered by between 1 and 2 5m in the private boreholes. The timing of each impact is also indicated in the table. This is linked to the mine schedule that will be implemented.

The most significant impact on private boreholes is expected for boreholes KR7 and KR8. Mining is expected to lower groundwater levels by up to 25m in these boreholes and the impact will most probably prevail over the life of the operations due to the proximity of the underground workings. Groundwater from borehole KR7 is not currently in use as the pump installed is not operational. The owner indicated during the hydrocensus that the borehole was previously used to supply the farm house and animals. There is a high risk that this borehole will dry up and will no longer be available for use by Mr Papenfus. As such, this impact is considered significant and should be managed with care, as detailed later in the report. Borehole KR8 is not in use.

Boreholes KR5 and 6 may experience a drawdown of 10m during Years 6 – 11 of mining. These two boreholes are not currently in use.

Lesser impacts are anticipated in boreholes KR3, KR4, KR10, KR11 and KR 12 and groundwater levels may be lowered by between 2 and 5m during mining. It is likely that this will not have a significant negative impact on the use of these boreholes. It is however prudent that the boreholes are effectively monitored to identify significant negative impacts timeously and to implement responsible groundwater management plans. These are discussed later in this report.

TABLE 4-20: IMPACT OF MINE DEWATERING ON PRIVATE BOREHOLES

AFFECTED BH	CURRENT USE	CURRENT ABSTRACTION VOLUME (L/HR)	ANTICIPATED LOWERING IN GROUNDWATER LEVEL (M)	TIMING OF IMPACT (YEAR OF MINING)
KR3	Wind pump: supply to animals	Not available	<2	Year 3 – 5
KR4	Open borehole: not in use	Not available	<2	Year 3 – 5
KR5	Open borehole: not in use	Not available	<10	Year 6 – 11
KR6	Open borehole: not in use	Not available	<10	Year 6 - 11
KR7	Submersible pump (not operational): supply to house and animals	Not available	<25	Year 1 - 14
KR8	Wind pump: not in use	Not available	<25	Year 1 - 14

KR10	Wind pump: supply to animals	Not available	<5	Year 10 - 14
KR11	Wind pump: supply to house and animals	Not available	<5	Year 1 – 5
KR12	Submersible pump: supply to house and animals	Not available	<2	Year 14

4.3.6.3 *Impact on Groundwater Quality*

The impact of mining on groundwater quality during the operational phase was assessed at the hand of sulphate concentrations, based on the results of leach tests, as presented in Table 9 of the specialist report. In order to do so, the maximum sulphate concentrations obtained from the leach tests were assigned to the mining areas and waste rock dumps. Based on the available information, sulphate concentrations of up to 250 mg/l is expected in the mining areas. This is equivalent to the SANS241:2015 drinking water standard for sulphate based on aesthetic considerations.

Under the prevailing conditions, sulphate concentrations are expected to increase to above 150 mg/l in all the mining areas, as shown. The extent of the zone of impact on groundwater quality is delineated in the two figures presented. Ambient sulphate concentrations are variable, but on average below 50 mg/l. An increase above 50 mg/l is therefore considered as the result of impact of mining.

Sulphate concentrations at the end of the operational phase in groundwater in the private boreholes within the delineated zone of influence. The most significant impact at the end of life of mine is expected to occur in the vicinity of boreholes KR7 and 8, where sulphate concentrations may increase to above 100 mg/l. It is however noted that at these concentrations, the groundwater will still be usable and should not pose any health or aesthetic risks from a sulphate concentration perspective. Sulphate concentrations in the other boreholes in the zone of influence are not expected to exceed 100 mg/l.

4.3.6.4 *Risk of Decant*

The rate of groundwater inflow to the mining areas will be determined by the flow gradients, the permeability of the rock formations intersected and the area over which groundwater seepage will take place. Initially the inflow to the underground workings will be fast, post closure, due to steep flow gradients towards the mining area. As the mines start to flood, the gradients will become shallower as groundwater levels rise, which will reduce the volume of groundwater inflow to near natural conditions.

Comparatively, the volume that groundwater inflow contributes post closure is lower than the volume of water added through recharged of rainwater. The rate of recharge to the mining areas is therefore the main driving force behind decant.

With the available dataset and mine plan, it is concluded that the risk of decant from the underground workings is very low. If no subsidence takes place, the rate of recharge to the underground workings will remain close to natural rates. Under these conditions, underground water levels are not expected to rise above natural trends, thus eliminating the risk of decant.

Decant is however possible from the pits as the rate of recharge to the backfilled pits are expected to be higher compared to natural conditions. If this is the case at closure, a total of 20 potential decant points were identified as part of this assessment. The timing of decant varies according to the rate at which groundwater and rainfall recharge may flood the pits and may occur between 6 and 39 years after mining ceases, depending on the prevailing conditions.

The volume of decant will be mainly driven by the rate of recharge to the backfilled pits. These volumes may vary between 1 160 and 21 900 m3/a, depending on the size of the pit and the success of the rehabilitation process.

The results of kinetic tests will provide more insight into the long-term water qualities expected at the operations. The static test results indicate that there is an acid generating potential for some of the material that will be handled on site, specifically the coal and discard material. For this reason, the quality of decant is not expected to be suitable for discharge to the environment. The decant is expected to be acidic (pH<5), with elevated salt and trace metal concentrations.

TABLE 4-21: POSSIBLE DECANT LOCATIONS

Decant No	Pit	X Coordinate	Y Coordinate	Decant elevation (mamsl)	Time to possible decant (yrs.)	Possible decant volume (m^3/a)
1	Pit 1	-98799	-2896533	1659	26	21873
2		-99224	-2895885	1672		
3		-97912	-2896949	1656		
4	Pit 2	-99579	-2895965	1665	16	7849
5		-100466	-2895956	1665		
6	Pit 3	-100963	-2896080	1666	14	2848
7	Pit 4	-101166	-2896267	1671	17	2257
8	Pit 5	-97885	-2894874	1661	19	23431
9		-97273	-2894688	1664		
10		-97850	-2893845	1667		
11	Pit 6	-97770	-2893668	1666	19	11732
12		-98861	-2892258	1668		
13	Pit 7	-99623	-2892453	1653	32	5118
14	Pit 8	-99881	-2892622	1652	39	15014
15	Pit 9	-97672	-2896808	1654	13	11908
16		-97362	-2896949	1653		
17	Pit 10	-96812	-2897180	1656	10	8078
18	Pit 11	-97282	-2895708	1655	6	1724
19	Pit 12	-99410	-2893606	1671	32	1635
20	Pit 13	-98045	-2897375	1663	13	1159

The most likely decant point at each pit is associated with the lowest topographical elevation. Five of the pits may have more than one decant point, due to small variations in the surface elevations of the pits and the error margin of the DTM used to assess the decant points. In all likelihood, decant will commence at the lowest topographical elevation at each of these pits. Depending on the head that may build up inside the pits, decant may also occur from the other decant points identified.

Decant points 2 and 3 are linked to the fault zones that intersect the mining areas. If groundwater is under pressure in the faults (as the current fieldwork dataset suggests), decant may take place along the fault zone, even though the surface elevation of these positions are higher compared to the other decant points identified.

The most significant impact of decant will be on wetland functioning. As the decant points are all associated with low-lying areas, they are typically associated with wetlands.

The impact of decant quality on the wetlands is considered most significant. If the decant is not contained, the acidic pH conditions and high salt and trace metal concentrations are expected to deteriorate wetland fauna and flora. These impacts would most probably be irreversible in the long-term.

In addition to impacting negatively on wetlands, the unmanaged decant will also flow across land to the pans and non-perennial streams that drain the project area. As with the wetlands, the decant will negatively affect water quality in these surface water bodies and will most probably result in irreversible acidification and unacceptable salt loads.

The collection, retention and possible treatment of decant in the closure and post-closure phases of the mine is therefore an important management measure that will need to be implemented by the applicant.

4.4 SOCIO-ECONOMIC ENVIRONMENT

A summary of the main socio-economic features of the study area is as follows:

- The proposed mining right area is located within the Gert Sibande District, within the Mpumalanga Province.
- Gert Sibande District comprises of seven local municipalities, being Chief Albert Luthuli, Dipaleseng, Govan Mbeki, Lekwa, Mkhondo, Muskaligwa, and Pixley KaSeme.
- The Municipality has 47 750 households, and 186 010 citizens. Located on the eastern escarpment of the Mpumalanga Province, the surface area is approximately 5 560 km^2.
- There are approximately 187 630 people residing in the municipality (StatsSA 2016 Community Survey). The major forces that drive population growth in the area are fertility, mortality, migration, HIV prevalence and access to Anti Retro Virals.
- The most dominant population group in the Municipality are Black African individuals, who represent more than 97.6% of the total population in the municipal area. White and Indian/Asian population groups comprise around 1.6% and 0.4% of the population respectively. The dominant languages in Chief Albert Luthuli Local Municipality are Siswati and isiZulu. Siswati is the most widely spoken language (56.6%).
- A total of 111 schools can be found in Chief Albert Luthuli Municipality, 48 of which are Secondary institutes.
- Piped water is accessed by about 68.7% of the Municipalities population and about 18.9% of the municipal population have access to flush toilets. About 19.3% of the population have access to a weekly refuse collection service[13].
- Within the Chief Albert Luthuli Local Municipality, 76% of households live in formal units, while 18% are found in informal housing units.
- The average household size in Chief Albert Luthuli Local Municipality is about 3.8, female headed households is about 49%, formal dwellings at 86% and the housing owned is at 52%.
- The Municipality has one fully-fledged fire station in Carolina, and a satellite fire station in Elukwatini; as well as an operational fire engine and three rescue vehicles.
- Health services are provided by clinics and hospitals in both urban and rural areas. There are a total of twenty one (21) clinics in the Chief Albert Luthuli Municipal area; grouped into two clusters; the Northern Cluster from Diepdale to Carolina (10), and Southern Cluster from Hartebeeskop to Badplaas (11).
- In addition, there are two Level 1 Hospitals (Carolina Hospital and Embhuleni Hospital), which receive patients referred from the clinics and provides outpatient services as well.
- Around 87.5% of household dwellings found in Chief Albert Luthuli Local Municipality have access to electricity. The Municipality is licensed to distribute electricity in Carolina, Silobela and part of Emanzana only. Eskom is licensed for the bulk supply and reticulation in the former Ekulindeni, Elukwatini and Empuluzi TLC areas. Electrification of households in the rural areas, the informal settlements and parts of Silobela Township is a compelling necessity.
- Between 2001 and 2011, there has been a decrease in the number of people unemployed and a concomitant increase in the number of employed people across the Chief Albert Luthuli Local Municipality.
- 35,4% of the 45 116 economically active individuals (i.e. those who are employed or unemployed but looking for work) are unemployed. Of the 24 506 economically active youth (15–35 years) in the municipality. 35.8% of youth remain unemployed in 2011.

[13] CALLM DIDP (2017/ 22 Part 1)

- The average household income is approximately R 9 601 – R 19 600. Obtaining any form of income generating employment within the municipality has become increasingly difficult in recent years. This is attributed to the lack of education, resulting in the uneducated experiencing the high incidences of poverty.

5 ANALYSIS AND CHARACTERISATION OF ACTIVITY

5.1 WATER MANAGEMENT

5.1.1 SITE DELINEATION FOR CHARACTERISATION

The location of the proposed surface and underground mining activities are fixed by the orebody and other mineral resources which are being targeted. Surface mining will be undertaken on sections of Portion RE, 2, 3, 5, and 7 of the farm Kranspan.

The proposed underground mining will be undertaken on a section of Portion 4, the northern section of Portion 2, the north western section of Portion 3 and the southern section of Portion 7 of the farm Kranspan.

5.1.2 WATER MANAGEMENT STRATEGY

The management of water and waste across the site will be based on the implementation of the following:

- Zero offsite discharge of effluent;
- Water conservation and demand management;
- Prevention of pollution to land, surface and groundwater resources through the implementation of the mitigation hierarchy; and
- Groundwater monitoring programme.

All dirty rainfall run-off will be separated from clean water through cut-off drains. The polluted run-off water collected will be stored in high-density polyethylene-lined (HDPE) pollution control dams (PCDs). The latter will be located adjacent to the coal process plant and in proximity to the open pits. The water from the PCDs will be used for dust suppression around the plant and the ROM and product stockpiles.

Water management across the site will be in compliance with all requirements of Government Notice 704, promulgated in terms of the National Water Act, Act 36 of 1998, specifically in respect of the following:

- Collection of the water arising within any dirty area, including water seeping from mining operations, or any other activity, into a dirty water system;
- Design, construction, maintenance and operation of the clean water and dirty water management systems so that it is not likely for either system to spill into the other more than once in 50 years;
- Design, construction, maintenance and operation of any dam that forms part of a dirty water system to have a minimum freeboard of 0.8 m above full supply level, unless otherwise specified in terms of Chapter 12 of the Act;
- Design, construction, and maintenance of all water systems in such a manner as to guarantee the serviceability of such conveyances, for flows up to and including those arising as a result of the maximum flood, with an average period of recurrence of once in 50 years; and
- Prevention of erosion or leaching of materials from any residue deposit or stockpile from any area and containment of material or substances so eroded or leached in such area by providing suitable barrier dams, evaporation dams or any other effective measures to prevent this material or substance from entering and polluting any water resources.

5.1.3 WATER BALANCE

Water requirements for use by the mine staff is calculated at 100 litres (L) per person per day. The total number of employees and subcontractors are estimated to be between 350 and 400 and the water supply capacity has therefore been calculated at 40 kilolitres (kL) per day.

Boreholes will be established to supply water for staff requirements. A small water treatment plant will be built at the mine to produce potable water from the borehole water.

The processing plant water consumption has been estimated to be between 10,000 and 20,000 m^3 per month.

5.1.3.1 Potable Water

Water requirements for use by the mine staff is calculated at 100 litres (L) per person per day.

The total number of employees and subcontractors are estimated to be between 350 and 400 and the water supply capacity therefore has to be 40 kilolitres (kL) per day. Boreholes will be established to supply water for staff requirements. A small water treatment plant will be built at the mine to produce potable water from the borehole water.

5.1.3.2 Process Water

Process water will be used at the processing plant, for dust suppression and for underground cooling. It is anticipated that the processing plant will require around 986m3/d. Process water may be sourced from ground- or surface water resources available to the mine, or from the dirty water containment facilities.The main users of water in the processing plant operation will be:

- Dense Medium for cyclones and Spirals;
- Dust suppression on coal conveyor, screening and crushing systems at the beneficiation (wash) plant; and
- General washing of the plant equipment and the floor area.

The alternatives for coal processing have been analysed and discussed in the EIA.

5.1.4 STORMWATER (CLEAN AND DIRTY WATER MANAGEMENT)

A stormwater management plan has been prepared for the proposed Kranspan project and is attached as Appendix 2.

The proposed Kranspan Mine has been designed as a "zero discharge Facility". Clean surface water runoff is directed around all contaminated areas by means of clean water diversion trenches and berms from where it will be released back into the catchment. All storm water management structures are designed in accordance to GN 704.

No retention ponds are required for the discharge from the clean water management areas as these diversions will not have an effect on the current flood hydrology curves. Energy dissipaters will be constructed in the outlet structures of the canals. The dirty water collection drains will be designed for a 1:50 year storm event.

Contaminated storm water runoff from around the opencast areas and water collected in the open pits from seepage inflows are contained in the PCD. Dirty stormwater runoff from the wash plant area, topsoil stockpile and ore stockpile are directed through surface drainage channels to the PCD.

Dirty stormwater runoff from the wash plant area, topsoil stockpile and ore stockpile are directed through surface drainage channels to the PCD. The water from the PCD facility is evaporated off and/or used for dust suppression. The dam will be lined with HDPE and designed in accordance with GN 704

The water from the PCD is lost to natural evaporation or used for dust suppression. The PCD's have a combined capacity of approximately 294 000 m^3 (including the plant PCD). The PCD's have been designed to fall within the limit of 50 000 m^3 capacity and 5 m high dam wall. In order to ensure that the dams can contain a 1:50 year storm event, a portion of each of the PCD capacity will be used for service water and normal rainfall collection.

5.2 WASTE MANAGEMENT

5.2.1 Waste Management Strategies

The NEMWA principle is to avoid waste generation where possible, and where this can be implemented, that waste production is minimised by following a hierarchy of reducing waste, recycling, recovery and disposal as presented in Figure 5-1.

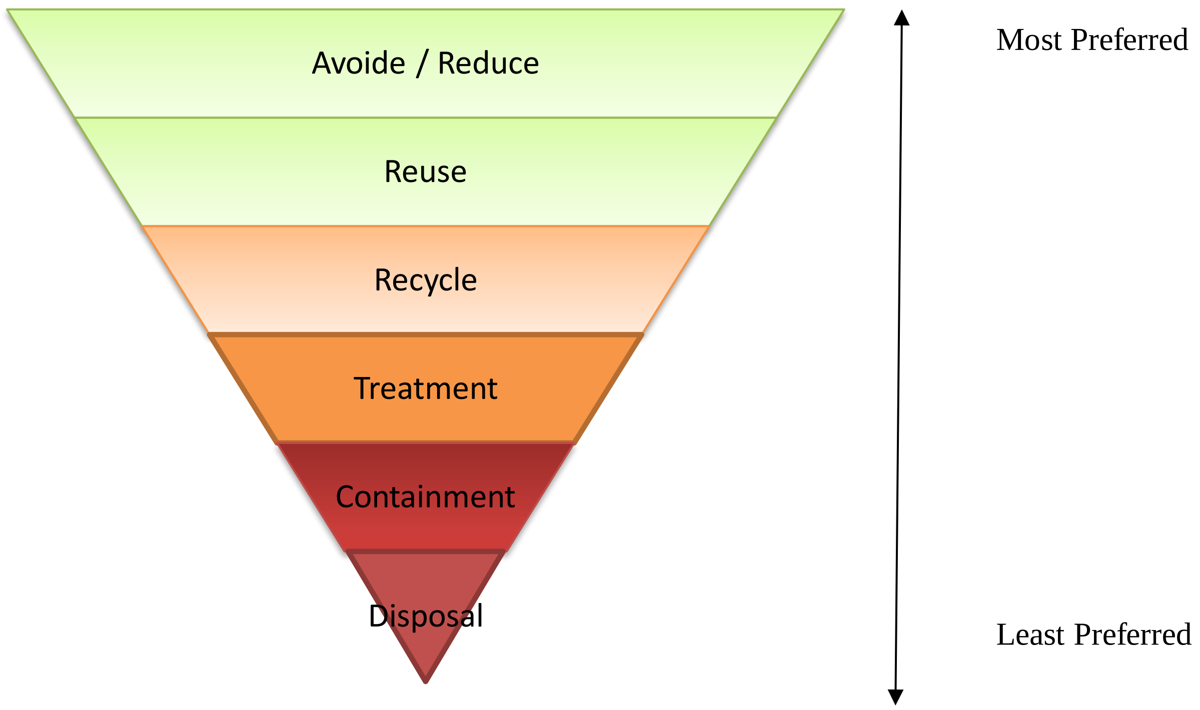


FIGURE 5-1: WASTE MANAGEMENT HIERARCHY

5.2.1.1 At-Source Waste Reduction

Waste reduction and avoidance is primarily achieved through selection of suppliers that provide operational consumables and materials with minimal packaging needs and careful stock management to ensure goods are utilised before their expiry date.

5.2.1.2 At-Source Waste Separation

Waste generated at the various areas of the Project site will be separated at source and placed into separate bins: labelled "Non-hazardous Waste" and "Hazardous Waste".

Additional labelled bins will be provided in areas known to generate specific types of non-hazardous or hazardous wastes. For example: Paper Waste; Food Waste; Glass Bottles; Metal; Oily Rags; Fluorescent Bulbs; etc. Recyclable wastes will be deposited into designated bins to ensure that the maximum amount of recyclable material is diverted away from landfill sites.

General waste will be kept separated from recyclable waste to avoid the contamination of the recyclables. The separation of waste at the source of generation will also create awareness and will ensure that the sorting of waste can take place as effectively as possible. This will be achieved through the implementation of colour coding bins.

The following colour scheme is recommended for waste separation:

- Domestic / General Waste (GREEN)
    - Disposal: Drums or containers
- Hazardous Waste (BLACK)
    - Disposal: As per hazardous materials management plan
- Fluorescent Tubes (YELLOW)
    - Disposal: Long tubes should be disposed in long flat plastic boxes and small fluorescent globes should be disposed in bins.
- Recyclable Waste. Colour coded bins may be used if available, where this is not possible green bins may be used with the following names and colours printed on it:
    - Paper-White
    - Plastic-Red
    - Cans- Grey
    - Food- Brown

5.2.1.3 On-Site Sorting

Waste will be collected from points of generation on a regular basis and taken to the on-site waste sorting facility. The waste management employees (either mine employees or an appointed waste management company) will manually sort the incoming waste into various waste streams, which are likely to include the following:

- General waste (mainly household/office waste);
- Cardboard and other paper products;
- Scrap wood;
- Scrap metals;
- HDPE (plastic);
- (Low Density Polyethelyne) LDPE (plastic);
- Polyethylene Terephthalate (PET) (plastic);
- Glass;
- E-Waste (electronic waste);
- Printer cartridges;
- Light bulbs;
- Used vehicle and house hold batteries;
- Concrete waste;
- Contaminated soil;
- Hazardous waste;
- Old PPE;
- Wire off cuts;
- Old building waste; and

The appropriate numbers and types of equipment required to effectively sort the waste including items like a sorting table, bins, skips, cleaning equipment, etc. will be made available.

5.2.1.4 *Disposal and Recycling*

No onsite disposal or recycling of waste will be undertaken. All waste is separated and then stored for offsite removal by an appropriately registered contractor:

- All domestic waste will be contained in a separate skip;
- All industrial and hazardous waste will be collected from appropriately demarcated containers on site by suppliers and either recycled or disposed of in or at a licensed facility. The management of this aspect will be controlled through the contracts that are entered into between the mine and its suppliers; and
- All dirty water is captured in the pollution control dam and reused wherever possible.

5.2.2 Sewage

New facilities for sewage will be constructed within the footprint of the process plant. The technology is likely to be a modular sewage package plant with a design throughout capacity, based on 1000 persons, of around 250 m^3 per day.

Chemical toilets will be used for the underground mining. These will be serviced at the required frequency by a contractor.

5.2.3 Hazardous Waste Management

5.2.3.1 *Storage*

The following will apply with regards to temporary and permanent storage of hazardous waste on site:

- Hazardous waste bins will be stored in the waste storing facility and will store all hazardous material generated.
- Hazardous waste storing facilities should be clearly marked and fenced.
- Waste storing facilities should be designed to prevent any spillage/contamination of the physical, biophysical and social environments. This can be accomplished through concrete floors, bunding and ensuring that the building is designed so that water cannot enter.
- Hazardous materials will be disposed of in accordance with all applicable regulations. Used motor oil, coolant, and hydraulic oil will be recycled.

5.2.4 Discard Management

Discard from the coal preparation plant is planned to be deposited back into the open pits, after extraction of the target coal seam has been completed.

If there is insufficient capacity for in-pit disposal, some discard material will be stored in an engineered surface discard stockpile.

The groundwater model was used to simulate the long-term impact of mining on groundwater quality. This was achieved by evaluating four scenarios, namely:

- Scenario 1: the long-term impact if all rehabilitation measures are implemented and deterioration in groundwater quality does not take place during the operational phase of mining. Post closure, sulphate concentrations were assumed to increase as a result of acidification, which is likely based on the results of static geochemical tests. The increase in sulphate concentration post closure is based on the author's experience in similar environments in the absence of the results of kinetic geochemical testing.
- Scenario 2: tested the impact of placing discard material into the mined-out pits. Although it is acknowledged that this will not take place in all of the pits as the volume of discard generated will be less than the void space available in all the pits, the model was used to identify the impact of backfilling all the pits with discard. This will allow identification of pits that may be more suitable for backfill with discard. In order to complete this scenario, it was assumed that the discard material will acidify during

the operational phase as well as post-closure resulting in an increase in sulphate concentrations. In the absence of more specific data, it was assumed that sulphate concentrations of up to 3000 mg/l would leach from the discard material. This assumption must be tested and re-evaluated once the results of the kinetic testing is available.

- Scenario 3: evaluates the impact of placing discard in a stockpile on surface within the plant area. The scenario assumes that the discard stockpile will not be lined, and the rate of seepage would be governed by the permeability of the weathered aquifer.
- Scenario 4: tested the effect of lining the discard stockpile with a Class C liner.

The model was run for a period of 100 years after mining stops and the results are summarised below.

Surface Discard Dump

- The most significant impact of an unlined discard stockpile will be on the weathered aquifer , the pan and the wetlands present down gradient of the facility.
- It is anticipated that an unlined discard stockpile will have a negative impact on pit water quality and thus long-term decant quality at Pit 1.
- With time after the simulation period of 100 years, the contamination that will leach from an unlined discard dump will however migrate towards the pan. This will result in an increased salt load to the pan.
- A lined facility is not expected to add significantly to sulphate contamination. Groundwater quality in the long-term will however still be impacted on by the surrounding mining activities.
- The discard facility design should take cognisance of the position of the fault zone and if necessary, must be moved to ensure that it does not overly the fault, if this is identified as the preferred alternative for discard management.

In-pit Discard Disposal

- The quality of decant from the pits post closure will be negatively affected by this activity. It is not possible to say with certainty what the decant quality will look like with the available dataset, but modelling results suggests that sulphate concentrations may increase by 30% in the long-term inside the pits. The results of the kinetic testing indicate that the discard material will most likely acidify in the long-term, which will compound the impact on groundwater quality, the wetlands and private boreholes.
- The pits around the largest pan should not be used for discard backfilling due to the anticipated negative long-term impact on the pan and the wetlands in this area. One of the known preferential flow paths to groundwater transects the pan and the mining area and for this reason it is not recommended that additional contamination potential is introduced in this area. The pits that should not be used for discard backfill due to proximity to the largest pan, wetlands and the presence of a preferential groundwater flow path include Pit 1, Pit2, Pit 3, Pit 4 and Pit 9.
- In addition, Pits 6 and 11 should also not be used for discard backfill due to the fact that the lineaments (preferential groundwater flow paths) transect the pits.
- It is furthermore not recommended that discard is placed in Pits 7, 8 and 10 due to the fact that they are situated immediately adjacent to non-perennial streams that drains the mining area. Should decant take place from these pits in the long-term, the streams will be directly impacted.
- Based on the current understanding of the project site, the only pit that can be considered for discard backfill is Pit 5. The pit is however not ideal, as it is situated adjacent to the second largest pan and two of the decant points identified will drain towards the pan. If discard is however placed in the bottom of the northern most section of this pit, leachate may be contained more successfully than in the other pits. The coal floor contours suggest that the seam dips in a northerly direction and that this would be the

deepest point of the pit. It is however noted that interflow between Pits 5 and 6 are possible in this area. It is important to maintain the boundary strip along the farm portion boundary in this area to avoid that from happening.

- It is strongly recommended that this assessment is tested and possibly re-evaluated once the results of the kinetic geochemistry testing are available.

Based on the above, only Pit 5 has been included in the IWULA for in-pit discard disposal.

If the discard quantity exceeds the capacity of the pit, a surface discard stockpile will be constructed with a Class C liner as required by legislation.

5.3 OPERATIONAL MANAGEMENT

5.3.1 RESOURCES AND COMPETENCE

Ilima is responsible for ensuring implementation of the EMP and this IWWMP. Ilima will also ensure that a procedure is developed such that all senior positions on site have their environmental responsibilities and accountabilities clearly outlined. These descriptions will form part of the contractual obligations upon which individual employees are engaged. Specific accountabilities and responsibilities outlined in the procedures will be communicated through the Mine Manager.

Ilima will continue to operate the site in accordance with their Environmental, Occupational Health and Safety, and Community Relations and Development policies. Periodic auditing and reviews will be conducted by internal and external auditors to verify conformance and confirm management behaviour is in accordance with these policies.

The Company is committed to ensuring that the Occupation Health & Safety (OHS) and Environment Departments' staffs are appropriately qualified for implementing their assigned responsibilities effectively. In order to fulfil this requirement, the Company shall recruit competent individuals and put in place a continuous training and skills upgrading program. Typical duties and responsibilities for the OHS and Environment staff will include, inter alia to:

- Ensure that environmental monitoring programs are carried out on schedule and correctly;
- Review environmental data and recommend appropriate actions;
- Monitor environmental compliance of all mine operations;
- Train others in the team and general personnel on mine environmental issues;
- Design and implement restoration of disturbed areas and re-vegetation studies;
- Establish, train and ensure readiness of the emergency response teams;
- Report on environmental data and incidents of significance as per regulations;
- Liaise with the appropriate regulatory authorities on incidences with environmental risks;
- Provide technical and environmental support to mining operations;
- Ensure commitments listed in the ESIA are met, and
- Review (periodically) the existing monitoring system and design

5.3.2 EDUCATION AND TRAINING

Ilima Management and Contractors shall ensure that adequate environmental awareness training of senior site personnel takes place and that all workers receive a general induction and understanding on the content of the IWWMP in conjunction with the EMP. As a minimum, training shall include:

- Explanation of the importance of complying with the EMP and IWWMP.
- Discussion of the potential environmental impacts of site activities.

- Employees' roles and responsibilities, including emergency preparedness.
- Explanation of the mitigation measures that must be implemented when carrying out their duties.
- Explanation of the specifics of this IWWMP and its specification.
- Explanation of the management structure of individuals responsible for matters pertaining to the Construction Environmental Management Plan.

Ilima shall keep records of all environmental training sessions, including names, dates and the information presented. These records will be presented at the monthly review meetings and to the Environmental Control Officer (ECO) on request during his/her monthly audits.

5.3.3 Internal and External Communication

Relevant aspects of the EMPr and IWWMP will be communicated internally and externally through appropriate communication structures including the steering committee to be established by Ilima and the CALLM.

5.3.4 Awareness Raising

Awareness raising will be implemented through on-site training and regular inductions. Community awareness can be achieved through community awareness programs to educate the community on water conservation.

5.4 RISK ASSESSMENT/BEST PRACTICE ASSESSMENT

A comprehensive assessment of the potential risks and impacts of the proposed mining activities on the environment has been undertaken in accordance with the requirements of the EIA Regulations, 2014 (as amended).

The impact assessment methodology comprised of a risk-based impact matrix in which the outcomes, impacts and residual risk of the project activities was determined as follows:

- Step 1: Identify and describe the impact in terms of its nature (negative or positive) and type (direct or indirect);
- Step 2: Assess the impact severity (including reversibility and the potential for irreplaceable loss of resources), impact duration and impact spatial scale (extent);
- Step 3: Assign an impact consequence rating;
- Step 4: Assess the impact probability;
- Step 5: Assign the impact significance rating;
- Step 6: Identify measures and controls by which the impact can be avoided, managed or mitigated; and
- Step: Repeat the impact assessment on the assumption that the mitigation measures are applied and assign the residual impact (post mitigation) significance rating.

The purpose of the impact assessment was not to identify every possible risk and impact which the proposed project activities may have on the receiving social environment. Rather, the assessment was focused on identifying and assessing the most material impacts, commensurate with the nature of the project activity and the characteristics of the receiving social environment.

All impacts were assessed in the following phases:

- Construction;
- Operation; and
- Decommissioning and Closure.

The mitigation hierarchy was applied throughout the S&EIR Process.

The mitigation hierarchy is an approach to mitigation planning and can be summarised into the following steps:

- Avoidance;
- Minimisation;
- Restoration; and
- Offsets.

In the Scoping Phase, mitigation measures are predominantly focussed on avoidance and minimisation. This is done through activities such as the site layout selection process and implementation of the environmental design criteria including the environmental sensitivity plan, by the engineering team.

In the Impact Assessment Phase, the findings and recommendations of the specialist studies were used to develop the environmental and operational controls which are focused on impact minimisation and restoration (as part of mine rehabilitation and closure).

5.4.1 RISK ASSESSMENT RELATING TO KRANSPAN MINING AREA

The Department of Water and Sanitation (DWS) has developed a risk assessment matrix for development activities within a wetland or watercourse. The wetland units associated to the project have all been delineated and the appropriate conservation buffer zones have been designated to the units. The risk assessment matrix is aimed at activities that are to take place within these areas. As infrastructure is planned for within wetland areas and wetland zones will be impacted, many ratings are defaulted to having a high risk. After calculation of the various impacts, all of the impacts were rated as having a high risk to the present ecological integrity of the surface water ecosystems and associated habitat units. The significance of the impacts is largely related to the scale and intensity of the wetland habitat that will be impacted, and therefore can be greatly reduced by taking into consideration that wetland delineation mapping and associated conservation buffer zones. The calculations of the DWS Risk Assessment, detailing of the impacts and outline of the mitigation measures are provided in the specialist report (Appendix 3).

5.4.2 IMPACTS TO GROUNDWATER AND SURFACE WATER RESOURCES

The geohydrological study has indicated that the mining activities, including the associated disposal of discard, may have an impact on groundwater availability and groundwater quality.

Key findings from the study are as follows:

- Mining activities will have a negative impact on groundwater availability in private boreholes and springs within the proposed mining right area. The hydrocensus indicated that boreholes predicted to be affected directly (destroyed) or indirectly (dewatering) are not in use at present;
- To manage the expected groundwater seepage during the operational phase of mining, the study recommends that each of the 6 planned PCDs include provision for 8 400 m^3 per annum of groundwater;
- Regional groundwater levels are expected to recover within 30 to 50 years after mining and mine dewatering ceases. During the time of recovery, groundwater flow will be reversed towards the mining areas, thus restricting the movement of contaminated groundwater outside of the mining right area;
- Sulphate concentrations, due to the open pit mining, at the end of the operational phase may increase to above 100 mg/l at two of the borehole locations (not in use at present). It is however noted that at these concentrations, the groundwater will still be usable and should not pose any health or aesthetic risks from a sulphate concentration perspective. Sulphate concentrations in the other boreholes in the zone of influence are not expected to exceed 100 mg/l;
- Contamination is not expected to move significant distances from the mining areas (approximately 300 m) due to the impact of mine dewatering and the reversal of groundwater flow towards the mining areas during the operational phase;

- The risk of decant from the underground workings is very low. Decant may occur from the rehabilitated open cast pits at 20 positions. Depending on several factors, the decant may occur between 6 and 39 years after mining ceases;
- The findings of the geochemical characterisation of the discard material, based on the static leach testwork, conclude that five of the six discard samples could be considered acid generating with a low acid neutralising capacity. The magnitude of the acid generating potential of the discard material and associated metals leaching is subject to ongoing kinetic leach testwork which is underway at present and is scheduled to be completed by November 2019;
- The overburden material poses a lower environmental risk with only one out of twenty samples taken demonstrating significant acid generating potential;
- Depending on the quality of the decant and if the decant is not contained, the most significant impact of poor quality decant is likely to be on the wetlands and pans in the proposed mining right area;
- The impact to groundwater quality in the long-term (100 years after mining ceases) was modelled on various scenarios, including mining with no discard disposal facility, mining with in-pit discard disposal in all open cast pits, mining with an unlined surface discard facility and mining with a lined surface discard facility. In all scenarios, sulphate concentrations are predicted to increase at various receptors with the maximum predicted sulphate concentration of 1200 mg/l associated with the scenario where discard is disposed in all open cast pits; and
- In general, with mitigation measures implemented, the impacts to groundwater availability and groundwater quality are expected to be contained predominantly within the proposed mining right area.

The study notes that the groundwater impact assessment was based on a worst-case scenario, which is in line with the requirements of the precautionary principle. Key assumptions in this regard were as follows:

- The study assessed the impact of in-pit discard disposal in all the open cast pits. This was important to determine which of the pits would not be suitable for in-pit disposal. From the recommendations of the study, only Pit 5 is now proposed to be used for the in-pit disposal of discard. This is expected to reduce the impact on groundwater quality;
- In the absence of more specific data, it was assumed that sulphate concentrations of up to 3000 mg/l would leach from the discard material. The static leach testwork completed on the Kranspan discard samples indicated a sulphate concentration of 250 mg/l. Kinetic leach tests and geochemical modelling are currently underway, which will improve the understanding of long-term leachate quality associated with the discard material; and
- Oxidation of the discard material during the operational phase and post-closure of the operations was assumed. These results have been used by the Applicant to refine the in-pit disposal design such that the placement of the discard in-pit will not be above the water table, minimising the extent to which the material may oxidise.

Within the management measures section of the geohydrological study, it is concluded that with the implementation of additional management measures, such as restrictions being placed on the pit location and depth to which the discard can be backfilled, the rate and extent to which the discard could oxidise will be reduced. The resultant discard leachate could therefore be of better quality than what was used for the simulations in the groundwater impact assessment. If the leachate associated with the discard is of better quality, the resultant impact on groundwater quality will be reduced.

For this reason, the geohydrological study recommends that the groundwater quality impact assessment is revised once the results of the kinetic tests and geochemical modelling are available. This, and the mitigation measures associated with restricting the in-pit disposal of discard material have been included in the EMPr and recommended as conditions to be included in the authorisation.

5.5 ISSUES AND RESPONSES FROM PUBLIC CONSULTATION PROCESS

A single public consultation process for all the relevant environmental applications, namely the applications for EA, IWUL and WML is undertaken. The details of the public consultation process undertaken to date, including a complete record of all correspondence is included in the EIR and water and waste related issues and responses is summarised Table 5-1.

TABLE 5-1: SUMMARY OF ISSUES RAISED BY I&APS WITH PARTICULAR REFERENCE TO WATER AND WASTE

INTERESTED AND AFFECTED PARTIES LIST THE NAMES OF PERSONS CONSULTED IN THIS COLUMN; AND MARK WITH AN X WHERE THOSE WHO MUST BE CONSULTED WERE IN FACT CONSULTED		DATE COMMENTS RECEIVED	ISSUES RAISED	EAPS RESPONSE TO THE ISSUES RAISED
Adjacent Occupiers of Site (Occupiers and users of land immediately adjacent to the Mining Rights Area Boundary)	**X**			
Community Member Farm Vaalbank 212		Comment received verbally during community survey on the 27th of February	Concerns during survey captured pertain to blasting impacts from surrounding mines. This community member has also noted degradation of surface water quality.	It is recommended that complaints pertaining to blasting and mining activities from adjacent mines be discussed with the mines directly. The findings of the impact assessment undertaken for the proposed Kranspan have been presented in this report and mitigation measures have been included in the EMPr.
Municipal Councillor	**X**			

Mxolisi Gumede Chief Albert Luthuli Local Municipality		Comment received via email on 18 December 2018	Herewith Areas where I am looking for more information in future studies of clarity as per current draft report: Section 5.2 (bullet 2) Clarity on the mentioned possible mining impact of surface/ground water bodies. What kind of impacts, are they on quality or quantity (how can the Municipality as a Water Service Authority, plan to cope with such impacts).	The impacts of the proposed mining project on surface and groundwater resources will be assessed through the specialist studies as described in Section 10 of the Final Scoping Report. These studies will be incorporated into the Draft Environmental Impact Report (EIR). On completion of the studies, registered I&APs will be provided with an opportunity to review the Draft EIR, including the specialist study reports.
Mxolisi Gumede Chief Albert Luthuli Local Municipality		Comment received via email on 18 December 2018	Section 5.2 (bullet 5) The mentioned climate change related impacts (what % contribution will the mining impact have in the region?)	The climate change impacts in Section 5.2 of the Scoping Report relate to coal combustion, particularly from coal-fired power stations, and not coal mining. The greenhouse gas emissions generated by the proposed mining activities will be considered in the air quality specialist study.
Department of Mineral Resources				
Azwihangwisi Nemulodi		Letter received on 12 April 2019.	• The occupiers of the land in question and the adjacent land owners must be included in the public participation process and proof and results must be included in the EIAr.	The occupiers and landowners within the mining right boundary as well as adjacent landowners and occupiers have been included in the consultation process.
Azwihangwisi Nemulodi		Letter received on 12 April 2019.	• Public participation must also include the private land owners of the Chrissiesmeer Panveld area.	The Chrissiesmeer Panveld owner's association chairperson has been informed of the proposed project and has been added to the I&AP database.
Azwihangwisi Nemulodi		Letter received on 12 April 2019.	• Public Participation Process must be transparent and all comments received during the process must be incorporated into the comments and response report of the	This requirement is noted.

			final Environmental Impact Report. Newspaper adverts, notice boards, written notice meetings e.t.c should form part of proof of public participation.	
Azwihangwisi Nemulodi		Letter received on 12 April 2019.	• Kindly make sure that during public participation for the EIA, interested and affected parties (especially communities at close proximity are made aware of the proposed working hours and the impacts (e.g. noise, dust, house cracks) and mitigation measures are outlined in details to those communities (this must be included in the EIAr).	This requirement is noted.
Azwihangwisi Nemulodi		Letter received on 12 April 2019.	• It has been noted that there will be blasting on site should the project be approved, please also include this issue during public participation as mentioned above and give details on how the impacts such as house cracks and vibrations will be mitigated (this must be included in the EIAr).	All impacts have been assessed and is presented in this report. The mitigations measures have been included in the EMP. It should be noted that the community on Portion 1 will be relocated by the adjacent Msobo mine and will thus reduce the impacts of the blasting on this community.
Azwihangwisi Nemulodi		Letter received on 12 April 2019.	• The table regarding the summary of issues raised by I&Aps must be completed in full i.e issues raised by I&Aps and the responses by the EAP or company must be summaried in this table. It has been noted that in the second report, not all issues raised and	This requirement is noted.

			responses were cuptured in the same table of the EIAr.	
Azwihangwisi Nemulodi		Letter received on 12 April 2019.	• All specialist studies mentioned in section 10.3 of the scoping report must be conducted and attached to the EIAr. • The specialist study must also focus on the possible impacts on the Chrissiesmeer Panveld.	All specialist studies undertaken have been attached in Appendix 7. The assessment on the entire Chrissiesmeer Panveld does not fall within the scope of work required for the proposed project. The direct impact of the Kranspan project on the panveld is the potential impact on one pan within the mining boundary and has been assessed as part of the EIA. Mitigation measures have been included in the EMP.
Organs of State with Jurisdiction	**N/A**			
Thabo Rasiuba Inkomati Usuthu Catchment Management Agency (IUCMA)		Comment received via email on 15 January 2019	Kindly send hard copies to Inkomati-Usuthu Catchment Management Agency for comment.	A hard copy of the Draft Scoping Report has been delivered to the IUCMA for review as requested. Please note that comments should reach ABS Africa by 28 January.
Dzhangi Thandi Inkomati Usuthu Catchment Management Agency (IUCMA)		Comment received via email on 8 February via email and attached letter	The Inkomati Usuthu Catchment Management Agency (IUCMA) assessed the report and the following comments are made:	No response necessary.
Dzhangi Thandi Inkomati Usuthu Catchment Management Agency (IUCMA)		Comment received via email on 8 February via email and attached letter	1. Page 11: Opencast Mining: It is indicated that a conventional strip mining method will be used for each of the opencast pits. *The material from the boxcut phase must be stored as per overburden classification. Stock-pilling of any material should not be located within 1:100-year flood line, delineated riparian zone or 100m from the watercourse, whichever is greatest. Stripped off topsoil must be re-used to rehabilitate any disturbed land and*	This requirement is noted and has been incorporated into the EMPr. Identified sensitive environmental features across the proposed mining right area has been assigned buffers so as to avoid impacting on these areas.

			must not be used for maintenance of access roads. If and where possible concurrent rehabilitation of all disturbed areas shall be done on an ongoing basis to prevent degradation of the natural environment.	
Dzhangi Thandi Inkomati Usuthu Catchment Management Agency (IUCMA)		Comment received via email on 8 February via email and attached letter	2. From the report and identified activities, the possible water uses that will be triggered in terms of Section 21 of the National Water Act (Act 36 of 1998) (NWA) are as follows: • Section 21 (a) – taking of water from a borehole for domestic water uses • Section 21 (c) and (i) – encroaching regulated areas (s) by mining and related activities within 500m of a wetland. • Section 21 (g) – the disposal of discard material on the engineered discard dump and establishment of pollution control dams (PCDs)	Please refer to section 4 for an extensive list of water uses identified. This is further discussed in the IWWMP.
Dzhangi Thandi Inkomati Usuthu Catchment Management Agency (IUCMA)		Comment received via email on 8 February via email and attached letter	3. Page 17: Sanitation-It is indicated that the new facilities for sewage management will be constructed on site and chemical toilets will be used for underground mining. *The use of potable toilets is supported, and the contents must be disposed into the authorised wastewater treatment facility. The IUCMA will request proof of service level agreement between the Applicant and the owner of the wastewater treatment facility. The Applicant shall ensure that no sanitary system is located*	This requirement is noted and has been incorporated into the EMPr.

			within 1: 100 year-flood line or delineated riparian zone, whichever is greatest	
Dzhangi Thandi Inkomati Usuthu Catchment Management Agency (IUCMA)		Comment received via email on 8 February via email and attached letter	4. Page 18: General Waste – It is indicated that there will be no solid waste disposal landfill on site and that the waste will be segregated into general and hazardous waste and contractors will be appointed to remove the waste to the licenced waste disposal facilities. *The IUCMA will require proof of Service Level Agreement between the applicant and the facility owner.*	This requirement is noted.
Dzhangi Thandi Inkomati Usuthu Catchment Management Agency (IUCMA)		Comment received via email on 8 February via email and attached letter	5. Page 18 Stormwater Management – It is indicated that the applicant will employ bets practice of clean and dirty water separation where dirty water is channelled and stored into PCD. *The footprint of the dirty area must be minimised to effectively manage dirty stormwater generated on site. The clean stormwater must be diverted away from the dirty areas. The dirty stormwater disposed into the PCD must be evaporated or be used for dust suppression provided it is authorised. The PCD must be operated and maintained to have a minimum freeboard of 0.8 metres above full supply level and all other dirty water systems related thereto must be operated is such a manner that it is at all times capable of handling the 1: 50 year flood-event on top of its mean operating level.*	These requirements have been summarised in Section 3.2.12 of the Draft EIR.
Dzhangi Thandi Inkomati Usuthu Catchment Management Agency (IUCMA)		Comment received via email on 8 February via email and	6. Page 43: Water Resources – It is indicated that there are three wetlands in the project areas. *The applicant is advised to prevent high ecological impact development around the perimeter of those*	The placement of infrastructure and mining pits have considered these wetlands and the associated buffers have been applied. The necessary water use licences have been applied for where intrusion within these buffers cannot be avoided

		attached letter	*wetlands. No activities should be located within 1: 100 year flood line, delineated riparian zone or 100m from a watercourse, whichever is the greatest without authorisation.*	
Dzhangi Thandi Inkomati Usuthu Catchment Management Agency (IUCMA)		Comment received via email on 8 February via email and attached letter	7. In terms of section 22 (1) of the NWA "a person may only use water- *(a) Without a licence-* *I. If water use is permissible under Schedule 1;* *II. If water use is permissible as a continuation of an existing lawful use (section 32); or* *III. If that water use is permissible in terms of general authorisation issued under section 39;* *(b) If the water use is authorised by a licence under this Act; or* (c) *If the responsible authority has dispensed with a licence requirement under subsection (3)'* Therefore, any other water use activities associated with this project that are not permissible as indicated above, must be authorised prior to such water use activities taking place.	All water use activities and associated licences required for the proposed project is summarised in Section 4 and the IWWMP and the relevant authorisation has been applied for.
Dzhangi Thandi Inkomati Usuthu Catchment Management Agency (IUCMA)		Comment received via email on 8 February via email and attached letter	8. Any pollution incident(s) originating from the proposed mining activity must be reported to the IUCMA within 24 hours.	This requirement is noted and has been incorporated into Section 20.
Dzhangi Thandi		Comment received via	9. The water user is therefore advised to engage with IUCMA or Department of Water and Sanitation	No response necessary.

Inkomati Usuthu Catchment Management Agency (IUCMA)		email on 8 February via email and attached letter	(DWS) for the guidance on the requirements for water use authorisation process. Additionally, water use applications ca be lodged on-line on the eWUULAS platform accessible at www.dws.gov.za	
Interested Parties	**X**			
Koos Davel		Comment received via email and attached letter on 8 May 2019	**1. Water related risk identification**	Responses have been provided individually on comments below.
Koos Davel		Comment received via email and attached letter on 8 May 2019	1.1 Back ground quality of the environmental water to be established. This investigation should include the water quality of boreholes, fountains, pans, vlei areas, streams surrounding and run-off the mining area as well as in the identified protected areas. Water in the downstream Nooitgedacht dam to be profiled.	This assessment has been completed as part of the EIA process and has been reported on in this EIA report as well as the ecological, geohydrology and surface water ecosystems specialist reports attached in Appendix 8.
Koos Davel		Comment received via email and attached letter on 8 May 2019	1.2 A waste classification and pollution potential to be established (Waste Act regulation 23 Aug 2013 R6363) on: (it is expected that this classification would at least be Class 3 waste, requiring a type 3 liner) 1.2.1 Material to be placed back in all open pit voids 1.2.2 Water captured in the open cast pits 1.2.3 Surface water as captured in the proposed PCD's 1.2.4 Process water	A Waste classification has been undertaken and is reported in the EIR as well as the geohydrology report attached as Appendix 8.
Koos Davel		Comment received via email and attached letter on 8 May 2019	1.3 Planned water management from the mining pits should include and specify: 1.3.1 Decant points from each pit. This should be included in the floor plan of each pit profile. (This to be made available in a recognised survey format) 1.3.2 The pollution plume progress from each pit. This should include saturated as well as unsaturated	This assessment has been undertaken and is reported in the EIR as well as the geohydrology report attached as Appendix 8.

			flow conditions. This pollution extend should be indicated on drawing of the area, referring to the duration of the impact.	
Koos Davel		Comment received via email and attached letter on 8 May 2019	1.4 It was noted with concern, that planned opencast mining activities is planned on the edge of the wetlands, pans and event within already recognised (legal) buffer zones. The mine and consultant to propose specific mitigation measures. (a 21g application after the mining event would not be acceptable)	Specific mitigation measures have been proposed in the IWWMP as well as the EMP (Part B of the EIR).
Koos Davel		Comment received via email and attached letter on 8 May 2019	**2. Mitigation Measures** The Ermelo coal field is known as Acid Mine generation. The following mitigation measures are identified and needs to be quantified and should be included in the scoping document:	Responses have been provided individually on comments below.
Koos Davel		Comment received via email and attached letter on 8 May 2019	2.1 Water leaving the mining site should be of an acceptable standard. This include surface and all seepage water. The water quality should meet with the environmental acceptable standard (not drinking water quality). The scoping document should include: 2.1.1 The volume of the water that would be impacted on by the mining activities. This include seepage from the environment as well as rainfall on the mining area (Hopkins) 2.1.2 Separation of dirty and clean water in terms of GN 704 of the Water Act	The scoping report identified the baseline environment, preliminary impacts and the plan of study for the environmental impact assessment process. This level of detail is thus not required for the scoping report.
Koos Davel		Comment received via email and attached letter on 8 May 2019	2.2 The introduction of a water treatment plant is proposed. The scoping study should cover (at least): 2.2.1 Nature of this water treatment plant to meet with the required water quality as determined in par 1.1. i.e. the environmental water quality 2.2.2 Capital and establishment cost of this plant construction. Commissioning cost and time to be specified	The scoping report identified the baseline environment, preliminary impacts and the plan of study for the environmental impact assessment process. This level of detail is thus not required for the scoping report. All engineering details and designs that do not have reference to the environmental and social impact assessment may be requested from Ilima directly.

			2.2.3 Operational cost of the water treatment plant for the duration of the impact. (Duration to be identified and quantified). The following specifics regarding the water treatment plant is required: 2.2.3.1 Manning, technical skills and maintenance requirements 2.2.3.2 Emergency procedures considering electrical power supply, industrial action, equipment failure 2.2.3.3 Brine and waste on site storage method and cost. Disposal site to be identified with take-off cost and method 2.2.3.4 The infrastructure collecting AMD/polluted water to be treated. This lay out to be specified with a lay-out and operating philosophy 2.2.3.5 Service life and maintenance schedule to be specified on, this to include: • HDPE liners • Electrical motors • Pumps • Reverse osmose filters • Pipe lines and valves • Buildings and structures • Security and protection to the water treatment plan 2.2.3.6 A trust fund (or financial guarantee) providing for the above items, over the impact duration to be established, prior to commencement of mining.	
Koos Davel		Comment received via email and attached	2.3 The design calculations on all PCD and evaporation ponds to be supplied.	Information on the PCD have been included in the EIR and IWWMP.

		letter on 8 May 2019		
Koos Davel		Comment received via email and attached letter on 8 May 2019	2.4 Lining of open cast pits and water storage facilities as per the abovementioned Waste Act Regulations. This would meet with GN 704 requirements	All GN 704 requirements have been adhered to and reported on. Exemption for a GN 704 will apply to the in-pit disposal.
Koos Davel		Email sent on 14 May 2019	Correct Chrissiemeer protected area Pse register as IAP	Is my understanding correct that you are representing the landowners of the Chrissiesmeer Panveld? Thank you for the feedback. You have been registered as an I&AP.

5.6 MATTERS REQUIRING ATTENTION

A geohydrology and surface water ecosystems specialist impact assessment has been undertaken by Ileh and Enviross respectfully. The key issues pertaining to surface and underground water features are summarised as follows:

- The proposed development area was shown to incorporate a relatively high proportion of wetland habitat units, ranging from valleyhead seeps, hillslope seeps, channelled and unchannelled valley-bottom and depression-type wetland units. These units have been delineated and their outer boundaries, together with a 100 m conservation buffer zone, are presented in Appendix 1.
- The DWS risk assessment indicates that all activities that will impact the wetland directly carry a high risk factor. The impact significance ratings also indicate that the potential impacts carry a high significance before mitigation. The significance of the impacts is largely due to the direct involvement of deleterious impacts to wetland habitat units. The significance is, however, largely dependent on the amount of wetland habitat that will be included into the layout planning and the severity of those impacts; Infrastructure layout planning that takes into consideration the wetland delineation mapping, associated conservation buffer zones, as well as the proposed mitigation measures can greatly reduce the overall significance of the impacts to the wetland systems associated with the site.
- Based on the outcome of provisional geochemical tests completed on waste rock and discard material sourced from the project site, the main source of contamination associated with the site is leachate from the discard. The study indicates that the waste rock samples poses a low environmental risk with only one out of twenty samples pointing to acidification of water in the long-term. The discard material on the other hand has a high probability of becoming acid generating if stored in a surface discard dump for a significant amount of time. There is however a level of uncertainty regarding the magnitude of the acid generating potential from the provisional geochemical tests. Greater clarity is expected once more sophisticated kinetic tests are completed. These are currently underway. The geochemical study confirms that sulphate is an indicator element associated with the project. Increased sulphate concentrations result from the oxidation of pyrite and other sulphide minerals in the coal, overburden and discard material. In the absence of the results of the kinetic tests, medium and long-term sulphate concentrations were inferred from literature-based values during the assessment.

The ongoing implementation of the management controls in the EMPr and IWWMP is important to ensure that pollution control dams and stormwater systems operate in compliance with the requirements of GN704 and for ensuring overall site compliance with the conditions of the IWUL.

5.7 ASSESSMENT OF LEVEL AND CONFIDENCE OF INFORMATION

Much of the information provided in this IWWMP was referenced from the proposed Kranspan EIA (2019) and associated specialist studies.

The IWWMP has also been reviewed by the Ilima management team and environmental advisor. Overall, the level of confidence with regards to the information provided is thus regarded as medium.

6 WATER AND WASTE MANAGEMENT PHILOSOPHY

6.1 STRATEGIES (PROCESS WATER, STORMWATER, GROUNDWATER AND WASTE)

Strategies implemented to manage water and waste at the Ilima Colliery has been discussed in Section 5.1 (Water Management) and Section 5.2 (Waste Management) of this IWWMP.

6.2 PERFORMANCE OBJECTIVES/GOALS

The aspects which are considered of importance to the development, including the respective management objectives and outcomes are provided in Table 6-1. The management objectives and outcomes will be achieved through the implementation of the management actions in this IWWMP and associated action plans which may be developed by the mine as part of their site management system.

TABLE 6-1: WATER AND WASTE MANAGEMENT OBJECTIVES AND OUTCOMES

ASPECT	MANAGEMENT OBJECTIVE	MANAGEMENT OUTCOME
Groundwater	➲ Surrounding land users unaffected by dewatering and other mine activities. ➲ Prevent the contamination of groundwater resources. ➲ Managed response to the clean-up of accidental spillages and leaks. ➲ Monitor groundwater to ensure that any changes in groundwater quality and quantity are identified and investigated	➲ Good stakeholder relations with community members. ➲ Groundwater resources protected from contamination. ➲ Accidental leaks and spillages responded to rapidly and all contamination remediated in accordance with legal requirements.
Surface water	➲ Control the flow of storm water across the site. ➲ Capture and treat dirty stormwater onsite prior to discharge. ➲ Allow for clean and dirty stormwater separation. ➲ Remain outside of the 30 m wetland buffer.	➲ Managed storm water flow. ➲ Uncontrolled release of dirty stormwater or effluent from onsite activities prevented. ➲ Wetland feature not impacted upon by mine activities.
Solid waste	➲ Waste reduction and recycling. ➲ Responsible disposal of waste material. ➲ Prevent littering and disposal of waste in unauthorised sites. ➲ Manage waste in accordance with the waste management hierarchy.	➲ Onsite waste segregation. ➲ Clean site with limited need for chemical pest control measures. ➲ Storage of waste in suitably designed facilities.

In addition, the following performance objectives apply to the proposed water uses:

- Reduce the amount of potable water used for mining activities;
- Maximise the reuse of water during mining activities;
- Ensure that no change to underground water quality occurs as a result of the water use; and
- Ensure that the taking of water has no impact on surrounding water users.

6.3 MEASURES TO ACHIEVE AND SUSTAIN PERFORMANCE OBJECTIVES

TABLE 6-2: SUMMARY OF MANAGEMENT MEASURES AND IMPLEMENTING PARTIES

ASPECT/ACTIVITY	IMPLEMENTATION AND MITIGATION MEASURE	PROJECT PHASE	RESPONSIBLE PERSONS
WASTE MANAGEMENT			
Separation	➲ To encourage the separation of waste at source into general/hazardous, recyclable and non-recyclable fractions of waste, easily distinguishable waste receptacles (skips, drums and bins) will be provided at designated positions within the mine administrative complex. ➲ Waste types will not be mixed, blended or otherwise treated unless it is to improve the potential for the waste to be re-used, recycled, recovered, treated or to reduce the risk associated with the management of the waste.	Operation / Closure	Mine Manager
Reuse	➲ Opportunities for the reuse of waste streams will be considered on an ongoing basis throughout the life of the operation. Specific waste streams for which reuse opportunities will be considered include the following: ➢ Clean building rubble, bricks and other construction materials; ➢ Wood pallets, wood poles and other clean wood products; ➢ Clean plastic and steel containers; ➢ Uncontaminated run-off water; and ➢ Grey water use from sewage package plants. ➢ Following segregation at source, the following waste streams will be temporarily stored and made available for recycling by approved contractors: ➢ Used oil, petrol and diesel; ➢ Paper; ➢ Scrap metal; ➢ Tins/cans; ➢ Glass;	Operation / Closure	Mine Manager Environmental Manager

	➢ Cardboard; ➢ Plastic bottles and plastic packaging; ➢ Printer and ink cartridges; ➢ Garden waste; and ➢ Plastic and steel containers.		
Storage	➲ A safety data sheet will be prepared for each waste stream classified as hazardous and the sheet will be displayed at the most appropriate location in closest proximity to the waste storage facility. ➲ At a frequency dependent on the waste type, drums/bins will be emptied into corresponding skips. Monthly inspections will be undertaken in each section of the mine to ensure that the separation of waste is taking place at source. ➲ Any container or storage facility holding hazardous waste will be labelled to reflect details of the contents and date of storage. ➲ Any hazardous waste which is stored in such a manner that it cannot be labelled will have a record reflecting the date and quantities of waste placed in the waste storage facility and the cumulative quantity of waste stored in the facility. ➲ Records of dates and quantities of all hazardous waste which is temporarily stored and periodically removed offsite will be maintained.	Operation / Closure	Mine Manager Environmental Manager
Treatment	➲ On-site treatment of waste will be limited to the following: ➢ Chemical and microbial treatment of hydrocarbon spills and leaks. ➢ Small scale sewage treatment plant.	Operation / Closure	Mine Manager Environmental Manager
Disposal	➲ No waste will be buried or burned on site. ➲ Waste material from drains and sumps in vehicle wash-bays and vehicle servicing areas will be removed on a regular basis. This material will be managed as hazardous waste.	Operation / Closure	Mine Manager
Transportation	➲ Waste management contractors appointed to remove waste from the site will collect the waste from each applicable storage area/waste receptacle at a time and frequency suitable for the relevant waste type.	Operation / Closure	Mine Manager Environmental Manager

	➲ Site personnel will inspect the waste transportation vehicle/s to ensure that the vehicle is suitable for the type of waste to be transported. ➲ Prior to leaving the site, site personnel will ensure that waste transporters with a hazardous waste consignment have provided a waste manifest document containing the following information: ➢ Name of transporter; ➢ Address and telephone number of transporter; and ➢ Declaration acknowledging receipt of the waste.		Administration Manager
Training	➲ Waste management training summarising the requirements for the management of non-mineral waste on the site will be included in the site induction training programme.	Operation / Closure	Mine Manager
Record-keeping	➲ The waste management records will be retained for a period of at least 5 years and will be available for review and inspection during audits or upon request by government departments. ➲ Waste management records will be maintained for all waste generated on the site. These records will reflect at least the following: ➢ The quantity of each waste generated; ➢ The quantities of each waste that has either been re-used, recycled, recovered, treated or disposed of; and ➢ Location and by whom each waste was re-used, recycled, recovered, treated or disposed of.	Operation / Closure	Mine Manager Environmental Manager
HAZARDOUS SUBSTANCES MANAGEMENT			
Risk	➲ A risk-based approach will be followed for the management of all hazardous substances. This approach will comprise of the following broad steps: ➢ Identify the hazardous substances on site; ➢ Assess the health and other hazards and risks which the hazardous substances present; ➢ Develop the control measures to reduce exposure; ➢ Monitoring and auditing to review effectiveness of controls; and ➢ Implement changes where necessary.	Operation / Closure	Chief Medical Officer Environmental Manager Safety Manager

Engineering controls	• Secondary containment e.g. drip trays appropriate to the hazardous substance will be provided for all hazardous materials containers, at connection points and at other possible overflow points.
	• For all above ground storage tanks:
	  ➢ The tanks will be fitted with gauges to measure the volume inside the tanks;
	  ➢ Dripless hose connections will be used for vehicle tanks and fixed connections will be used with storage tanks;
	  ➢ Automatic fill shutoff valves will be installed on storage tanks;
	  ➢ Secondary containment structures appropriate to the hazardous substance for which it is designed to safely hold. These structures will be capable of holding the larger of 110% of the largest tank volume or 25% of the combined tank volumes. The secondary containment design will not permit the mixing of incompatible substances;
	  ➢ Provision of overfill or over pressure vents to allow controlled release to a capture point;
	  ➢ Transfer or filling points will have impervious surfaces to prevent loss to the environment. These surfaces will be sloped to a containment structure for removal by an approved contractor; and
	  ➢ Oil water separators will be installed at all transfer or filling points and an approved contractor will be appointed to clean the separators at an appropriate frequency.
		Operation / Closure	Mine Manager
			Project Manager
			Safety Manager

Policies and procedures	• Written procedures will be compiled for the handling, transfer, storage and use of all hazardous substances. • Hazard warning signs will be clearly displayed at the entrance to all danger areas, magazines and other areas where hazardous substances are stored.	Operation / Closure	Mine Manager Safety Manager
Safety equipment	• Fire-fighting appliances and emergency equipment will be provided in such a manner that it is visible, accessible and available for use when required. • Appropriate PPE will be provided to all personnel required to handle hazardous substances on site.	Operation / Closure	Mine Manager
Training	• Hazardous substances training summarising the requirements for the use of hazardous substances on the site will be included in the site induction training programme.	Operation / Closure	Mine Manager Safety Manager

Record-keeping	➲ A hazardous substances register will be maintained on site with at least the following details: ➢ Product name; ➢ MSDS date; ➢ Classification in terms of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS); ➢ On-site use of the substance; ➢ Procedure to be followed in the case of an accident involving exposure to the substance or release to the environment; ➢ Supplier contact details; and ➢ Storage location.	Operation / Closure	Mine Manager Safety Manager
WATER MANAGEMENT			
Dewatering	➲ The volume and quality of groundwater that is currently abstracted from private boreholes within the delineated zone of influence must be established before mining commences. This is a critical step in understanding what impact mining will have on these boreholes and must be use as a basis for managing the loss of any groundwater to private users during mining. In order to achieve this, pumping tests should be completed on the identified boreholes to establish borehole yield. A groundwater sample must be taken from each borehole and submitted for chemical analysis according to the details provided in Table 6 of the specialist report; ➲ An attempt must be made to measure the flow of KR_Spring5 in order to establish baseline conditions. A sample must also be taken from the spring for chemical analysis. These tests must be completed prior to the commencement of mining and must be used as a basis for entering into negotiations with the owner regarding the potential loss of this spring during mining; ➲ Negotiations must be entered into with the owners of private boreholes that will be destroyed during opencast mining. These boreholes are listed in Table 19 of the specialist report; ➲ A dedicated groundwater monitoring programme must be implemented in all private boreholes within the delineated zone of influence. These boreholes are listed in Table 20 of the specialist report. This monitoring programme must include groundwater level and quality measurements. Should monitoring information indicate adverse impacts, Ilima must enter into	Operation	Mine Manager

	negotiations with the affected landowners to negotiate alternative water supply options of equivalent quantity and quality; ➲ Feedback must be provided to owners of boreholes within the affected zones regarding progress made with mining activities, rehabilitation and the outcome of monitoring programmes on a quarterly basis when groundwater monitoring will take place to ensure that they are informed of aspects of mining that may be of significance; ➲ The volume of water pumped from underground to surface during the operational phase must be recorded. This information must be used to update the impact assessment presented in this report, as necessary; ➲ If water-bearing structures are intersected during mining that contribute significant volumes of seepage to the pits and underground workings, they must be characterised and quantified. The risk and timing of decant must be re-assessed taking this information into consideration; ➲ If subsidence over underground workings is identified as a possibility, a geotechnical study must be completed to delineate areas of possible subsidence. This information must be used to re-asses the risk of decant and to quantify the associated impacts. Current simulations assumes that no subsidence will take place over the underground workings; ➲ Surface and underground rehabilitation measures must be designed to minimise the risk of decant. In order to do so, the adit must be sealed upon mine closure and concurrent rehabilitation of the opencast pits must be maintained throughout the life of mining; ➲ Groundwater levels must be monitored on a monthly basis in the dedicated monitoring boreholes. This information together with daily on-site rainfall measurements must be used to improve the understanding of the rate of recharge as well as of aquifer parameters like storage coefficients and specific yield; ➲ The numerical model used in this assessment should be updated, verified and re-calibrated on a regular basis as monitoring information becomes available; and ➲ The final model must be prepared at least five years prior to mine closure to ensure that predictions of long-term impacts are undertaken with the highest possible level of confidence.		
Underground and open cast mining	➲ Dedicated monitoring boreholes must be maintained in the two lineaments that transect the mining area. Boreholes 1-130, 1-130b, 5-110 and 5-110b are suitable for this and are situated down gradient of the plant area. Boreholes 6-220 and 6-220b are also situated on one of the lineaments. Based on the available information, it is anticipated that borehole KR11 is also	Operation	Mine Manager Environmental Manager

	situated on this fault and should therefore be included in the monitoring programme. If any of these boreholes are destroyed during mining, they must be replaced. ➲ Surface infrastructure, like the plant and the alternative discard stockpile option, must be positioned off the lineaments. Prior to the establishment of these areas, a geophysical survey must be completed to pin-point the faults. The positions of boreholes 1-130 and 5-110 can be used as a guideline in this regard. ➲ If the preferred discard disposal method is backfilling into mined out pits, only Pit 5 should be considered. It is preferable that discard is placed in the bottom of the northern most part of this pit to contain seepage and limit impacts. The boundary pillar between Pits 5 and 6 must be kept in place to avoid inter-pit flow of leachate associated with the discard. A groundwater monitoring borehole must be drilled down gradient of the area where discard is backfilled to the pit in order to monitoring the impact of this on groundwater quality. ➲ Prior to the implementation of either a surface discard stockpile of in-pit disposal of the discard, a geochemical study must be completed to evaluate the impact of placement of the discard material. In this study, it was assumed that leachate from the discard would deteriorate according to the description in Section 3 of this report. These assumptions must be confirmed and re-assessed once the results of the kinetic geochemical tests are available. In addition, it is recommended that geochemical modelling is undertaken to establish the potential quality of leachate if the discard is placed at the bottom of the pit and flooded to eliminate contact with oxygen. Conversely, the impact on leachate quality should be assessed if the discard is placed above the coal seam level and remains in contact with oxygen and water. In the latter instance, it is likely that the quality of leachate will deteriorate. Once the outcome of this study is available, the contaminant transport simulations presented in this report must be re-assessed. ➲ If the surface discard stockpile alternative is implemented, it is recommended that at least a compacted clay liner be considered in order to reduce long-term adverse impacts on groundwater and decant quality. This facility must be designed according to legal requirements. ➲ If the option to backfill discard to Pit 5 is implemented, it is important that measures are put in place to monitor and control in-pit water levels. The discard must be placed in the northern section of this pit, where the coal floor contours dip away from the nearby downstream pan and wetlands. The volume of discard that can be placed in this area must be assessed as part of the design phase for this option to determine whether or not it would be sufficient for the		

	life of the operations. Seepage that collects in the portion of Pit 5 that is used for discard disposal should be removed through a penstock or similar measures indicated by the professional engineer appointed to design the facility. A groundwater monitoring borehole should be drilled to the north of this area (between Pits 5 and 6) to monitor the impact of placing discard in this area. This borehole must be drilled prior to the commencement of this activity. The designs for the facility must furthermore take cognisance of the potential decant point that was identified in this area of Pit 5. Potential decant at this position post closure of the facility can be mitigated by creating a PCD or a return water dam in this area to contain seepage and potential decant. It is noted that the pit is not likely to decant if it is kept open for discard disposal during the operational phase of mining. The risk of decant in the long-term can be controlled with the penstock or similar water collection system identified during the design stage of the facility and/or contained in the proposed PCD. ➲ Once the kinetic geochemical test results are available, the impact assessment presented in this report should be updated and amended, as necessary. ➲ A monitoring programme must be implemented to establish underground water quality during the life of operations. This information must be used to update the long-term impact of mining on groundwater quality presented in this report. ➲ Updated contaminant transport simulations must be undertaken once this information is available in order to improve the confidence levels in long-term predictions. These simulations must be completed at least five years prior to mine closure to ensure that effective measures are developed to manage long-term impacts; ➲ If subsidence over underground workings is identified as a possibility, a geotechnical study must be completed to delineate areas of possible subsidence. This information must be used to re-asses the risk of decant and to quantify the associated impacts. Current simulations assume that no subsidence will take place; ➲ If water-bearing structures are intersected during mining that contribute significant volumes of seepage to the pits and underground workings, they must be characterised and quantified. The risk and timing of decant must be re-assessed taking this information into consideration; ➲ The quality of decant cannot be assessed without completing kinetic leach tests and geochemical modelling. It is however generally assumed that the quality of decant will be poor and should not be allowed to flow uncontrolled into the environment. Should this be allowed		

	to happen, the poor-quality water will have a negative impact on surface water, soil and wetlands; ➲ Surface and underground rehabilitation measures must be designed to minimise the risk of decant. Opencast mining areas and box cuts must be backfilled, shaped and made free draining to limit the rate of recharge of rainwater to the absolute minimum; and ➲ Measures must be taken during the operational phase of mining to contain all decant anticipated. The PCDs must be sized to take decant volumes into consideration and cut-off trenches and berms must be put in place to divert decant to the PCDs. The planning and possible re-sizing of PCDs must be completed prior to mine closure. ➲ Stormwater management must ensure erosion protection at the outfall points into the receiving environment; ➲ Any soil that is removed for trenching purposes must be stored in their respective layers and returned to the excavation in reverse order; ➲ The soils must be stored outside of the wetland and buffer zones in order not to smother established wetland vegetation. Adequate site reinstatement must be implemented in order to abate the formation of erosion through modification of the surface water hydrology; ➲ Silt traps and fencing should be used in areas of steeper topography (if applicable); ➲ The movement of heavy machinery within wetland zones should be limited to only single access roadways. Upon completion of the construction phase, this roadway should be ripped and/or disk ploughed to loosen the compacted soils and to allow for the establishment of vegetation within the affected areas, which should be a mixture of veld grasses typical of the surrounding area within similar habitat units; and ➲ Indiscriminate habitat destruction should be avoided and the construction footprint, including service and support areas should be kept to a minimum.		

6.4 OPTION ANALYSES AND MOTIVATION FOR PREFERRED OPTIONS

Various options for the development were considered as part of the S&EIR Process, including location, activity, and site layout alternatives. These are described in detail in Section 6 of the EIR.

In summary, the alternatives analysis concluded as follows:

- The location of the proposed surface and underground mining activities are fixed by the orebody and other mineral resources which are being targeted;
- The proposed mining method of conventional drill, blast and hauling to be used for the surface mining and the LHOS and Drift and Fill methods proposed for underground mining are the only methods deemed suitable for the safe and efficient extraction of the ore;
- The design of the mineral processing plant is similarly based on the demands of the export market;
- The broad placement of the surface infrastructure was informed by an environmental sensitivity plan which considered the location of all known sensitive physical, social and environmental features within the Mine Rights Application surface area. Buffer distances (minimum safe distances), determined primarily from legislation, including GN704 and the MHSA, were then applied.; and

Consideration was also given to alternative options for the water to be removed as part of the dewatering programme, including discharge, onsite reuse, and treatment for offsite reuse. These are described in Section 2.1.3 of the IWWMP. None of the options investigated were considered to be feasible.

6.5 IWWMP ACTION PLAN

The action plan proposed to meet the objectives of the IWWMP is provided in Table 6-3 below.

TABLE 6-3: ACTION PLAN

ASPECT	SUB-ASPECT	ACTIONS / CONTROLS	IMPLEMENTATION			COMPLIANCE MONITORING		
			IMPLEMENTATION TIMEFRAME	IMPLEMENTATION MONITORING METHOD	PERSONS RESPONSIBLE	COMPLIANCE MONITORING TIMEFRAME	COMPLIANCE MONITORING MECHANISM	PERSONS RESPONSIBLE
General	**Administrative Controls**	An appropriately qualified, trained and experienced ECO shall be designated to fulfil the compliance monitoring requirements in this IWWMP	Duration of Works	Self-check by Contractor and once-off inspection by Owner	ECO			
		THE FOLLOWING RECORDS SHALL BE MAINTAINED ON SITE:						
		EMPr; IWUL and IWWMP	Duration of Works	Self-check	ECO	Quarterly	Internal audit	SHE Representative
		Compliance monitoring and auditing data/reports and results of inspections conducted	Duration of Works	Self-check	ECO	Weekly	Inspection	SHE Representative
		Approved SHE method statements	Duration of Works	Self-check	ECO	Weekly	Inspection	SHE Representative
		Waste management records	Duration of Works	Self-check	ECO	Quarterly	Internal audit	SHE Representative

		Equipment maintenance records	Duration of Works	Self-check	ECO	Quarterly	Internal audit	SHE Representative
		Maintenance and inspection of all safety equipment e.g. fire extinguishers	Duration of Works	Self-check by Contractor and once-off inspection by Owner	ECO	Weekly	Inspection	SHE Representative
		A completed and signed environmental incident/non-conformance report in respect of each reported environmental incident or nonconformity	Within 24 hours of an incident or as otherwise required by the EA	Self-check	ECO	Weekly	Inspection	SHE Representative
		A completed and signed environmental incident/non-conformance register	Duration of Works	Self-check	ECO	Quarterly	Internal audit	SHE Representative
		Emergency contact register	Duration of Works	Self-check by Contractor and once-off inspection by Owner	ECO	Quarterly	Internal audit	SHE Representative
		A hazardous substances register	Duration of Works	Self-check by Contractor and once-off inspection by Owner	ECO	Quarterly	Internal audit	SHE Representative
Soil and Groundwater Resources	**Hazardous Substances**	All construction vehicles, equipment and machinery shall be equipped with drip trays and spill response kits	Duration of Works	Self-check	ECO	Weekly	Inspection	SHE Representative

		Hydrocarbon spillages shall be cleaned as soon as possible and no longer than one day after the spillage event	Duration of Works	Self-check	ECO	Daily	Inspection	SHE Represent ative
		Polluted soils are to be treated with appropriate absorbents or be removed from areas where incidents have occurred. This soil shall be properly contained before being disposed of at appropriately licensed waste management facilities	Duration of Works	Self-check	ECO	Daily	Inspection	SHE Represent ative
		Secondary containment e.g. drip trays appropriate to the hazardous substance shall be provided for all hazardous materials containers, at connection points and at other possible overflow points	Duration of Works	Self-check	ECO	Weekly	Inspection	SHE Represent ative
		Petrochemicals, oils, solvents, paints and other identified hazardous substances shall only be stored under controlled conditions. All hazardous materials will be stored in a secured, appointed area that is fenced and has restricted entry	Duration of Works	Self-check	ECO	Quarterly	Internal audit	SHE Represent ative
		Hazard warning signs shall be clearly displayed at the entrance to all areas where	Duration of Works	Self-check	ECO	Weekly	Inspection	SHE Represent ative

		hazardous substances are handled and stored						
		No vehicles or machines shall be washed or serviced outside of the wash-bay / maintenance area. No oil or lubricant changes shall be made except in case of breakdown or emergency repair	Duration of Works	Self-check	ECO	Weekly	Inspection	SHE Representative
Water Management	**Water Balance**	The water balance must be updated annually as per the IWUL requirements.	Duration of Works	Self-check	ECO	Annually	Internal audit	ECO
	Groundwater	Implement groundwater monitoring as per the specialist recommendations and IWUL requirements	Duration of Works	Self-check	ECO	Annually	Internal audit	ECO
Health and Safety	**Emergency Contact Details**	All applicable emergency contact details shall be confirmed and displayed at various locations across the Site. The emergency contact details of the following are to be provided as a minimum: ➲ Site Supervisor ➲ Project Manager ➲ Nearest municipal fire station Nearest clinic and hospital ➲ Nearest police station ➲ Appointed sub-contractor to handle	Prior to construction activities commencing	Self-check by Contractor and once-off inspection by Owner	Contractor / Owner	Quarterly	Internal audit	SHE Representative

		incidents related to hazardous substances						
	Hazardous Substances	An onsite hazardous substances register shall be maintained. The register shall contain at least the following details: ➲ Product name ➲ MSDS date ➲ Classification in terms of the Globally Harmonised System ➲ Onsite use of the substance ➲ Procedure to be followed in the case of an accident involving exposure to the substance or release to the environment ➲ Supplier contact details and storage location	Duration of Works	Self-check	Contractor	Weekly	Inspection	SHE Representative
	Training and Awareness	The environmental awareness plan in the EMPr shall be implemented	Duration of Works	Self-check	Contractor	Weekly	Inspection	SHE Representative
Solid waste	**Operational Controls**	No waste shall be buried or burned on site	Duration of Works	Self-check	Contractor	Daily	Inspection	SHE Representative

		Records of dates and quantities of all hazardous waste which is temporarily stored and periodically removed offsite shall be maintained	Duration of Works	Self-check	Contractor	Quarterly	Internal audit	SHE Represent ative
		Waste shall only be removed from Site by appropriately registered waste transporters	Duration of Works	Self-check	Contractor	Weekly	Inspection	SHE Represent ative
		To encourage the separation of waste at source into general/hazardous and recyclable and non-recyclable fractions of waste, easily distinguishable waste receptacles (skips, drums and bins) shall be provided at designated positions within the Site	Duration of Works	Self-check	Contractor	Weekly	Inspection	SHE Represent ative

7 CONTROL AND MONITORING

7.1 SURFACE WATER MONITORING

During storm events there is the potential for the storm water run-off to collect sediment as it flows across the mine area. This leads to the potential from the release of sediment-rich storm water into the waterways and out into the receiving environment. However, the Storm Water Management Plan has been designed to retain storm waters for a period of 24 hours. During this time, the sediment will be able to settle out of suspension. Therefore, there is no need to monitor the level of sediments in the storm water every time water collects in the ponds.

The mine will monitor the quality of the water in the PCDs as part of the routine monitoring schedule

In addition, a sample of any surface water that flows into the area will be assessed in terms of the incoming or upstream water quality, with a sample of any water that might originate on the neighbours property (Upslope areas), and a second sample being taken from the non-perennial stream (when flowing – wet) and a sample on the downstream or outgoing water point before it enters the receiving environment.

The monitoring parameters to be assessed should include the following:

Monitoring frequency:

- Every month

TABLE 7-1: SURFACE WATER MONITORING PARAMETERS:

Aluminium	Ammonia	Chloride	Conductivity
Dissolved Oxygen	Fluoride	Iron	Magnesium
Nitrate	pH	Phosphate	Sodium
Sulphate	EC	TDS	

7.1.1 PERFORMANCE INDICATORS AND EVALUATION OF MONITORING RESULTS

In order for monitoring data to be useful, the results must be evaluated as they are received. It is advisable to store all results in a spreadsheet and project the results graphically to determine exceedance of the Resource Quality Objectives (RQO) DWAF standards which must be presented in the graph, as well as previously monitored results.

If exceedance of the standards or the previous monitored results are recorded, the following steps must be taken and documented:

- Determine the source of the pollution and if it is as a result of mining related activities.
- If so, determine if this is as a result of a once off incident or a routine event.
- Determine how the incident can be prevented, or if this is not possible, managed in future.
- Appropriate mitigation measures must be implemented (the implementation of appropriate measures will be dependent on the practicality and cost of the proposed measures).
- The success of mitigation measures must be confirmed through the follow-up monitoring after the next storm event.
- If it is observed that pollution continues after two subsequent samples have been analysed (after two storm events) alternative preventative/mitigation measures must be implemented. The success of these new measures must once again be confirmed through the sampling.

7.2 GROUNDWATER MONITORING

7.2.1 Groundwater Monitoring

Groundwater monitoring for the project should be undertaken to meet the following objectives:

- To measure the impacts of mining on groundwater levels and quality.
- To detect short- and long-term water level and quality trends.
- To calculate aquifer parameters, like the rate of recharge and storage coefficients.
- To recognise changes in groundwater characteristics, to enable analysis of their causes and to trigger the appropriate groundwater management response.
- To check the accuracy of predicted impacts.
- To use the information gathered for model calibration and/or verification.
- To develop improved practices and procedures for groundwater protection.

7.2.2 Monitoring locations

A groundwater monitoring programme must be implemented in all of the dedicated monitoring boreholes drilled as part of this assessment. These boreholes are listed in Tables 2 and 3 of the specialist report (Appendix 3, Geohydrological Report).

All private boreholes that fall within the affected zones of influence must be included in the routine mine monitoring programme. These boreholes are listed in Tables 20 and 21 of the specialist report (Appendix 3, Geohydrological Report).

The following additional monitoring boreholes are recommended:

- A shallow and deep monitoring borehole set down gradient of the northern section of Pit 5, should the option of backfilling discard to this pit be opted for. The deep borehole must be sited using geophysical methods and must be drilled to the depth of mining in this part of the pit. The borehole must be screened from top to bottom. The shallow borehole must be drilled to the depth of weathering.
- A dedicated shallow and deep monitoring borehole set must be drilled on the northern most lineament near the position of the private borehole KR11. The construction of these boreholes must adhere to that presented in Tables 2 and 3 of the specialist report Appendix 3, Geohydrological Report. The objective of this borehole is to monitor preferential flow of contamination from the mining areas towards the largest pan.

7.2.3 Monitoring Requirements

The parameters to be included during monitoring as well as the proposed frequency of monitoring is presented in Table 7-2.

TABLE 7-2: GROUNDWATER MONITORING REQUIREMENTS IN PRIVATE AND MINE MONITORING BOREHOLES

Monitoring parameter	Element for analysis	Monitoring frequency
Depth to groundwater level	Groundwater level	Quarterly
Surface and Groundwater quality	All elements included in Table 7	Monthly
Spring flow	Actual spring flow rates, where possible. If not, record the visual condition of all springs listed above	Quarterly
Spring water quality	All elements included in Table 7	Quarterly
Rainfall	Rain depth (mm)	Daily on site

All monitoring information must be entered into a spreadsheet for record keeping and analysis. Copies of the certificates of analyses must be kept on file for inspection.

If a significant exceedance is recorded during the monitoring programme, the following actions should be taken:

- Log the exceedances in the incident reporting system within 24-hours of it occurring.
- Report the exceedances to the Environmental and General Managers as well as to the regulatory authority.
- Undertake an investigation to identify causes of the exceedances.
- Consult with any landowner or affected party that may be impacted by the exceedances to determine their concerns and to negotiate remedial actions.
- Implement the necessary remedial actions according to the outcome of the investigation and consultation with the affected parties.
- Track the incident until completion.

Regular monitoring reports must be prepared for internal use as well as for submission to the authorities, as required by the operations' water use licenses.

7.3 BIO MONITORING

The monitoring of ongoing wetland ecological function and overall health and integrity is aimed at monitoring the same points that are utilised in assessing overall wetland health initially, viz vegetation status, hydrology and geomorphology. Water quality should also be monitored for at least every six months during normal operations, but will increase in response to accidental spillages or other incidences that warrant more frequent monitoring.

Site photographs from set points at all of the monitoring stations should be taken for all monitoring periods for reference and comparative purposes. These will be useful when undertaking trend analyses of the various monitoring aspects.

The following points should be included in the monitoring:

7.3.1 VEGETATION FEATURES

- Extent of vegetation cover and the trend of increasing or decreasing extent of cover should be monitored for;
- Species composition and analysis of indigenous versus exotic species communities. Grass species composition should be analysed in terms of status (pioneering, decreaser of increaser species) as an indication of succession;
- Exotic vegetation must be monitored for to enable early detection of exotic invasive species so that this can be timeously managed;
- A change in floral species communities will also indicate the extent of the wetland functioning areas. A decrease or increase in facultative of obligatory wetland species over time will alert to this change.

7.3.2 HYDROLOGICAL FEATURES

- The changes in baseflows will be most noticeable if the water levels within the instream impoundments are monitored. Cumulative data will indicate trending data over time and allow for the trends pertaining to seasonal variation to be accounted for during data interpretation;
- Increases of flow volumes emanating from the stormwater/clean water runoff from the site should be monitored to determine if the increase capacity is creating scouring impacts within the receiving environment;
- Decreases in water volume should also be monitored and areas of wetland desiccation should be flagged for increased monitoring frequency. This is due to the impact that desiccation has on hydromorphic soil structures, which exposes them to structural failure and subsequent erodibility.

7.3.3 GEOMORPHOLOGICAL FEATURES

- Geomorphological features pertain to the sediment load and the sediment transport capacity of the wetland feature. Soil erosion within the wetland unit falls within this category and is perhaps the primary and most pertinent monitoring aspect that warrants active and ongoing management;
- Lowered vegetation cover, increased exotic vegetation invasion, increased water volumes and velocity within a channel and modification of soil features are all interplaying aspects that manifest in modification of geomorphological features of a wetland unit;
- Emerging erosion, in all forms, must be routinely monitored for throughout all areas of the wetland units and management intervention must be undertaken immediately once a problem area has been identified. Erosion is relatively simple to rectify if caught early but increases in scale and complexity with time. Early intervention also allows for the use of natural features (natural vegetation to stabilise soils, etc), whereas a perpetuating erosion impact will eventually require costly civil structure intervention;

7.3.4 WATER QUALITY MONITORING

- A functioning wetland unit provides a water quality remediation process and therefore adds a protection factor to perhaps more sensitive aquatic habitat located downstream within the system. The capacity for water purification has an obvious limit and is different from one wetland unit to the next. Preserving the overall ecological integrity and functionality of a wetland unit will enhance its capacity for water purification;
- The quality of the water that is being discharged into the wetland units (be it clean stormwater runoff, dirty process water or just the water the flows within the wetland zones) needs to be monitored and the results compared to target water quality guideline values. General water quality parameters, elemental scans and bacteriological counts should be part of routine analysis, undertaken at least every six months;
- If an incident occurs on site, such as an accidental spill, chemical leaks, sewerage contamination and the like, then a water quality monitoring schedule, targeting specifically the offensive pollutant, must be implemented at a frequency recommended by the ECO designated to the site;
- If poor or deteriorating water quality trends are observed, then the source of the pollutants must be identified and remedied appropriately, according to the type of pollution impacts identified;
- Water quality monitoring should be undertaken at the same site each time and the sampled analysed at an accredited laboratory;
- Water samples were taken during the baseline survey and these same sampling points should be considered for the routine monitoring. This can be modified at the discretion of the plant management if necessary;
- Monitoring should be undertaken within watercourses prior to the impact zones as well as within the same watercourses as they leave the impact zones;
- Monitoring points must also include as many of the local catchments within the site as possible to gain an overall understanding of the impacts to water quality, how those contaminants are being transported and to where they are being transported to. Managing a local catchment that has a single draining watercourse is then easier to manage, should the need arise.

7.4 WASTE MONITORING

This IWWMP will link to the Water Management section on various items such as contamination prevention and management, maintenance of pollution control/containment facilities, correct storage and disposal of all waste streams (liquid, general domestic, industrial and hazardous) and good housekeeping practices. Monitoring practices will ensure:

Monitoring practices will ensure:

- The classification of all waste streams;

- Monitoring of the storage, handling and disposal of all wastes - from receipt of products through to final disposal destination - commencing with the verification of the effectiveness of engineering designs in handling waste;
- Recording, analysis and reporting of all waste amounts, including validation of models and predictions, and verification of all legal compliance levels;
- Maintaining MSDSs;
- Monitoring the training, PPE and other requirements of all employees exposed to waste and;
- Checking the effectiveness of any waste transportation, management or storage infrastructure/facilities for leaks, spills, unauthorised releases or any other issues.

7.5 MONITORING OF CHANGE IN BASELINE (ENVIRONMENT) INFORMATION (SURFACE WATER, GROUNDWATER AND BIO-MONITORING

Ongoing monitoring will be undertaken as per the IWUL requirements and reports will be submitted to DWS within the required timeframes.

7.6 AUDIT AND REPORT ON PERFORMANCE MEASURES

The following compliance monitoring and reporting actions shall be undertaken:

7.6.1 INSPECTION

SHE inspections of the Works shall be conducted daily on an *ad hoc* basis and formally at least once a week.

7.6.2 INTERNAL AUDITING

Internal SHE compliance audits shall be conducted on a quarterly (every 3 months) basis. The purpose of the internal compliance audits shall be to confirm that all management actions outlined in the IWWMP have been implemented. The Contractor / Owner will be responsible for the implementation of corrective measures that may result from the findings of such audits, which will investigate at least the following:

- Completeness of SHE documentation, including planning documents and inspection records;
- Compliance with monitoring requirements;
- Suitability of IWWMP in addressing general environmental performance at the Site;
- Efficacy of management controls to address any non-compliance with monitoring requirements; and
- Training activities and record keeping.

7.6.3 EXTERNAL AUDITING

External audits shall be completed in the manner and frequency determined in the conditions of the WUL.

7.6.4 ENVIRONMENTAL INCIDENTS AND NON-COMPLIANCES

The reporting of an environmental incident and or non-compliance shall be as follows:

- Site personnel shall, as soon as possible, inform the Contractor or Operator (as relevant) of the incident and/or non-compliance, the severity thereof and the corrective actions taken;
- The incident and/or non-compliance details shall be recorded on a register maintained on site;
- Depending on the level of the incident, the Contractor / Operator shall inform the Owner and the relevant authorities of the incident / non-compliance; and
- Any corrective actions required following the incident and / or non-compliance, including any rehabilitation requirements, shall be implemented by the Contractor / Operator.

7.7 AUDIT AND REPORT ON RELEVANCE OF IWWMP ACTION PLAN

Annual reviews and audits must be implemented to identify gaps or shortcomings in the action plan. The gaps should be addressed, and the action plan and objectives must be updated to ensure the site requirements and management stay relevant.

8 CONCLUSION

8.1 REGULATORY STATUS OF ACTIVITY

The mine and associated activities are regulated in terms of the Minerals and Petroleum Resources Development Act 28 of 2002.

8.2 STATEMENT OF WATER USES REQUIRING AUTHORISATION, DISPENSING WITH LICENCING REQUIREMENT AND POSSIBLE EXEMPTION FROM REGULATION

The proposed water use falls within the ambit of the following:

- Section 21 a (taking of water from a water resource);
- Section 21 c&i (impeding or diverting the flow and altering the bed, banks or course of a watercourses);
- Section 21 g (disposing of wastein a manner which may detrimentally impact on a water resource); and
- Section 21 j (Removing, discharging or disposing of water found underground if it is necessary of the efficient continuation of an activity or for the safety of the people).

8.3 MOTIVATION IN TERMS OF SECTION 27(1) OF THE NWA

Please refer to Table 8-1 below.

TABLE 8-1: SECTION 27 MOTIVATION

Aspect	Motivation
a. Existing lawful water uses:	There are no existing lawful uses applicable to the activities or the properties described in this IWWMP.
b. the need to redress the result of the past racial and gender discrimination:	The ownership structure of Ilima Coal Company (Pty) Ltd includes a 50.25% Black Economic Empowerment shareholding. The Applicant has compiled a Social and Labour Plan (SLP) in consultation with the Chief Albert Luthuli Local Municipality (CALLM) in the Gert Sibande District Municipality and the DMR. The SLP addresses the Applicant's plans for ensuring that it achieves commercial success whilst also developing its employees and community for the better and in compliance with transformation targets as stipulated in the Mining Charter III. This is the third SLP of the company, the second one has expired at the end of December 2017. The company successfully implemented almost all the programmes and projects committed in the second SLP. The latest SLP indicates that Ilima will employ an integrated Human Resource Development Programme that seeks to maximize the productive potential of people involved with the mine to equip them with accredited and transferable skills to be able to seek alternative employment at the end of the LOM. The following plans will be implemented to achieve this objective:

	- A skill development Plan that focuses on equipping employees with skills to promote their progression in the mining industry and their development into other sectors according to their aspirations. - A Mentorship Plan, Internship and Bursary Plans that are used as career development tools. These would endeavor to enable the individuals to assume high levels of responsibility within the workplace. - A Career Progression Plan involve the communications at the mine of all future forum meetings to ensure that all the employees are aware of and understand the generic career paths within their operation and opportunities available at the mine. - An employment Equity Plan is committed to the principle of employment development and advancement of the HDSAs and WIM and aim to achieve equitable representation of designated groups in the workplace. In addition to the employment equity targets of 40% HDSAs in Management and 10% WIM at the mine, the following goals are ascribed to in pursuit of transformation in the mining sector: - Ensure that an Environment is created and maintained in which employees are empowered to realize their full potential and are advanced and rewarded on merit. - Ensure that a culture is developed and maintained where diverse groups can work together in harmony - Support will be provided to employees recruited into and placed on accelerated training programmes (talent pool identification and fast tracking) with coaching, mentorship, time, advice and guidance. - Promotions and other employment opportunities will be dependent on an applicant being suitably qualified to satisfy the inherent requirements of the job. - ICC and its contractors will comply with the provisions of Employment Equity Act (Act No.55 of 1998) and will submit a report to the Director General as required by section 21 of the act. ICC is currently implementing an integrated and sustainable LED strategy in the area that was developed in the previous SLPs. The approach to LED projects is a “Bottom-up” one, whereby projects are envisaged, initiated, and sustained by local community members. In this way, the community will build its own skills base and have ownership of projects from the onset. The community therefore will not be reliant on the mine for future income opportunities and ICC serves only to capacitate the community to achieve and continue their own development

	goals. Based on extensive research in the local Carolina community, it was decided that the most effective means by which to promote socio-economic development within the community would be to form a Community Development Trust. This trust has formed Ilima Development Agency (IDA), which is the central pivot mechanism around which all LED projects are initiated. Proposed LED and Infrastructure projects to be implemented from 2018 until 2022 financial years: • Cattle Farming Project • Purchase of farming land • Entrepreneurial Development Programme • Violet Jiyane School six (6) additional classrooms • Fencing for Carolina Cemetery.
c. Efficient and beneficial use of water in the public interest	➲ The use of water as applied for and described in this IWWMP for the purpose of coal mining and processing is considered to be in the public interest for the following reasons: ➢ The Applicant, through the IWWMP, is committed to using water responsibly throughout the LOM and has specifically agreed to the implementation of water and waste management controls which include: ➢ Zero offsite discharge of effluent; ➢ Water conservation and demand management; ➢ Prevention of pollution to land, surface and groundwater resources through the implementation of the mitigation hierarchy; and ➢ Implementation of a comprehensive groundwater monitoring programme. ➲ Without the water uses, the proposed mining operation will not be implemented, and this will have the following effect: ➢ The royalties and tax revenue from mining will not accrue to the South African Government; ➢ The local economic development opportunities associated with the procurement of local goods and services to support the mine activities will not be realised; ➢ Projected employment opportunities during the construction and operational phases will not be fulfilled; and ➢ The various local economic development projects agreed in principle with the CALLM as

	part of the applicant's social and labour plan commitments, will not be implemented. ➢ Pollution and degradation of the water resources are minimised, and that water will be reused and recycled where possible.
d. The socio-economic impact; i, of the water use or uses if authorised; ii, of the failure to authorise the water use or uses.	The development will create direct employment opportunities in the construction and operational phase respectively. Many more indirect employment opportunities will also be created. Implementation of the commitment to maximise local employment wherever practicable will increase the significance of this positive impact. Procurement of local goods and services by the mine, employees and contractors will stimulate local business and create opportunities for entrepreneurship. In addition, implementation of the seven agreed LED projects committed to in the SLP will have a significant positive impact for the broader community. Implementation of the HRD programme, as described in the SLP is expected to result in skills transfer, career progression, re-skilling and improved levels of literacy in the community as a whole. The mining will generate royalties in accordance with the MPRDA, payable to the national government. Furthermore, the development of the site and connection to municipal services will result in the payment of rates and taxes to the CALLM. If the IWUL was not granted, mining could not proceed, and the socio-economic benefits associated with the mine would not be realised.
e. any catchment management strategy applicable to the relevant water resource	The catchment is managed by the Inkomati-Usuthu Catchment Management Agency. The resources quality objectives are discussed in more detail in Section 4.2.10
f. The likely effect of the water use to be authorised on the water resource and on other water uses	**Dewatering** The extent of the cones of depression around the opencast pits are less pronounced due to their comparatively short lives and the effect of concurrent rehabilitation. The cones of depression are steep around the mining areas and do not extend significantly beyond 200m from the mining areas. This is due to the low average permeability of the matrix of the fractured rock aquifer. The preferential drawdown is expected along the northern most lineament, which may result in a connection between the mining areas and the largest of the pans. Simulations suggest that a

	drawdown of up to 2m may occur along the lineament in the vicinity of the pan. The most significant impact on private boreholes are expected for boreholes KR7 and KR8 on portion 3. Mining is expected to lower groundwater levels by up to 25m in these boreholes and the impact will most probably prevail over the life of the operations due to the proximity of the underground workings. Groundwater from borehole KR7 is used to supply the farm house and animals. There is a high risk that this borehole will dry up and will no longer be available for use. As such, this impact is considered significant and should be managed with care, as detailed later in the report. Borehole KR8 is not in use. Boreholes KR5 and 6 may experience a drawdown of 10m during Years 6 – 11 of mining. These two boreholes are not currently in use. Lesser impacts are anticipated in boreholes KR3, KR4, KR10, KR11 and KR 12 and groundwater levels may be lowered by between 2 and 5m during mining. It is likely that this will not have a significant negative impact on the use of these boreholes. It is however prudent that the boreholes are effectively monitored to identify significant negative impacts timeously and to implement responsible groundwater management plans. **Impact on Groundwater Quality** The impact of mining on groundwater quality during the operational phase was assessed at the hand of sulphate concentrations, based on the results of leach tests, as presented in section 4.3.3. In order to do so, the maximum sulphate concentrations obtained from the leach tests were assigned to the mining areas and waste rock dumps. Based on the available information, sulphate concentrations of up to 250 mg/l is expected in the mining areas. This is equivalent to the SANS241:2015 drinking water standard for sulphate based on aesthetic considerations. Under the prevailing conditions, sulphate concentrations are expected to increase to above 150 mg/l in all the mining areas, as shown. The extent of the zone of impact on groundwater quality is delineated in the two figures presented. Ambient sulphate concentrations are variable, but on average below 50 mg/l. An increase above 50 mg/l is therefore considered as the result of impact of mining. Sulphate concentrations at the end of the operational phase in groundwater in the private boreholes within the delineated zone of influence. The most significant impact at the end of life of mine is expected to occur in the vicinity of boreholes KR7 and 8, where sulphate concentrations may increase to above 100 mg/l. It is however noted that at these concentrations, the groundwater will still be usable and should not pose any health or aesthetic risks from a sulphate concentration perspective. Sulphate concentrations in the other boreholes in the zone of influence are not expected to exceed 100 mg/l.

	Risk of Decant The risk of decant depends on several factors, which are discussed in more detail in the specialist report. The main factor that controls the risk of decant is the rate of recharge of rainwater to the disturbed areas. It is unlikely that the opencast mining areas could be rehabilitated to natural recharge conditions and for this reason, decant is likely from all the pits. The most likely decant point at each pit is associated with the lowest topographical elevation and a total of 20 possible decant locations are listed below for the thirteen planned pits.
g. The class and resource quality objectives of the water resource	Class and resource quality objectives for X11B are determined by the DWS and has been discussed in detail in Section 4.2 of this report.
H. Investment already made and to be made by the water user in respect of the water use in question	The applicant has already invested hundreds of millions of Rands into the development of the mineral resource, with a view to commencing with construction in 2019. The intended mining activities will create employment and stimulate local economic development activities in an area which is keenly seeking investment of this nature to assist with the high levels of unemployment.
I. The strategic importance of the water use to be authorised	The positive attributes of the proposed operations include economic growth, employment and income generation in the area as well as the development of BEE opportunities.
J. The quality of the water in the water resource which may be required for the reserve and for meeting international obligations	The Incomati is an international river basin shared between the Republic of Mozambique, the Kingdom of Swaziland and the Republic of South Africa. The most recent agreement on water sharing is the Interim IncoMaputo Agreement for Co-operation on the Protection and Sustainable Utilisation of the Incomati and Maputo Watercourses. Water Quality in the Inkomati Water Management Area as a whole can be said to be generally good. However, there have been trends identified that are worrisome. Specific areas in the Elands, Kaap and the Crocodile (downstream) are highlighted as worrying spots. Electrical Conductivity (EC) is rising steadily in all the catchments, which is due to the increasing concentration of various dissolved substances. Faecal coliform pollution in the IWMA is a common feature and it is affecting the use of the water resource. Pollution of the rivers by untreated or semi-treated sewage has raised alarm in the IWMA. Water quality degradation will displace dependent biodiversity and will have an impact that will perpetuate throughout the system for a long way downstream as well. Possible sources of contamination include hydrocarbons (from poorly-designed and managed fuelling stations and/or workshop and maintenance areas), and runoff water from processing areas that should be kept separate from clean water runoff with a suitable stormwater management system, and general surface water runoff that should be processed prior to release into the environment. Erosion management also plays an important role in preventing water quality degradation

K. The probable duration of any undertaking for which a water use is to be authorised	In terms of the MPRDA, the maximum period a mining right may be issued for is 30 years, with the option to renew for another 30 years. The application is therefore for a period of 30 years.

DISCLAIMER

Advisory on Business and Sustainability Africa (Pty) Ltd. (ABS Africa) has prepared this report specifically for Ilima Coal Company (Pty) Ltd.

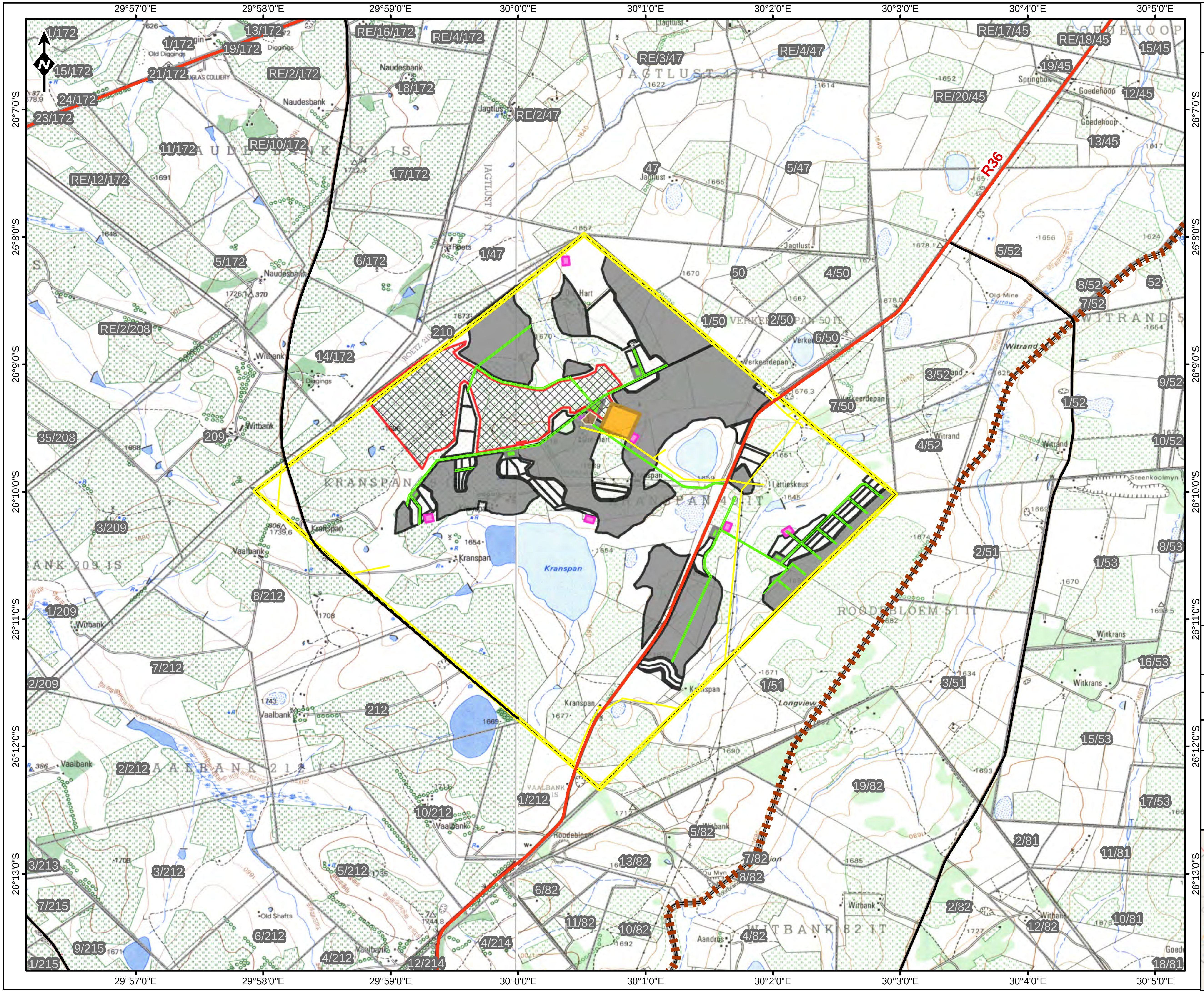
The contents of this report:

- Are based on the relevant procedural requirements, as defined in applicable legislation, and the scope of services as defined within the contractual undertakings between Ilima and ABS Africa.
- Are specific to the intended development at the proposed site. The report shall not be used nor relied upon neither by any other party nor for any other purpose without the written consent of ABS Africa. ABS Africa accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.
- Reflect the best judgement of ABS Africa in light of the information available at the time of preparation.

  The analyses contained in this report has been developed from information provided by Ilima and other parties. This information is not within the control of ABS Africa and ABS Africa has not audited such information and makes no representations as to the validity or accuracy thereof

APPENDIX 1: MAPS

MAP 1: REGIONAL MAP



Kranspan MRA Project

Legend

Road Network

- Main Road
- Secondary Road
- Railway Line
- Haul Road
- Powerlines

Mine Infrastructure

- Adit
- Alternative Surface Discard Disposal Site
- Mine Offices and Workshop
- Opencast
- PCD
- Plant
- Product Stockpile
- ROM
- Topsoil & Overburden Facilities
- Underground Mining Area
- Weighbridge / Security
- Farm Portions
- Proposed Kranspan MRA

LOCALITY

0 0.5 1 2 Kilometers

Reviewed:	Drawn by:
P. Furniss Environmental Scientist	NH Cele GIS Specialist

Coordinate System: GCS WGS 1984
Datum: WGS 1984

ABS Africa
Sustainability Advisors

Scale: 1:50 000

Version: Final

Date: 2019/05/21

Hendrina
Carolina

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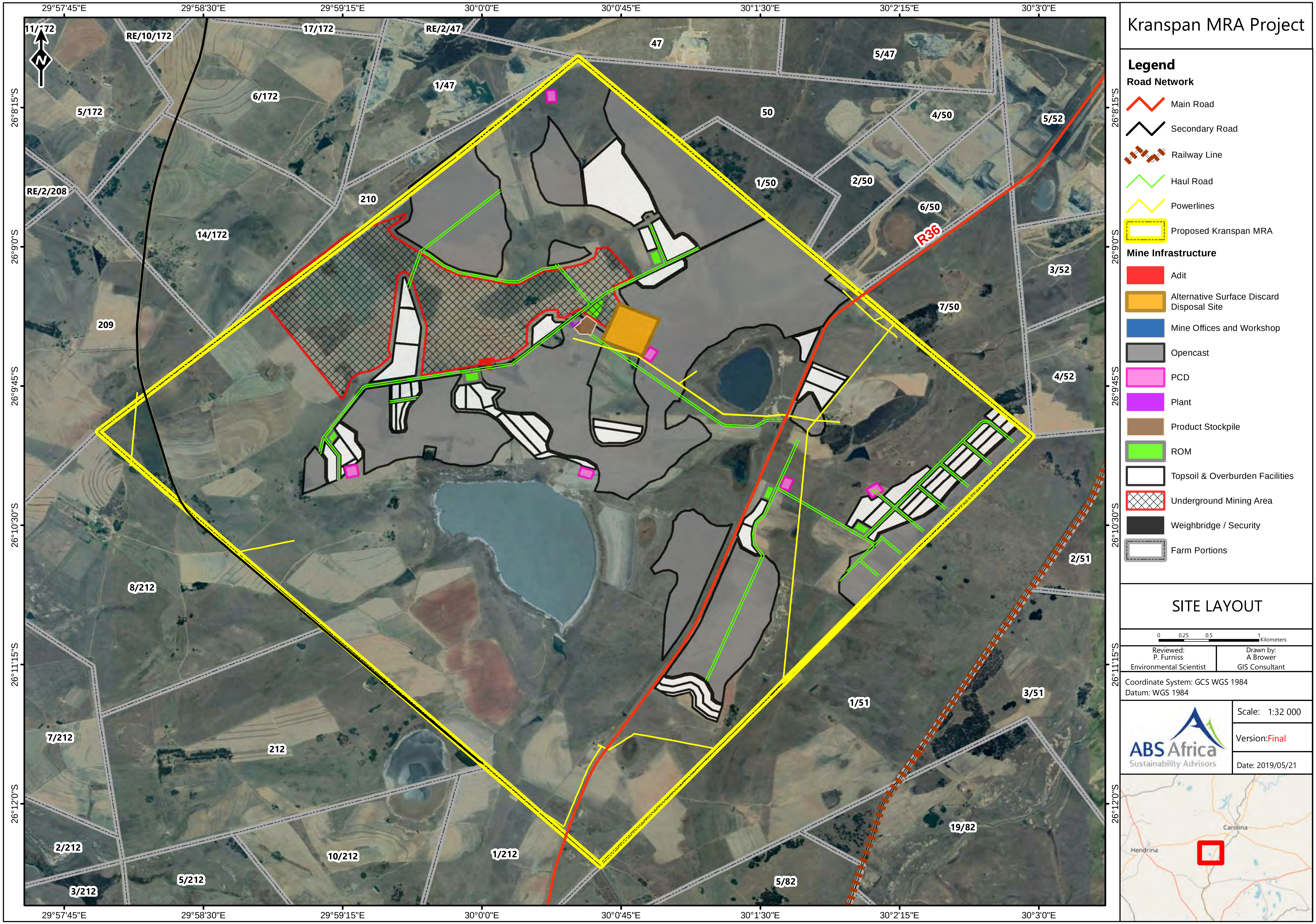
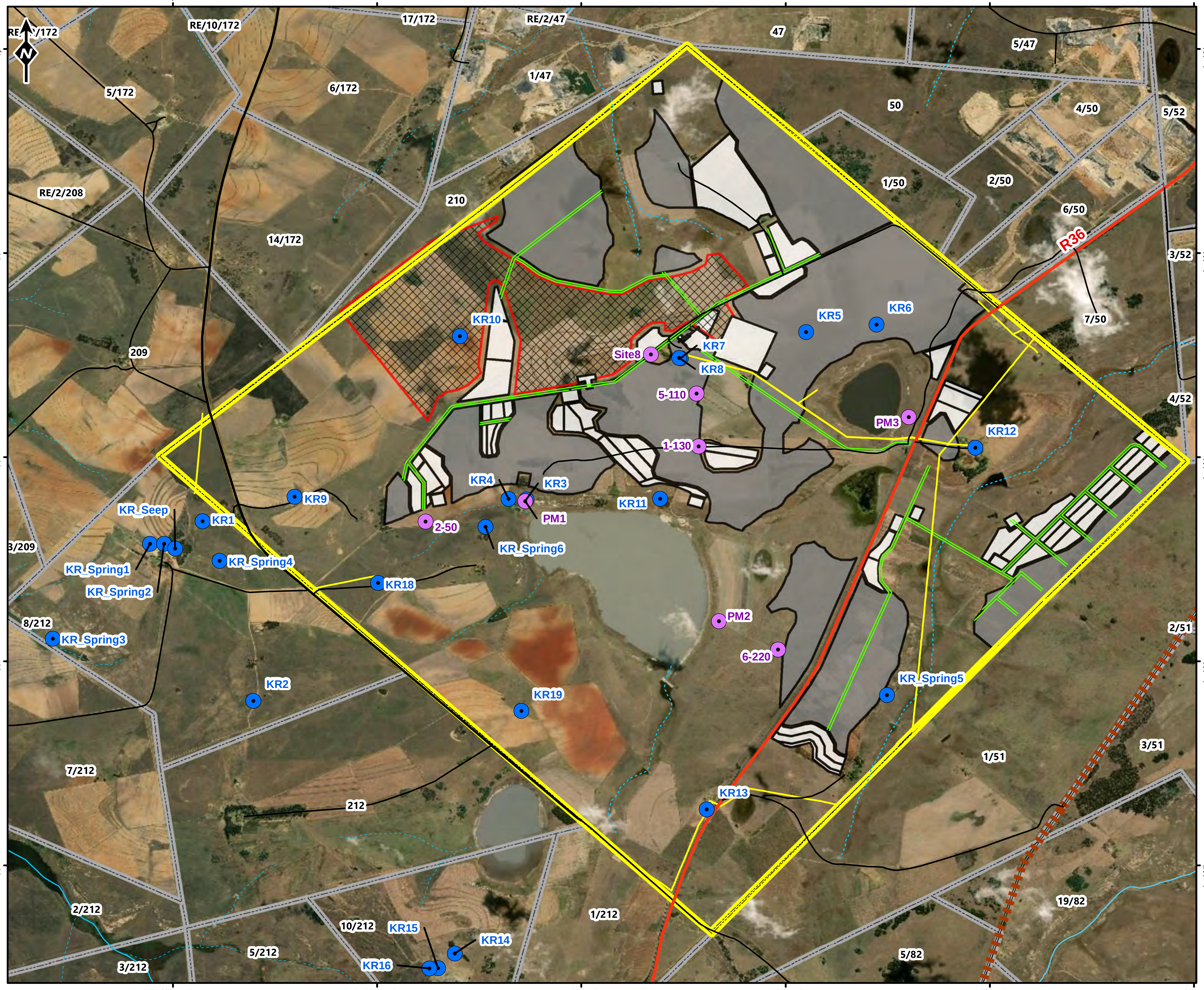
MAP 2: FINAL SITE LAYOUT MAP


Kranspan MRA Project
Legend
Road Network
Main Road
Secondary Road
Railway Line
Haul Road
Powerlines
Proposed Kranspan MRA
Mine Infrastructure
Adit
Alternative Surface Discard Disposal Site
Mine Offices and Workshop
Opencast
PCD
Plant
Product Stockpile
ROM
Topsoil & Overburden Facilities
Underground Mining Area
Weighbridge / Security
Farm Portions
SITE LAYOUT
0 0.25 0.5 1 Kilometers
Reviewed: P. Furniss Environmental Scientist
Drawn by: A Brower GIS Consultant
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Scale: 1:32 000
Version: Final
Date: 2019/05/21
ABS Africa
Sustainability Advisors
Carolina
Hendrina
R36
N
29°57'45"E
29°58'30"E
29°59'15"E
30°0'0"E
30°0'45"E
30°1'30"E
30°2'15"E
30°3'0"E
26°8'15"S
26°9'0"S
26°9'45"S
26°10'30"S
26°11'15"S
26°12'0"S
11/172
RE/10/172
17/172
RE/2/47
47
5/47
1/47
6/172
5/172
50
4/50
5/52
RE/2/208
210
1/50
2/50
6/50
14/172
3/52
7/50
209
4/52
2/51
8/212
3/51
1/51
7/212
212
19/82
2/212
10/212
1/212
5/212
5/82
3/212
Data Source: Google Earth - Image Date: 2018/05/22. Proposed site layout provided by the client.

MAP 3: HYDROCENSUS AND MONITORING LOCATION

Kranspan MRA Project



Legend

Road Network

Rivers & Streams

HYDROCENSUS & MONITORING BOREHOLES

0 0.25 0.5 1 Kilometers

Reviewed: C Pretorius Environmental Scientist	Drawn by: A Brower GIS Consultant

Coordinate System: GCS WGS 1984
Datum: WGS 1984

ABS Africa Sustainability Advisors

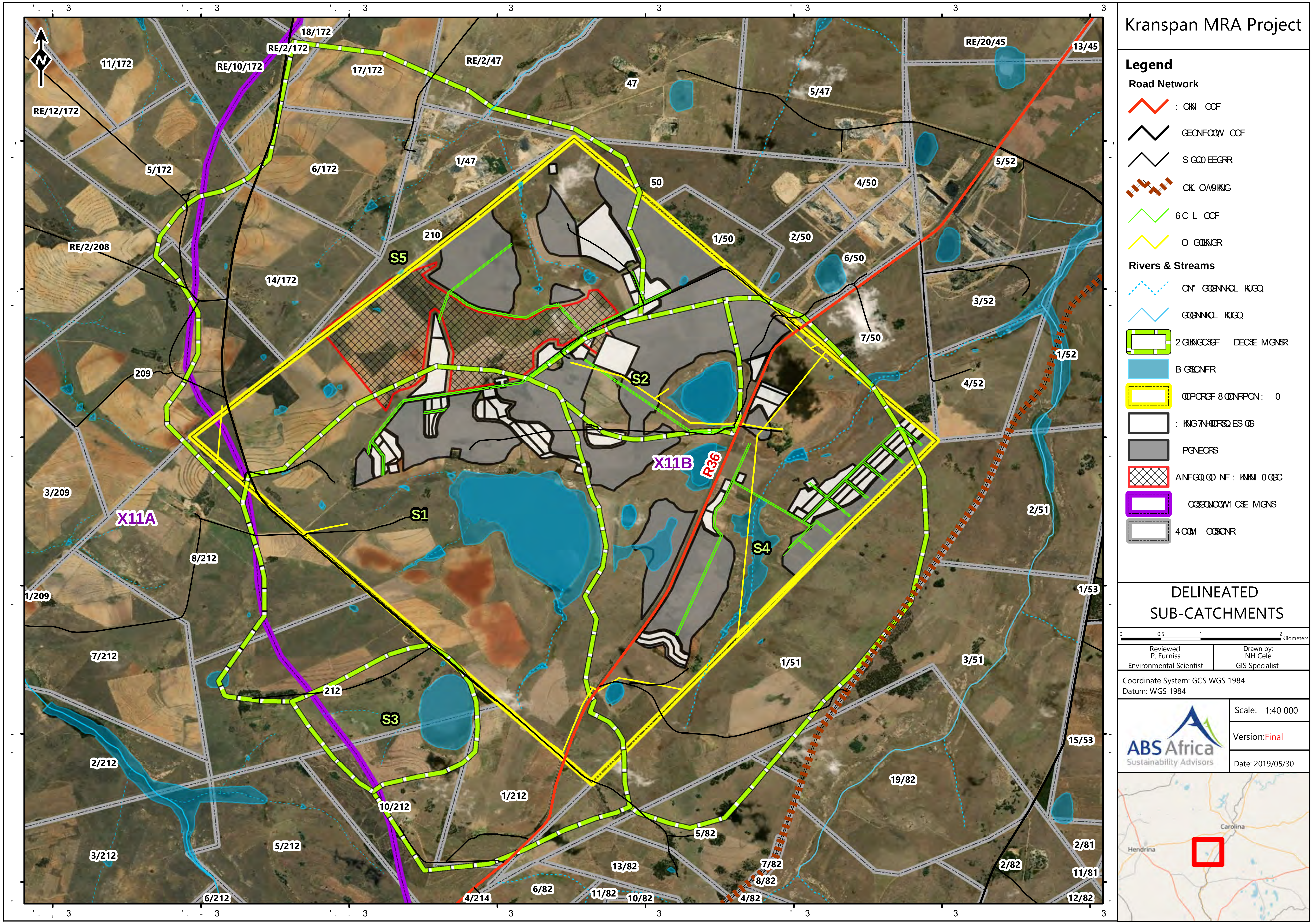
Scale: 1:32 000

Version: Final

Date: 2019/05/22

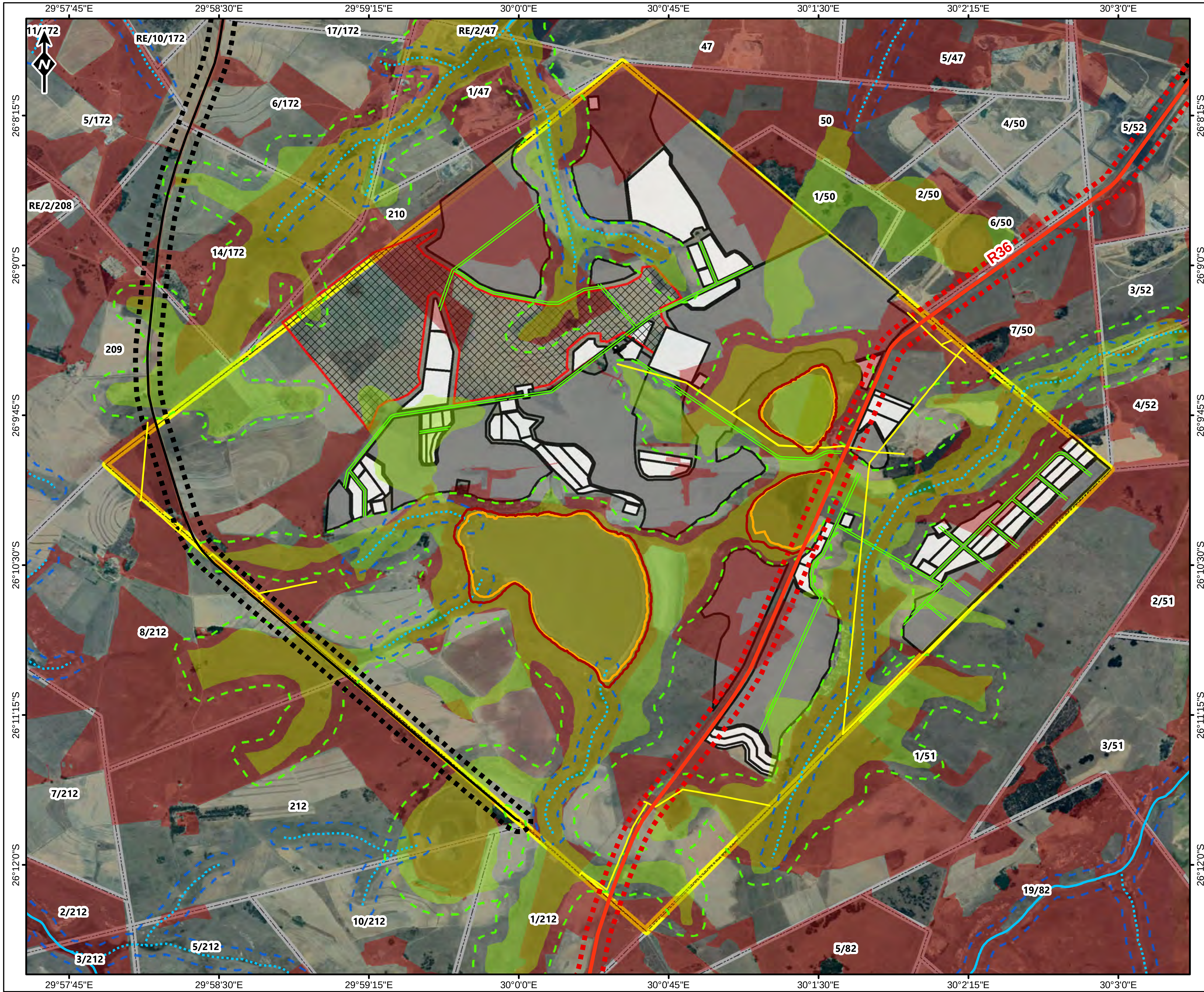
Carolina
Hendrina

MAP 4: DELINEATED CATCHMENTS



Kranspan MRA Project
Legend
Road Network
Rivers & Streams
DELINEATED SUB-CATCHMENTS
0
0.5
1
2
Kilometers
Reviewed:
P. Furniss
Environmental Scientist
Drawn by:
NH Cele
GIS Specialist
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Scale: 1:40 000
Version: Final
Date: 2019/05/30
ABS Africa
Sustainability Advisors
Carolina
Hendrina
S1
S2
S3
S4
S5
X11A
X11B
R36
18/172
RE/2/172
RE/10/172
11/172
17/172
RE/2/47
47
RE/12/172
5/172
6/172
1/47
50
RE/2/208
210
14/172
209
3/209
8/212
1/209
7/212
212
2/212
3/212
5/212
10/212
1/212
6/212
4/214
6/82
11/82
10/82
13/82
7/82
8/82
4/82
5/82
19/82
1/51
3/51
2/51
1/53
15/53
2/81
2/82
11/81
12/82
RE/20/45
13/45
5/47
5/52
4/50
1/50
2/50
6/50
3/52
7/50
1/52
4/52

MAP 5: ENVIRONMENTAL SENSITIVITY



Kranspan MRA Project

Legend

Road Network
- Main Road
- Secondary Road

Floodlines
- 100yr floodline for the 24 hour storm
- 100yr floodline for the 7day storm

Rivers and Streams
- Non-perennial
- Perennial
- Haul Road
- Powerlines
- R36 100m Buffer
- Secondary Road 100m Buffer
- 100m river buffer
- Delineated Wetland
- Specialist wetland buffer

Critical Biodiversity Assessment
- Critical Biodiversity Area
- Ecological Support Area
- Other Natural Areas
- Mine Infrastructure
- Opencast
- Underground Mining Area
- Proposed Kranspan MRA

ENVIRONMENTAL SENSITIVITY BUFFERS

0 0.25 0.5 1 Kilometers

Reviewed: P. Furniss Environmental Scientist

Drawn by: A Brower GIS Consultant

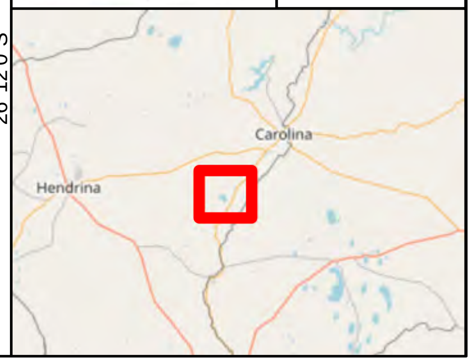
Coordinate System: GCS WGS 1984
Datum: WGS 1984

Scale: 1:32 000

ABS Africa Sustainability Advisors

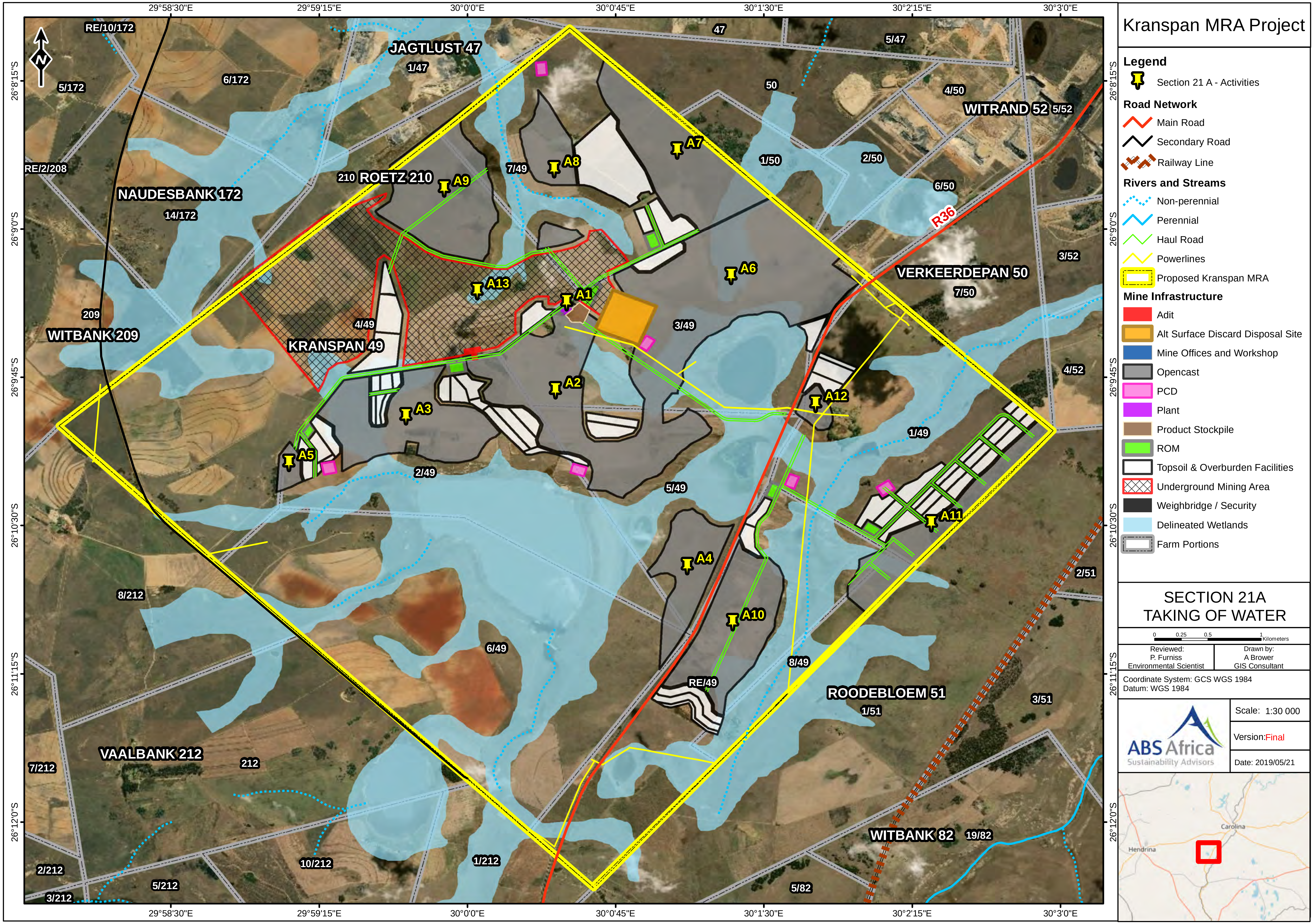
Version: Final

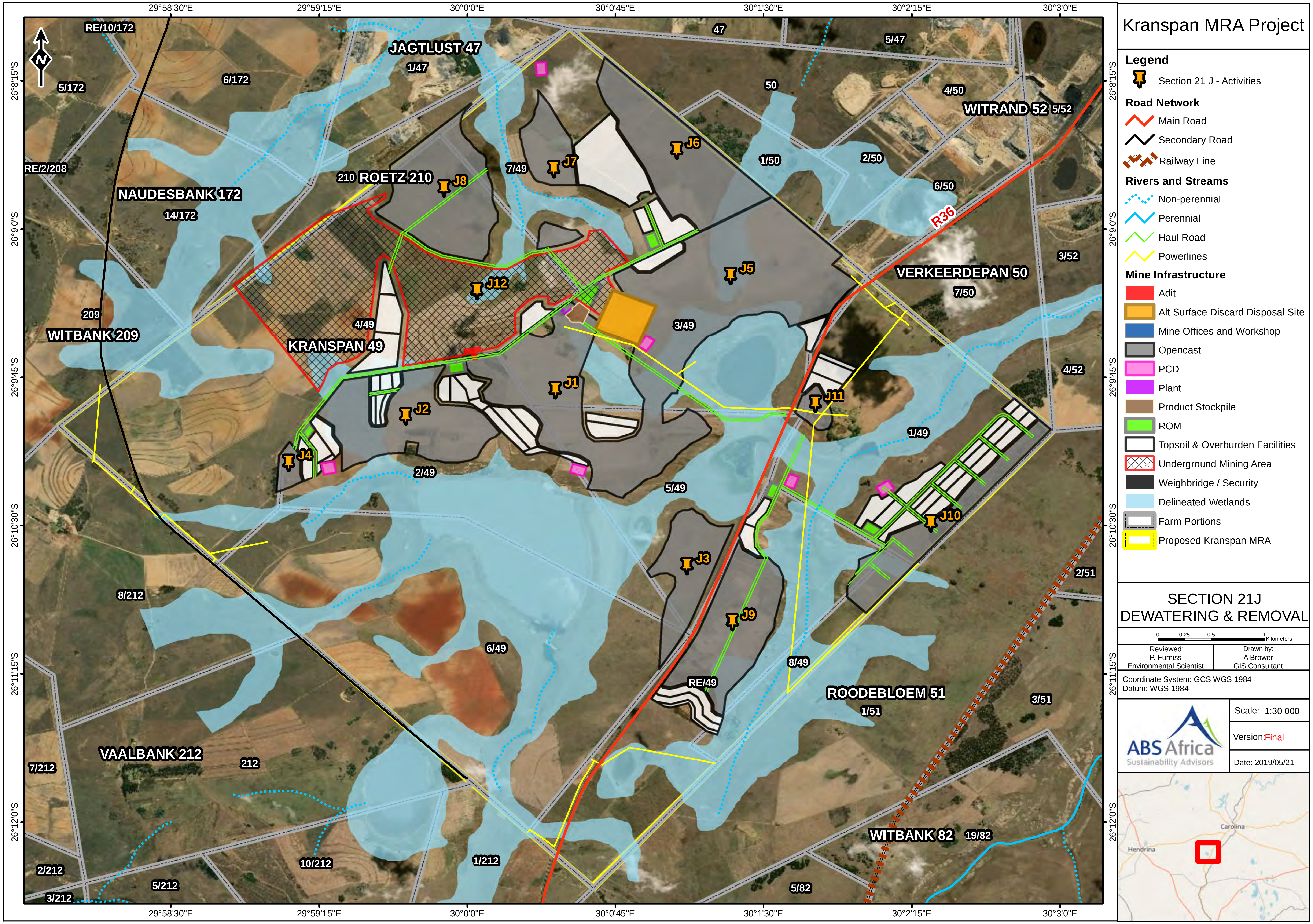
Date: 2019/06/04



Data Source: Google Earth - Image Date: 2018/05/22. Proposed site layout provided by the client.

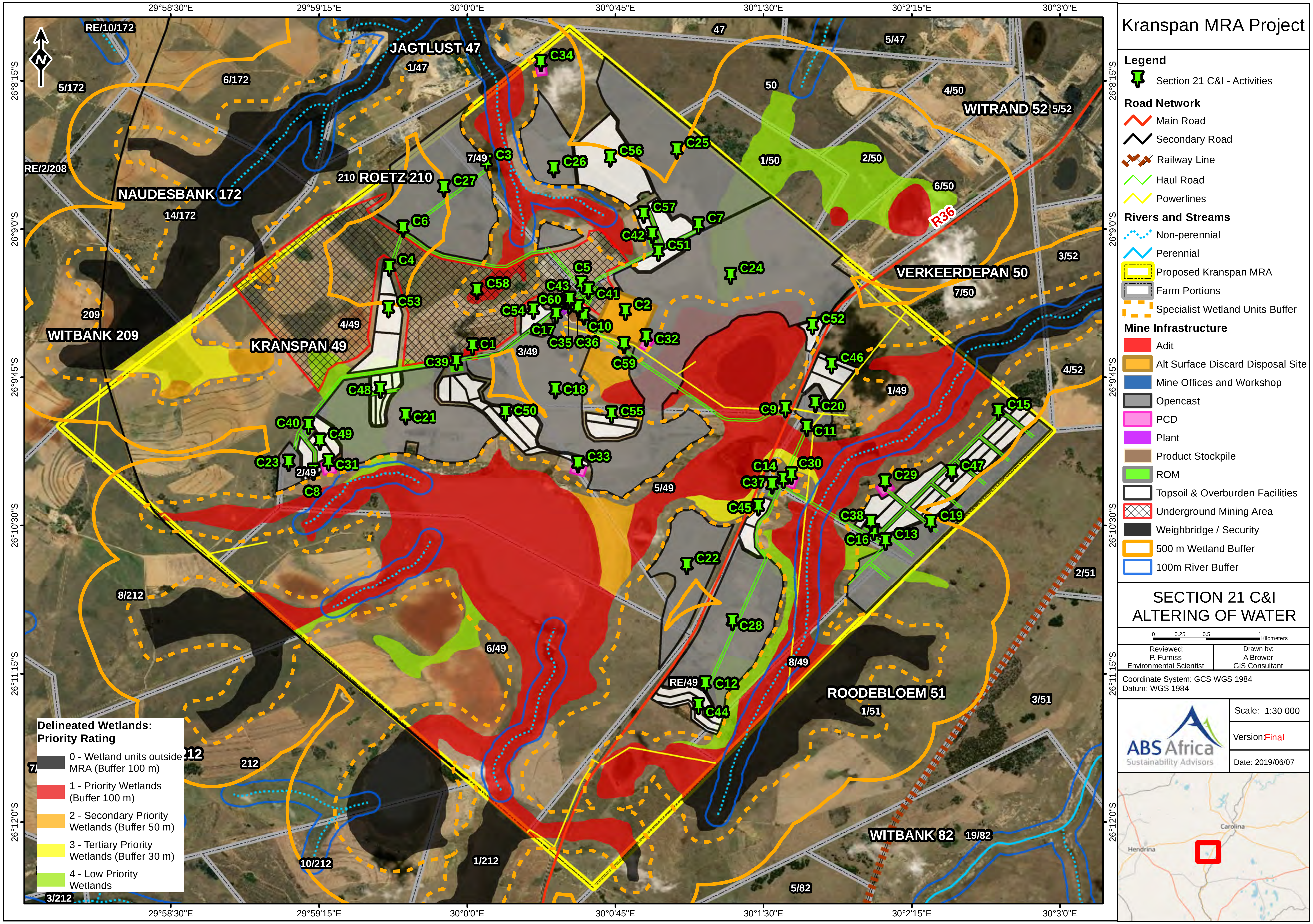
MAP 6: LOCATION OF SECTION 21A AND 21J WATER USES


Kranspan MRA Project
Legend
Section 21 A - Activities
Road Network
Main Road
Secondary Road
Railway Line
Rivers and Streams
Non-perennial
Perennial
Haul Road
Powerlines
Proposed Kranspan MRA
Mine Infrastructure
Adit
Alt Surface Discard Disposal Site
Mine Offices and Workshop
Opencast
PCD
Plant
Product Stockpile
ROM
Topsoil & Overburden Facilities
Underground Mining Area
Weighbridge / Security
Delineated Wetlands
Farm Portions
SECTION 21A
TAKING OF WATER
0 0.25 0.5 1 Kilometers
Reviewed:
P. Furniss
Environmental Scientist
Drawn by:
A Brower
GIS Consultant
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Scale: 1:30 000
Version: Final
Date: 2019/05/21
ABS Africa
Sustainability Advisors
Carolina
Hendrina
29°58'30"E
29°59'15"E
30°0'0"E
30°0'45"E
30°1'30"E
30°2'15"E
30°3'0"E
26°8'15"S
26°9'0"S
26°9'45"S
26°10'30"S
26°11'15"S
26°12'0"S
JAGTLUST 47
NAUDESBANK 172
ROETZ 210
KRANSPAN 49
WITBANK 209
VERKEERDEPAN 50
WITRAND 52
ROODEBLOEM 51
VAALBANK 212
WITBANK 82
R36
RE/10/172
5/172
6/172
1/47
47
5/47
50
4/50
5/52
RE/2/208
14/172
210
7/49
1/50
2/50
6/50
3/52
7/50
209
4/49
3/49
4/52
1/49
2/49
5/49
2/51
8/212
6/49
8/49
RE/49
1/51
3/51
7/212
212
2/212
10/212
1/212
19/82
5/212
3/212
5/82
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13



Kranspan MRA Project
Legend
Section 21 J - Activities
Road Network
Main Road
Secondary Road
Railway Line
Rivers and Streams
Non-perennial
Perennial
Haul Road
Powerlines
Mine Infrastructure
Adit
Alt Surface Discard Disposal Site
Mine Offices and Workshop
Opencast
PCD
Plant
Product Stockpile
ROM
Topsoil & Overburden Facilities
Underground Mining Area
Weighbridge / Security
Delineated Wetlands
Farm Portions
Proposed Kranspan MRA
SECTION 21J
DEWATERING & REMOVAL
0 0.25 0.5 1 Kilometers
Reviewed: P. Furniss Environmental Scientist
Drawn by: A Brower GIS Consultant
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Scale: 1:30 000
Version: Final
Date: 2019/05/21
ABS Africa
Sustainability Advisors
Carolina
Hendrina
29°58'30"E
29°59'15"E
30°0'0"E
30°0'45"E
30°1'30"E
30°2'15"E
30°3'0"E
26°8'15"S
26°9'0"S
26°9'45"S
26°10'30"S
26°11'15"S
26°12'0"S
N
JAGTLUST 47
NAUDESBANK 172
ROETZ 210
KRANSPAN 49
WITBANK 209
WITRAND 52
VERKEERDEPAN 50
ROODEBLOEM 51
VAALBANK 212
WITBANK 82
R36
J1
J2
J3
J4
J5
J6
J7
J8
J9
J10
J11
J12
RE/10/172
5/172
6/172
RE/2/208
14/172
209
1/47
47
5/47
50
4/50
5/52
1/50
2/50
6/50
7/49
210
4/49
3/49
3/52
7/50
4/52
1/49
2/49
5/49
2/51
8/212
6/49
8/49
RE/49
3/51
1/51
7/212
212
19/82
2/212
10/212
1/212
5/212
3/212
5/82

MAP 7: LOCATION OF SECTION 21 C AND 21I WATER USES


Kranspan MRA Project
Legend
Section 21 C&I - Activities
Road Network
Main Road
Secondary Road
Railway Line
Haul Road
Powerlines
Rivers and Streams
Non-perennial
Perennial
Proposed Kranspan MRA
Farm Portions
Specialist Wetland Units Buffer
Mine Infrastructure
Adit
Alt Surface Discard Disposal Site
Mine Offices and Workshop
Opencast
PCD
Plant
Product Stockpile
ROM
Topsoil & Overburden Facilities
Underground Mining Area
Weighbridge / Security
500 m Wetland Buffer
100m River Buffer
SECTION 21 C&I
ALTERING OF WATER
0 0.25 0.5 1 Kilometers
Reviewed:
P. Furniss
Environmental Scientist
Drawn by:
A Brower
GIS Consultant
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Scale: 1:30 000
Version: Final
Date: 2019/06/07
ABS Africa
Sustainability Advisors
Hendrina
Carolina
Delineated Wetlands:
Priority Rating
0 - Wetland units outside MRA (Buffer 100 m)
1 - Priority Wetlands (Buffer 100 m)
2 - Secondary Priority Wetlands (Buffer 50 m)
3 - Tertiary Priority Wetlands (Buffer 30 m)
4 - Low Priority Wetlands
29°58'30"E
29°59'15"E
30°0'0"E
30°0'45"E
30°1'30"E
30°2'15"E
30°3'0"E
26°8'15"S
26°9'0"S
26°9'45"S
26°10'30"S
26°11'15"S
26°12'0"S
N
JAGTLUST 47
NAUDESBANK 172
ROETZ 210
WITBANK 209
KRANSPAN 49
VERKEERDEPAN 50
WITRAND 52
ROODEBLOEM 51
WITBANK 82
R36
RE/10/172
5/172
6/172
14/172
RE/2/208
209
210
1/47
47
5/47
7/49
4/49
3/49
2/49
1/49
5/49
6/49
8/49
RE/49
50
1/50
2/50
4/50
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7/50
5/52
3/52
4/52
2/51
1/51
3/51
8/212
212
10/212
1/212
3/212
19/82
5/82
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C16
C17
C18
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C24
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C31
C32
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C36
C37
C38
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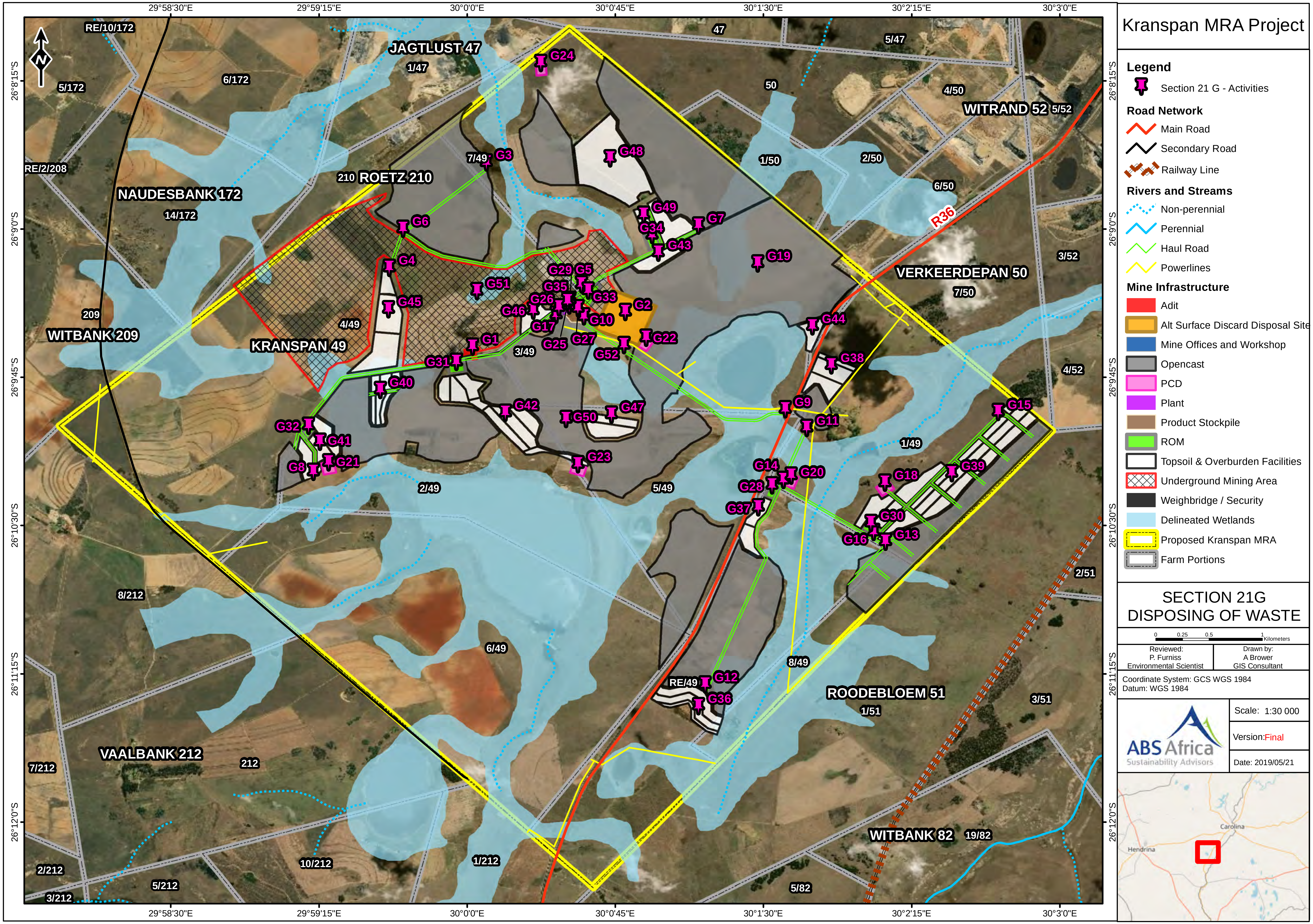
C40
C41
C42
C43
C44
C45
C46
C47
C48
C49
C50
C51
C52
C53
C54
C55
C56
C57
C58
C59
C60

MAP 8: LOCATION OF SECTION 21G WATER USES



Kranspan MRA Project
Legend
Section 21 G - Activities
Road Network
Main Road
Secondary Road
Railway Line
Rivers and Streams
Non-perennial
Perennial
Haul Road
Powerlines
Mine Infrastructure
Adit
Alt Surface Discard Disposal Site
Mine Offices and Workshop
Opencast
PCD
Plant
Product Stockpile
ROM
Topsoil & Overburden Facilities
Underground Mining Area
Weighbridge / Security
Delineated Wetlands
Proposed Kranspan MRA
Farm Portions
SECTION 21G
DISPOSING OF WASTE
Kilometers
Reviewed:
P. Furniss
Environmental Scientist
Drawn by:
A Brower
GIS Consultant
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Scale: 1:30 000
Version: Final
Date: 2019/05/21
ABS Africa
Sustainability Advisors
Hendrina
Carolina
29°58'30"E
29°59'15"E
30°0'0"E
30°0'45"E
30°1'30"E
30°2'15"E
30°3'0"E
26°8'15"S
26°9'0"S
26°9'45"S
26°10'30"S
26°11'15"S
26°12'0"S
N
JAGTLUST 47
NAUDESBANK 172
ROETZ 210
WITRAND 52
VERKEERDEPAN 50
WITBANK 209
KRANSPAN 49
VAALBANK 212
ROODEBLOEM 51
WITBANK 82
R36

APPENDIX 2: STORMWATER REPORT

ILIMA COAL COMPANY (PTY) LTD.

KRANSPAN COLLIERY

MPUMALANGA

STORMWATER MANAGEMENT PLAN

DOCUMENT NO: 0151-01-01

REVISION 00

FINAL

PROJECT NUMBER: 0151

MARCH 2019

CONSULTING ENGINEERS **DEVELOPER**

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LIST OF ABBREVIATION TERMS

JBU	**:**	JB Umwelttechnik
IWWMP	**:**	Integrated Water and Waste Management Plan
MAR	**:**	Mean Annual Rainfall
PCD	**:**	Pollution Control Dam
DTM	**:**	Digital Terrain Modelling
NGL	**:**	Natural Ground Level
SWMP	**:**	Storm Water Management Plan

1. INTRODUCTION

In 2018 JB Umwelttechnik (Pty) Ltd. was appointed by Ilima Coal Company (Pty) Ltd., to compile a Storm Water Management Plan for the KRANSPAN coal mine, South-West of Carolina in the Mpumalanga province. The Site comprises an area of approximately 111ha. See Fig. 1 for the site location. This area comprises mostly of agricultural land and farming infrastructure. . The area falls in the X11B sub-catchment.

The kranspan mine will consist of opencast mining and surface works:

2. SITE LOCATION

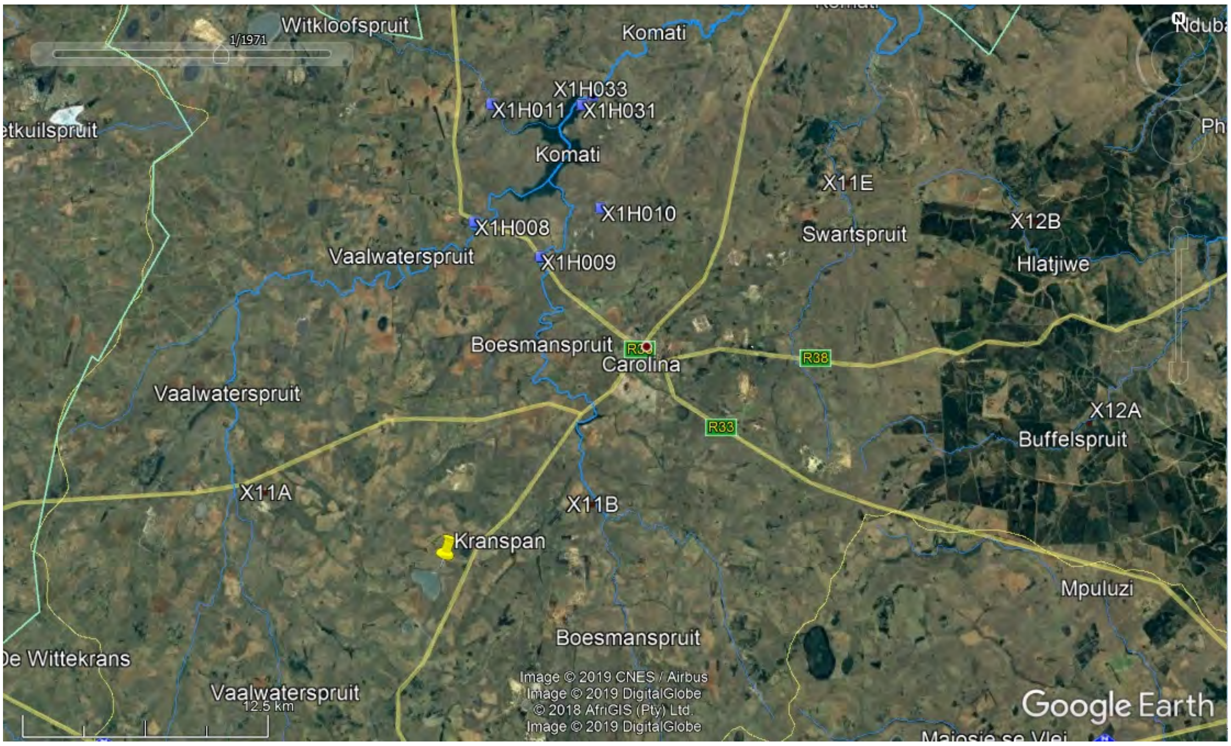

Figure 1: Site Location

3. WATER MANAGEMENT AREA AND CATCHMENTS

The catchment area is into various dirty sub catchment areas that corresponds to the proposed mining blocks. Each sub-catchment will be handled as a stand-alone system. The areas are divided as follow:

Figure 2: Dirty water areas

4. DESIGN METHOLDOLOGY

Watson (1981) states that run-off calculation techniques used in South Africa are inadequate and often based on unverified catchment and rainfall data. The use of various models should be used to derive the most probable values and to ensure that gross errors in estimation are eliminated. The ILLUDAS and RATIONAL methods were selected to derive run-off for the purpose of this study. The background to each method and the calculation methodologies are briefly explained below.

Since its inception in 1851, the Rational Method has become one of the world's most widely used methods for determining peak flows from small catchments. The basis of the relationship is the conservation of mass and the premise that the flow rate is directly proportional to the size of the contributing area and rainfall intensity. Rainfall intensity is a function of the return period. Peak flow is obtained by the following relationship:

$Q = \frac{CIA}{3.6}$

$\frac{CIA}{3.6}$

where:

Q = peak flow (m3/s);

C = run-off coefficient;

I = average rainfall intensity over catchment (mm/hour);

A = effective area of catchment (km2); and

3.6 = conversion factor.

Despite the Rational Method's shortcomings and widespread criticism, it provides realistic results, especially in combination with other run-off estimation models. The method is based on the following assumptions:

- The rate of rainfall is constant throughout the storm and uniform over the entire catchment
- Catchment imperviousness remains constant for the duration of the storm
- The contributing impervious area is uniform over the entire catchment

Assumption 1 can underestimate, as can assumption 3; however assumption 2 tends to overestimate. In most cases, these inaccuracies tend to cancel each other out producing a reasonably accurate result and a good first design approximation, in most situations and for smaller catchments (<150 hectares), the method can be used for full design.

Although The ILLUDAS method is not as sensitive as the Rational Method to user input and an entire hydrograph can be calculated for flood routing purposes. Peak flows, derived with the ILlUDAS method, were thus selected to check canal sizes for the dirty water areas at the Kranspan Coal Mine site.

Generally it was found that the peak outflow rates at the outfall locations for the dirty water catchments were similar using both the ILLUDAS and Rational methods. The time of concentration, i.e. time taken to achieve peak flow, varied between the two design methods.

5. STORM WATER MANAGEMENT PLAN

The KRANSPAN Mine has been designed as a "zero discharge Facility". This means that provisions have been made to divert storm water falling in areas where non-coal related activities are taking place away from the operational area and collecting storm water from dirty areas in the proposed pollution control dams on each of the defined mining areas. (PCD's)

The clean water diversion berms will be sized for a 1:100 year storm. This water is discharged directly into the environment as it is not contaminated by carbonaceous material from the site. For the purpose of this report, all the sizes have been designed to accommodate a 1:100 year storm as directed by Department of water affairs.

No retention ponds are required for the discharge from this areas as these diversions will not have an effect on the current flood hydrology curves. Energy dissipaters will be constructed in the outlet structures of the canals.

The dirty water collection drains will be designed for a 1:50 year storm. The dirty water will be collected in the PCD's on the eastern and southern end of the site, where it will either evaporate or be used as service water (Dust suppression). The PCD's together have a capacity of approximately 1 450 000m^3. The PCD's have been designed to fall within the limit of 50 000m^3 capacity and 5m high dam wall. In order to ensure that the dams can contain a 1:50 year storm, a portion of each of the PCD capacity will be used for Service water and normal rainfall collection. All haul roads that can contain carbonaceous material will be bermed of to ensure no contamination of surrounding clean areas.

6. CLEAR WATER DRAINAGE SIZING

Clean water catchment area falls beyond the scope of this report as it will have no influence on the Dirty water footprint, and have thus been left out of the scope.

7. POLLUTION CONTROL DAM

The capacities of the pollution control dams have been sized to contain a 1:50 year storm event from a run-off area of 46ha. Although this area is smaller than the total respective mining areas, the whole area will not be stripped at any one time as the "roll – over" mining method will ensure simultaneous rehabilitation behind the mining face. The dams will be lined with 1500 micron HDPE as well as a suitable clay lining to prevent any groundwater contamination (type C barrier). The projected lifespan of the lining is longer than the expected life of the facility (LOM: 6 years). The dams will be constructed to have an 800mm freeboard as directed in DWS best practice guidelines.

The dams will be designed to be accessible for maintenance purposes, but access controlled for safety.

The canals will be designed to allow for a 30% silt load to ensure proper operation and serviceability.

Specifications for each of the dams are as follow:

Dirty water runoff area 1 (A1 Open cast mining):

Area	=	1.11km² (0.46km² actual)
Longest water course	=	1198m (800m actual)
Level difference	=	24m
Slope	=	0.03m/m

Table 1: Dirty water runoff area: A1 Open cast mining

Description	Value
Area	0.46km²
Longest Water Course	0.8km
Level Difference	24m
Slope	0.03m/m
Return period	1:50
Cover	0.3
Seasonal rainfall	Summer
Average Annual Rainfall	750mm
Tc (Overland)	0.703
Slope Coefficient	0.03
Permeability Coefficient	0.16
Cover Coefficient	0.245
Runoff Coefficient "C"	0.361
Peak flow 1:50	4.85m³/sec

Dirty water runoff area 1 (B1 Open cast mining):

Area	=	1.46km² (0.46km² actual)
Longest water course	=	1198m (800m actual)
Level difference	=	44m (24m actual)
Slope	=	0.03m/m

Table 2: Dirty water runoff area: B1 Open cast mining

Description	Value
Area	0.46km²
Longest Water Course	0.8km
Level Difference	24m
Slope	0.03m/m
Return period	1:50
Cover	0.3
Seasonal rainfall	Summer
Average Annual Rainfall	750mm
Tc (Overland)	0.703
Slope Coefficient	0.03
Permeability Coefficient	0.16
Cover Coefficient	0.245
Runoff Coefficient "C"	0.361
Peak flow 1:50	4.85m³/sec

Dirty water runoff area 1 (C1 Open cast mining):

Area	=	5.23 km^2 (0.46km^2 actual)
Longest water course	=	1198m (800m actual)
Level difference	=	44m (23m actual)
Slope	=	0.03m/m

Table 3: Dirty water runoff area: C1 Open cast mining

Description	Value
Area	0.46km^2
Longest Water Course	0.8km
Level Difference	24m
Slope	0.03m/m
Return period	1:50
Cover	0.3
Seasonal rainfall	Summer
Average Annual Rainfall	750mm
Tc (Overland)	0.703
Slope Coefficient	0.03
Permeability Coefficient	0.16
Cover Coefficient	0.245
Runoff Coefficient “C”	0.361
Peak flow 1:50	4.85m^3/sec

Dirty water runoff area 1 (EX1 Surface works):

Area	=	0.08 km^2 (0.08km^2 actual)
Longest water course	=	412m (412m actual)
Level difference	=	12m (12m actual)
Slope	=	0.03m/m

Table 4: Dirty water runoff area: EX1 Surface works

Description	Value
Area	0.08km^2
Longest Water Course	04
Level Difference	12m
Slope	0.03m/m
Return period	1:50
Cover	0.3
Seasonal rainfall	Summer
Average Annual Rainfall	750mm
Tc (Overland)	0.703
Slope Coefficient	0.03
Permeability Coefficient	0.16
Cover Coefficient	0.245
Runoff Coefficient “C”	0.361
Peak flow 1:50	4.92m^3/sec

Dirty water runoff area 1 (D1 Open cast mining):

Area	=	5.23 km^2 (0.46km^2 actual)
Longest water course	=	1198m (800m actual)
Level difference	=	44m (23m actual)
Slope	=	0.03m/m

Table 5: Dirty water runoff area: C1 Open cast mining

Description	Value
Area	0.46km^2
Longest Water Course	0.8km
Level Difference	24m
Slope	0.03m/m
Return period	1:50
Cover	0.3
Seasonal rainfall	Summer
Average Annual Rainfall	750mm
Tc (Overland)	0.703
Slope Coefficient	0.03
Permeability Coefficient	0.16
Cover Coefficient	0.245
Runoff Coefficient “C”	0.361
Peak flow 1:50	4.75m^3/sec

Dirty water runoff area 1 (E1 Open cast mining):

Area	=	1.473 km² (0.46km² actual)
Longest water course	=	1500m (800m actual)
Level difference	=	45m (24m actual)
Slope	=	0.03m/m

Table 6: Dirty water runoff area: E1 Open cast mining

Description	Value
Area	0.46km²
Longest Water Course	0.8km
Level Difference	24m
Slope	0.03m/m
Return period	1:50
Cover	0.3
Seasonal rainfall	Summer
Average Annual Rainfall	750mm
Tc (Overland)	0.703
Slope Coefficient	0.03
Permeability Coefficient	0.16
Cover Coefficient	0.245
Runoff Coefficient "C"	0.361
Peak flow 1:50	4.85m³/sec

8. OPEN CANAL DESIGN

The surface operations area (1) will drain via overland flow into an open canal system that will drain to the PCD's. These canals have been sized to accommodate a 1:50 year storm.

Table 7: Open Canal Design

Description	Value
Bed width	0.1.1m
LSH Side Slope	2.5m/m
RHS Side Slope	2.5m/m
Depth	0.53m
Grade	0.03m/m
Manning "n" value	0.015
Flow capacity	7.5m³/s

The canals will be designed to allow for a 30% silt load to ensure proper operation and serviceability.

9. PUMPSTATION

Due to the short LOM predicted for each of the areas, it was decided to omit dry-well pump stations and transfer water from the dam by means of floating pump systems. This pumping systems will be manually operated in order to enable the use of the water in the PCD's for dust suppression and other operational water.

10. CONCLUSION AND RECOMMENDATIONS

The storm water management plan ensures a fit-for-purpose design of all storm water management infrastructure that will be able to contain a storm of 1:50 year magnitude. The proposed infrastructure also minimizes the negative effect on the environment should a larger storm occur.

The dams and drain sizes in this project will be sized optimally with some minor additional capacity to act as a safety factor.

Care should however be taken to keep dam levels to a minimum in the wet season.

ANNEXURE A
PCD LAYOUT AND DETAILS

APPENDIX 3: SPECIALIST REPORTS

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PREPARED FOR:

ABS Africa
Sustainability Advisors

KRANSPAN COAL MINE
HYDROLOGICAL SPECIALIST REPORT

TITLE	**KRANSPAN COAL MINE** **HYDROLIGICAL SPECIALIST REPORT**
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DATE	18/02/2019
REFERENCE NUMBER	0155_KRANSPAN_HYDROLOGICAL SPECIALIST REPORT
PROJECT TEAM	H.S Peens  *Pr.TechEng.*
STATUS	*SECOND DRAFT REPORT*

EXECUTIVE SUMMARY

Peens and Associates was appointed by ABS Africa (Pty) to produce a Hydrological Specialist Report for the proposed Kranspan Coal Mine that is situated on the farm Kranspan 49 Portions 1 to 8 and Remainder near Carolina in the Mpumalanga Province.

This report covers the current hydrological situation of the proposed mining right area. The outputs generated in the report will be utilised to populate the relevant sections of the EIA and EMPR.

The conclusions drawn from the analyses done for the current situation are as follows:

- The proposed mining right area is located in the **X11B** quaternary sub-catchment of the Komati River Drainage Basin;
- The Boesmanspruit is the major stream flowing past the proposed mining right area with effective catchment areas of **597** km^2;
- The proposed mining right area has a Mean Annual Precipitation (MAP) of **698** mm;
- The proposed mining right area has a Mean Annual Evaporation (MAE) of **1 450** mm;
- The Nett Mean Annual Runoff (MAR) of the Boesmanspruit is **26.2** mil m^3;
- The proposed mining right area contributes **1.05** mil m^3 or **4.0**% of the nett mean annual runoff of the Boesman Spruit
- The Base / Normal Flow of the Boesmanspruit is **0.1** m^3/s;
- The proposed mining right area contributes **0.0044** m^3/s or **4.0**% of the base flow for the Boesman Spruit
- The drainage density of the proposed mining right area was calculated at **0.18** km/km^2;
- The recommended 100 year flood levels of the three most significant pans are as follows:
  - “S1” = 1 654.90 masl
  - “S2” = 1 654.66 masl
  - “S3” = 1 651.80 masl

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Peens and Associates was appointed by ABS Africa (Pty) to produce a Hydrological Specialist Report for the proposed Kranspan Coal Mine that is situated on the farm Kranspan 49 Portions 1 to 8 and Remainder near Carolina in the Mpumalanga Province.

This report covers the current hydrological situation of the proposed mining right area. The outputs generated in the report will be utilised to populate the relevant sections of the EIA and EMPR.

2. APPROACH AND METHODOLOGY

The following approach and methodology was adopted during the compilation of the hydrological specialist report:

- Gather existing information from credible sources such as those available from the Department of Water and Sanitation and site observations.
- Evaluate data sets such a rainfall data and river flow records for errors.
- Compile drawings and sketches on the 1:50 000 topographical maps for catchment delineation, catchment and river characteristics.
- Analyse data sets to determine the outputs such as the mean annual precipitation and the mean annual runoff.

3. DESCRIPTION OF BASELINE

3.1. CATCHMENT DESCRIPTION

3.1.1. Drainage Region

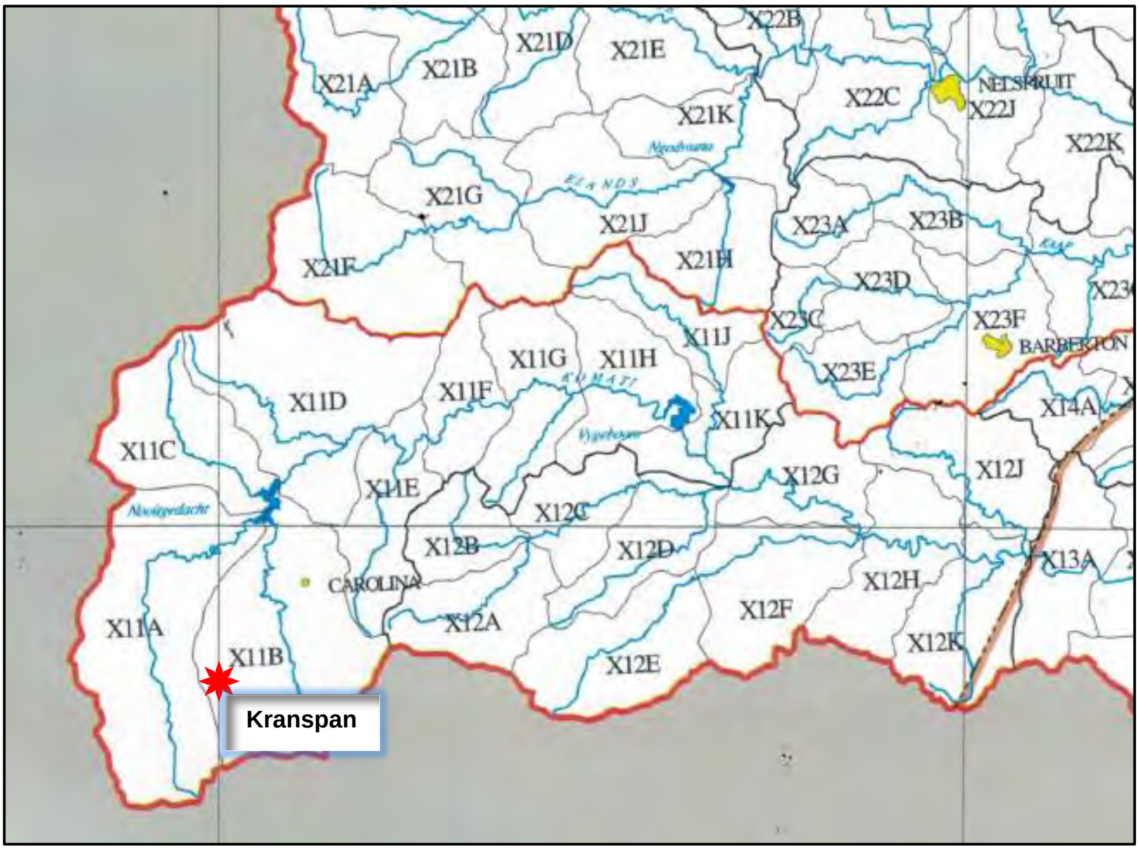
The proposed mining right area is situated in the X11B quaternary sub-catchment of the Komati River Drainage Region as per the Volume VI: Water Resources of South Africa 1990.

The Nooitgedacht Dam is the major reserving water body of the X11B quaternary sub-catchment that might be impacted by the proposed mine. The Nooitgedacht Dam total catchment area, i.e. quaternary sub-catchments; X11A, X11B and X11C combined is 1 588 km^2. The mean annual runoff (MAR) into Nooitgedacht Dam is 64.1 million m^3 per annum.

Quaternary sub-catchment X11B under laying geology is basic or mafic and ultramafic intrusive lavas, which forms part of the igneous group. Igneous rocks are formed by volcanic activities and in moderate to wet regions it decompose to form clay. The overburden soils are moderate to deep sandy loam.

The mean annual rainfall/ precipitation (MAP) of the quaternary sub-catchment is 714mm and the mean annual runoff (MAR) is 44mm. Quaternary sub-catchment X11B has a catchment area of 597 km^2 and its Nett MAR is 26.2 million m^3 per annum.

FIGURE 1: LOCATION OF PROPOSED MINING RIGHT AREA IN QUATERNARY SUB-CATCHMENT X11B



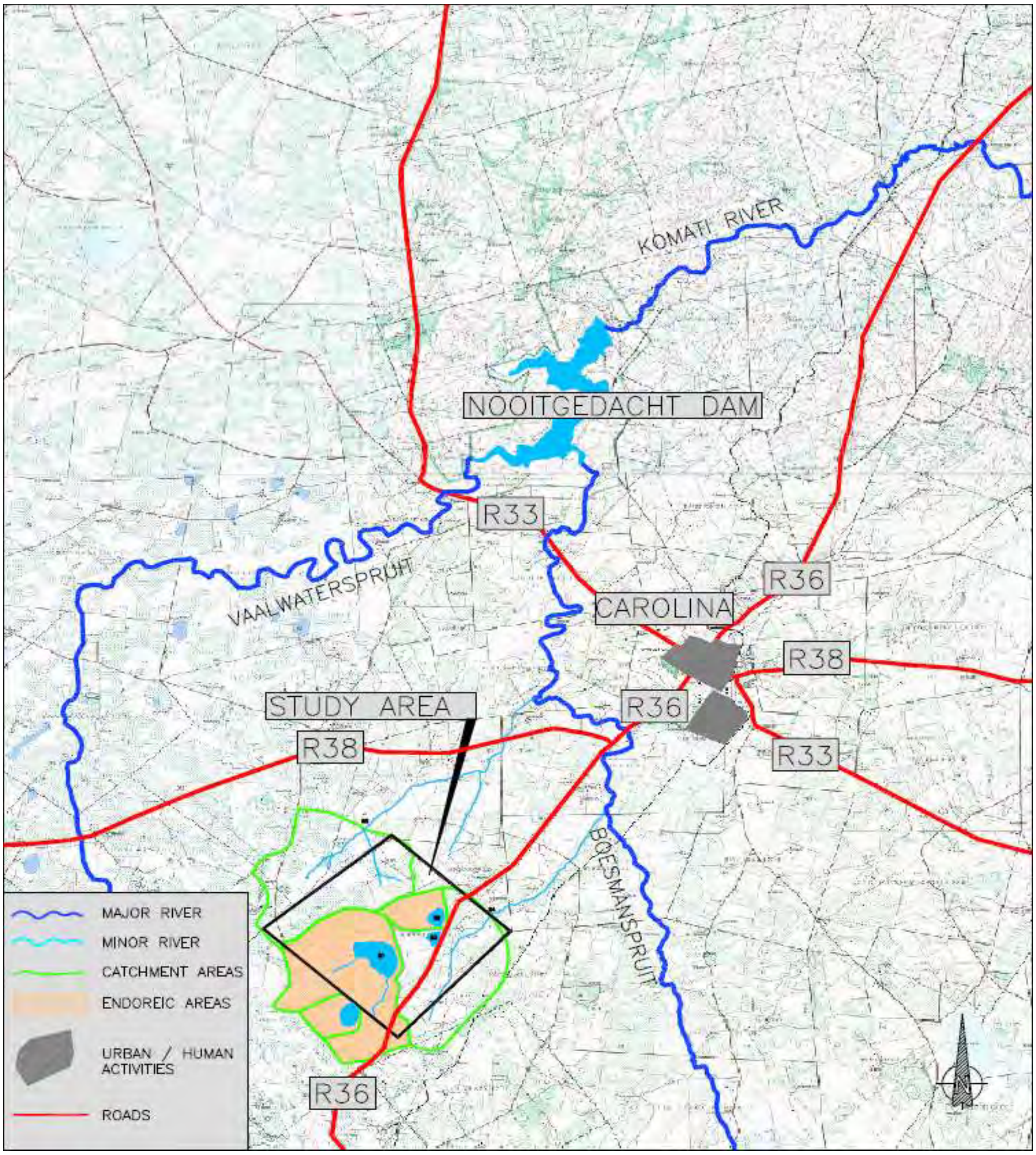
3.1.2. Major Rivers and Receiving Water Bodies

The Kranspan proposed mining right area is in the Boesmanspruit catchment area on the watershed between the Boesmanspruit and the Vaalwaterspruit catchments. Both the Boesmanspruit and the Vaalwaterspruit are tributaries of the Nooitgedacht Dam and the Komati River.

Three pans are located within the proposed mining right area of which two have no outflow and their catchment areas can therefore be classified as endorheic areas that do not contribute to the runoff towards Nooitgedacht Dam.

The proposed mining right area is 33.8 km^2 in size of which 37.6% (12.7km^2) is endorheic areas; hence the portion of proposed mining right area contribution to the Boesmanspruit runoff is 21.1 km^2. Thus the portion of the proposed mining right area that contributes to runoff in the Boesmanspruit is 3.5% of the Boesmanspruit catchment, which has a total catchment of 597 km^2.

FIGURE 2: PROPOSED MINING RIGHT AREA IN RELATION TO MAJOR RIVERS AND RECEIVING WATER BODIES



3.1.3. Minor Rivers / Watercourses in Proposed Mining Right Area

The proposed mining right area consists both of endorheic areas and non-endorheic areas. Nodes S1 and S2 are accumulation points of such endorheic areas, node S3 acts as an attenuation system with only extreme flood events discharging into the catchment of node S4.

However the discharge from S3 will never contribute to the flood peaks of S4 as the response times of the catchments will not synchronise with the same storm events. The locations for nodes S4 and S5 were selected to obtain the minimum catchment area of each stream that will be affected by the proposed mining right area. The catchment areas mainly consist of grass lands and cultivated fields with predominantly flat slopes. The overburden soils are moderate to deep sandy loam and are classified as permeable soils.

FIGURE 3: SUB-CATCHMENTS AND NODES

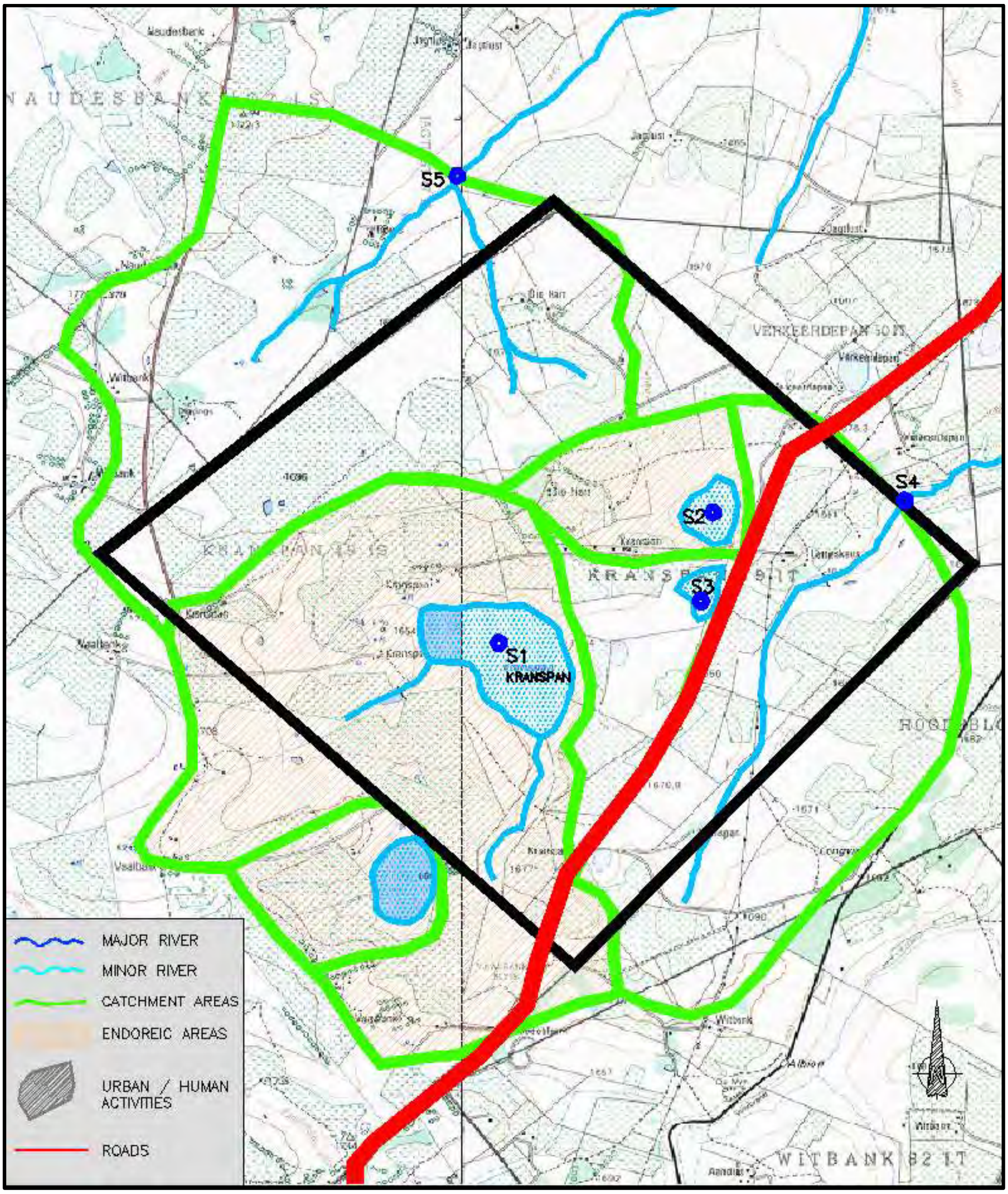


TABLE 1: SUMMARY OF WATERCOURSES CATCHMENTS ON SITE

Node Name	Effective Catchment Area (km^2)	Stream Length (Km)	10-85 Method Avg. Slope (1 :.....)	Overland Flow Length (Km)	Overland Avg. Slope (1: .....)
S1	15.490	3.62	49.35	-	-
S2	2.485	-	-	1.77	32.18
S3	2.222	-	-	3.37	134.77
S4	11.86	5.74	107.64	-	-
S5	16.49	4.62	86.66	-	-

Note: where no defined water course or stream is present in the catchment area the longest overland flow length and slope is determine to calculate the response time of the catchment.

3.2. SURFACE WATER RESOURCES HYDROLOGY

3.2.1. Rainfall

The rainfall characteristics of the proposed mining right area are documented in the Surface Water Resources of South Africa 1990 Volume VI and within the X1A rainfall zone as per Map No 1.3 in the Book of Maps. The closest rainfall station to the proposed mining right area is the South African Weather Station 0480267W – Kranspan which is located on the south-western boundary of the proposed mining right area, 2 km south-west of the node S1.

3.2.1.1. Mean Annual and Monthly Rainfall

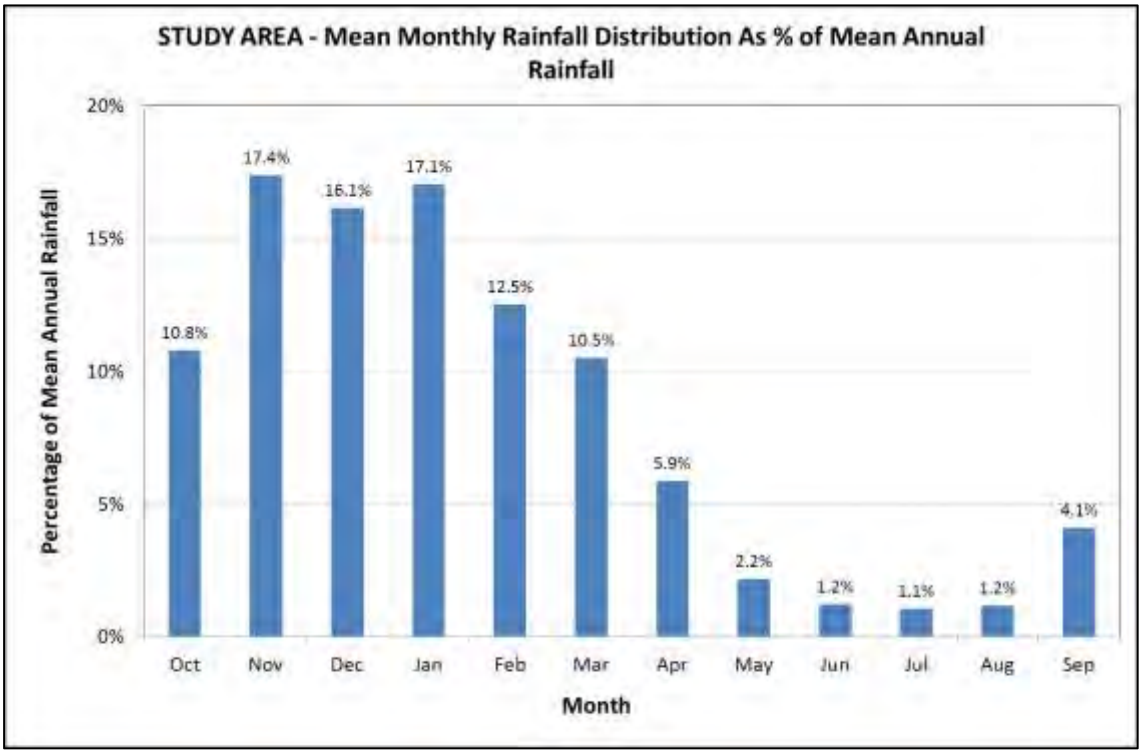
The mean annual rainfall for South African Weather Station 0480267W – Kranspan is **698mm** based on 44 years of data as indicated in the TR102 Southern African Storm Rainfall from PT Adamson. The mean monthly rainfall distributions as listed in the Surface Water Resources of South Africa 1990 Volume VI Appendix 2.2 were used to calculate the mean monthly rainfall and the annual standard deviation was used to estimate the typical wet and dry seasons.

The mean monthly rainfall distributions from Surface Water Resources of South Africa 1990 Volume VI Appendix 2.2 are listed in the table and shown in the figure below.

TABLE 2: MEAN MONTHLY RAINFALL DISTRIBUTIONS IN PERCENTAGE (%)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep
Distribution	10.8	17.4	16.1	17.1	12.5	10.5	5.9	2.2	1.2	1.1	1.2	4.1

FIGURE 4: PERCENTAGE MEAN MONTHLY DISTRIBUTION OF MEAN ANNUAL RAINFALL (MAP)



The mean monthly and annual rainfall for the proposed mining right area as well as that for typical wet and dry years is listed in the table below.

TABLE 3: MEAN MONTHLY AND ANNUAL RAINFALL (MM)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
Wet	87	139	129	137	100	84	47	17	11	8	10	33	802
Mean	75	121	113	119	87	73	41	15	9	7	9	29	698
Dry	64	103	96	101	74	62	35	13	8	6	8	24	594

3.2.2. Evaporation (S – Pan)

There are no weather stations with evaporation data in the vicinity of the proposed mining right area, hence the recommended values in the Water Research Commission's "Surface Water Resources of South Africa 1990 Manual" Volume 1 were used.

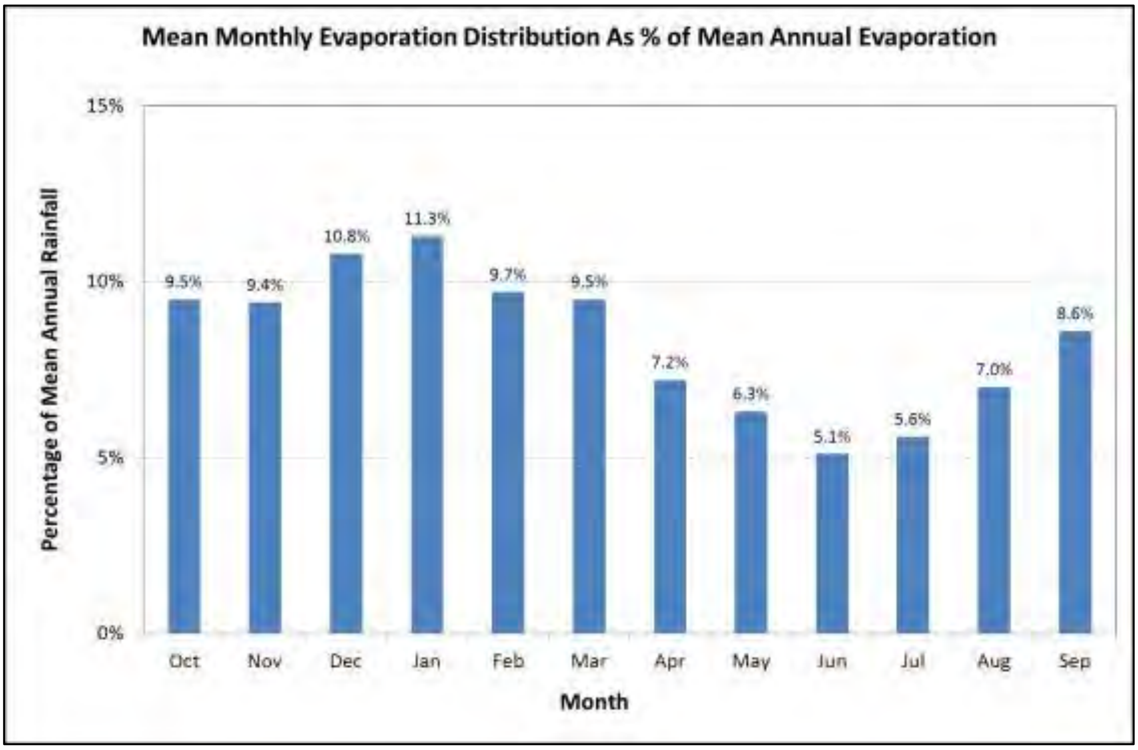
All the sub-catchments in the proposed mining right area are situated in quaternary sub-catchment X11B with a Mean Annual Evaporation (MAE) of 1 450mm. Quaternary sub-catchment X11B is within evaporation zone 5A.

The mean monthly evaporation distributions from Surface Water Resources of South Africa 1990 Volume VI Appendix 3.2 for zone 5A are listed in the table and shown in the figure below.

TABLE 4: MEAN MONTHLY EVAPORATION DISTRIBUTIONS IN PERCENTAGE (%)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep
Distribution	9.5	9.4	10.8	11.3	9.7	9.5	7.2	6.3	5.1	5.6	7	8.6

FIGURE 5: PERCENTAGE MEAN MONTHLY DISTRIBUTION OF MEAN ANNUAL EVAPORATION (MAE)



The mean monthly and annual evaporation for the proposed mining right area is listed in the table below.

TABLE 5: MEAN MONTHLY AND ANNUAL EVAPORATION (MM)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
Mean	138	136	157	164	141	138	104	91	74	81	102	124	1 450

3.2.3. Runoff

3.2.3.1. Mean Annual Runoff

There is no river flow gauging station in the Boesmanspruit in the vicinity of the proposed mining right area. Further, no gauging station could be located with sufficient data that can be used as a representation of this catchment area. In the absence of representative data, the recommended values in the Water Research Commission's "Surface Water Resources of South Africa 1990 Manual" Volume 1 were used.

a) Boesmanspruit

The proposed mining right area falls within quaternary sub-catchment X11B - Boesmanspruit. The calculated net MAR for the Boemanspruit is ***26.2 million m^3***.

TABLE 6: MEAN ANNUAL RUNOFF FOR THE BOESMANSPRUIT

Quaternary Sub – catchment Name	Net Area (km2)	Net MAR (10^6 m^3/a)
X11B	**597**	**26.2**

b) Proposed Mining Right Area

All the sub-catchments in the proposed mining right area are situated in quaternary sub-catchment X11B. The mean annual rainfall for this site is 698mm. The rainfall / runoff response number for this quaternary sub-catchment is 8, relating to a mean annual runoff (MAR) of 37mm runoff depth.

TABLE 7: MEAN ANNUAL RUNOFF OVER PROPOSED MINING RIGHT AREA

Catchment Name	Catchment Size (km^2)	MAR (m^3/a)	Comment
S1	15.490	573 130	Does not contribute to the mean annual runoff for the Boesmanspruit.
S2	2.485	91 945	
S3	2.222	82 214	
S4	11.86	438 820	Contributes to Boesmanspruit
S5	16.49	610 130	Contributes to Boesmanspruit
TOTAL	28.35	1 048 950	Total excludes S1, S2 and S3

3.2.3.2. Mean Monthly Runoff

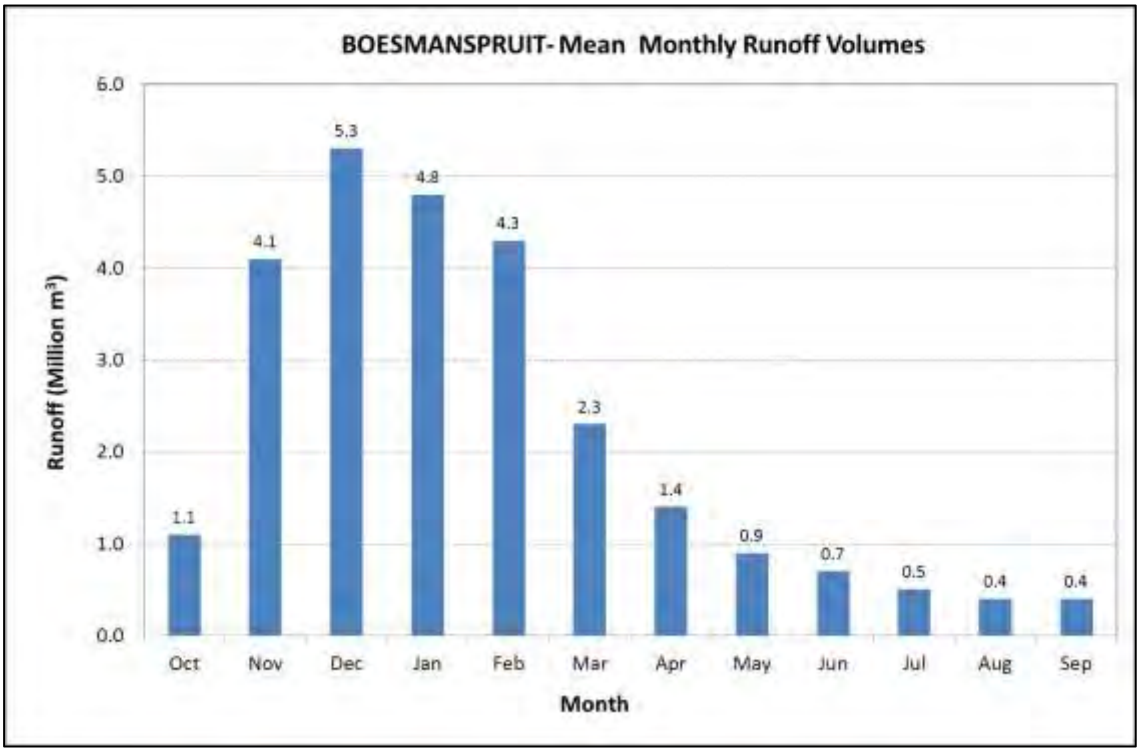
a) Boesmanspruit

The mean monthly runoff distribution ratios are obtained from the Water Research Commission's "Surface Water Resources of South Africa 1990 Manual Volume 1". The entire catchment of the Boesmanpruit is situated within the HYDRO Zone VI-P for which the manual recommends a percentage of the MAR for each month of the hydrological year.

TABLE 8: BOESMANSPRUIT MEAN MONTHLY RUNOFFS AND RATIOS

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
$10^6 m^3$	1.1	4.1	5.3	4.8	4.3	2.3	1.4	0.9	0.7	0.5	0.4	0.4	26.2
%	4.3	15.6	20.2	18.2	16.3	8.7	5.3	3.8	2.5	1.9	1.5	1.7	100

FIGURE 6: BOESMANSPRUIT MEAN MONTHLY RUNOFF VOLUMES



b) Proposed Mining Right Area

The mean monthly runoff distribution ratios used for the Boesmanspruit were utilised for each sub-catchment within the proposed mining right area and are listed in the tables below.

TABLE 9: "S1" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
$10^6 m^3$	0.02	0.09	0.12	0.10	0.09	0.05	0.03	0.02	0.01	0.01	0.01	0.01	0.573

TABLE 10: "S2" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.00	0.01	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.091

TABLE 11: "S3" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.00	0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.082

TABLE 12: "S4" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.02	0.07	0.09	0.08	0.07	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.439

TABLE 13: "S4" MEAN MONTHLY RUNOFF

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Annual
10^6m^3	0.03	0.10	0.12	0.11	0.10	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.610

3.2.3.3. Base flow

The Water Act defines "Normal Flow" or base flow as that portion of the stream flow that can be beneficially used for irrigation without the aid of storage at a site.

Base flow is often estimated as the flow available 70% of the time during the critical irrigation season, i.e. the period of maximum demand and minimum runoff. This occurs usually during the months of June to September in the summer rainfall areas.

For the purpose of preliminary estimates the "Surface Water Resources of South Africa 1990 Manual" Volume 1 provides Deficient Flow – Duration – Frequency curves from where the base flow can be related to a percentage of the mean annual runoff.

TABLE 14: BASE FLOW FOR BOESMANSPRUIT

Quaternary Sub – catchment Name	Base Flow Ratio of MAR (%)	Base Flow (10^6 m^3/a)	Average Monthly Base Flow (10^6 m^3/a)	Average Base Flow Rate (m^3/s)
X11B	4.34	1.14	0.285	0.11

TABLE 15: BASE FLOW FOR SUB-CATCHMENT (S4)

Node Name	Base Flow Ratio of MAR (%)	Base Flow (10^6 m^3/a)	Average Monthly Base Flow (10^6 m^3/a)	Average Base Flow Rate (m^3/s)
S4	4.34	0.019	0.005	0.0018

TABLE 16: BASE FLOW FOR SUB-CATCHMENT (S5)

Node Name	Base Flow Ratio of MAR (%)	Base Flow (10^6 m^3/a)	Average Monthly Base Flow (10^6 m^3/a)	Average Base Flow Rate (m^3/s)
S5	4.34	0.026	0.007	0.0026

3.3. FLOOD HYDROLOGY

3.3.1. Design Storm

The closest rainfall gauging station to the proposed mining right area is the 0480267W – Kranspan. The design rainfall events associated with this gauging station is documented in the TR 102 Southern African Storm Rainfall.

For storm duration less than 6 hours the following relationship developed by Hershfield and later modified by Alexander is used to calculate point rainfall:

$P_t,T = 1.13(0.41 + 0.64^* \ell n\ T)(-0.11 + 0.27^* \ell n\ t)(0.79M^{0.69}R^{0.20})$

* R = 60 days/year that thunder is seen.

TABLE 17: DESIGN 24 HOUR RAINFALL DATA

Station Number	Description	MAP (mm)	24-Hour Rainfall (mm)						
			1:2	1:5	1:10	1:20	1:50	1:100	1:200
0480267	Kranspan	698	62	82	97	112	135	153	173

3.3.2. Flood Peaks and Volumes

The flood peaks was calculated utilising the Rational Method. The flood volume was calculated using a triangular hydrograph with the time of concentration equal to a third of the storm duration.

The table below summarises the peak flows and flood volumes for the range recurrence intervals.

TABLE 18: FLOOD PEAKS AND VOLUMES FOR WATER COURSES IN PROPOSED MINING RIGHT AREA

Catchment Name		Recurrence Interval						
		1:2	1:5	1:10	1:20	1:50	1:100	1:200
S1	Flood Peak (m^3/s)	32.7	58.9	81.3	107.1	141.5	171.6	194.3
	Flood Volume (10^3 m^3)	141.6	255.0	351.9	463.6	612.6	742.9	841.1
S2	Flood Peak (m^3/s)	4.0	7.2	10.0	13.0	17.2	20.9	23.7
	Flood Volume (10^3 m^3)	25.1	45.1	62.6	81.4	107.7	130.9	148.5
S3	Flood Peak (m^3/s)	2.3	4.2	5.8	7.6	10.1	12.2	13.8
	Flood Volume (10^3 m^3)	27.1	49.4	68.3	89.5	118.9	143.6	162.5
S4	Flood Peak (m^3/s)	14.2	25.5	35.5	46.4	61.4	74.4	84.3
	Flood Volume (10^3 m^3)	118.1	212.1	295.2	385.9	510.6	618.7	701.0
S5	Flood Peak (m^3/s)	23.7	42.6	59.2	77.4	102.4	124.2	140.6
	Flood Volume (10^3 m^3)	153.6	276.0	383.6	501.6	663.6	804.8	911.0

3.4. DRAINAGE DENSITY

The drainage density is the total stream and river lengths in a particular catchment divided by the total catchment area. The density of the drainage system will directly influence the proportion of the precipitation that will contribute to direct runoff.

The proposed mining right area's drainage density is therefore ***0.18 km/km²***.

4. Flood Levels In Pans

4.1. FLOOD VOLUMES

The maximum 100 year return period flood level in the pans was determined by calculating the water level associated with the largest runoff volume between the 1:100 year flood peak volume, the 1:100 year 1 day storm and the 1:100 year 7 day storm.

This approach was taken as the pans do not have outflows except for S3 which will only discharge a small portion of the incoming flood under extreme floods due to the culvert crossings under the R36 road beings roughly 1m above the current surveyed water level.

The flood volumes associated with various storm events are listed in the table below.

Table 19: Flood Volumes Into Pans

Node Name	1:100 year (flood peak volume) (10^3 m^3)	1:100 year (1 day storm flood volume) (10^3 m^3)	1:100 year (7 day storm flood volume) (10^3 m^3)
S1	742.9	710.9	***1 291.8***
S2	130.9	114.1	***207.2***
S3	143.6	127.1	***231.0***

4.2. PANS STAGE – STORAGE DATA

The stage versus storage volumes were calculated based on the survey with 1m contour intervals provided for the project. Although the pans dry up in winter the water edge level as on the day of the survey was taken as the normal water level. The mean annual runoff into all the pans is between two and four time less than the maximum 100 year flood volume.

It is expected that only during extreme events a noticeable rise in water level will be observed in the pans. The tables below list the stage vs accumulative storage volumes for the three pans marked as nodes “S1”, “S2” and “S3”

Table 20: Node “S1” Stage vs Volume

Node “S1”			
Stage (masl)	**Accu. Volume (10^3 m^3)**	**Stage (masl)**	**Accu. Volume (10^3 m^3)**
1654	0	1656	3 098
1655	1 444	1657	4 912

TABLE 21: NODE "S2" STAGE VS VOLUME

Node "S2"			
Stage (masl)	**Accu. Volume (10^3 m^3)**	**Stage (masl)**	**Accu. Volume (10^3 m^3)**
1654	0	1657	670.1
1656	312.8	1658	1 062.7

TABLE 22: NODE "S3" STAGE VS VOLUME

Node "S3"			
Stage (masl)	**Accu. Volume (10^3 m^3)**	**Stage (masl)**	**Accu. Volume (10^3 m^3)**
1651	0	1653	720.4
1652	298.3		

4.3. 100 YEAR FLOOD LEVELS

The water levels associated with the flood volumes for the three scenarios were calculated by applying a regression curve to the stage versus storage curves for each pan. In all three cases the 7 day storm event resulted in the highest water levels in the pans, the instantaneous flood peak events and the 1 day storm events produced similar levels.

These results support the observations from the site visit that no outflow from S1 and S2 is possible and that outflow from S3 is only expected for extreme events since the level reached during a 100 year event is still less than the estimated invert level of the culvert under the R36.

TABLE 23: 100 YEAR FLOOD LEVELS

Node Name	1:100 year (flood peak volume) Water Level (masl)	1:100 year (1 day storm flood volume) Water Level (masl)	1:100 year (7 day storm flood volume) Water Level (masl)
S1	1654.51	1654.49	***1654.90***
S2	1654.42	1654.37	***1654.66***
S3	1561.51	1561.46	***1651.80***

5. CONCLUSIONS

The conclusions drawn from the analyses done for the current situation are as follows:

- The proposed mining right area is located in the **X11B** quaternary sub-catchment of the Komati River Drainage Basin;
- The Boesmanspruit is the major stream flowing past the proposed mining right area with effective catchment areas of **597** km^2;
- The proposed mining right area has a Mean Annual Precipitation (MAP) of **698** mm;
- The proposed mining right area has a Mean Annual Evaporation (MAE) of **1 450** mm;
- The Nett Mean Annual Runoff (MAR) of the Boesmanspruit is **26.2** mil m^3;
- The proposed mining right area contributes **1.05** mil m^3 or **4.0**% of the nett mean annual runoff of the Boesman Spruit
- The Base / Normal Flow of the Boesmanspruit is **0.1** m^3/s;
- The proposed mining right area contributes **0.0044** m^3/s or **4.0**% of the base flow for the Boesman Spruit
- The drainage density of the proposed mining right area was calculated at **0.18** km/km^2;
- The recommended 100 year flood levels of the three most significant pans are as follows:
  - "S1" = 1 654.90 masl
  - "S2" = 1 654.66 masl
  - "S3" = 1 651.80 masl

6. REFERENCES

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*Alexander, W.J.R. 2000. **Flood risk reduction measures**, Revised Edition University of Pretoria*

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*Department of Water Affairs, PT Adamson, 1981, **Southern Africa Storm Rainfall, TR102***

APPENDIX A
WR90 - FIGURES AND TABLES

B.7

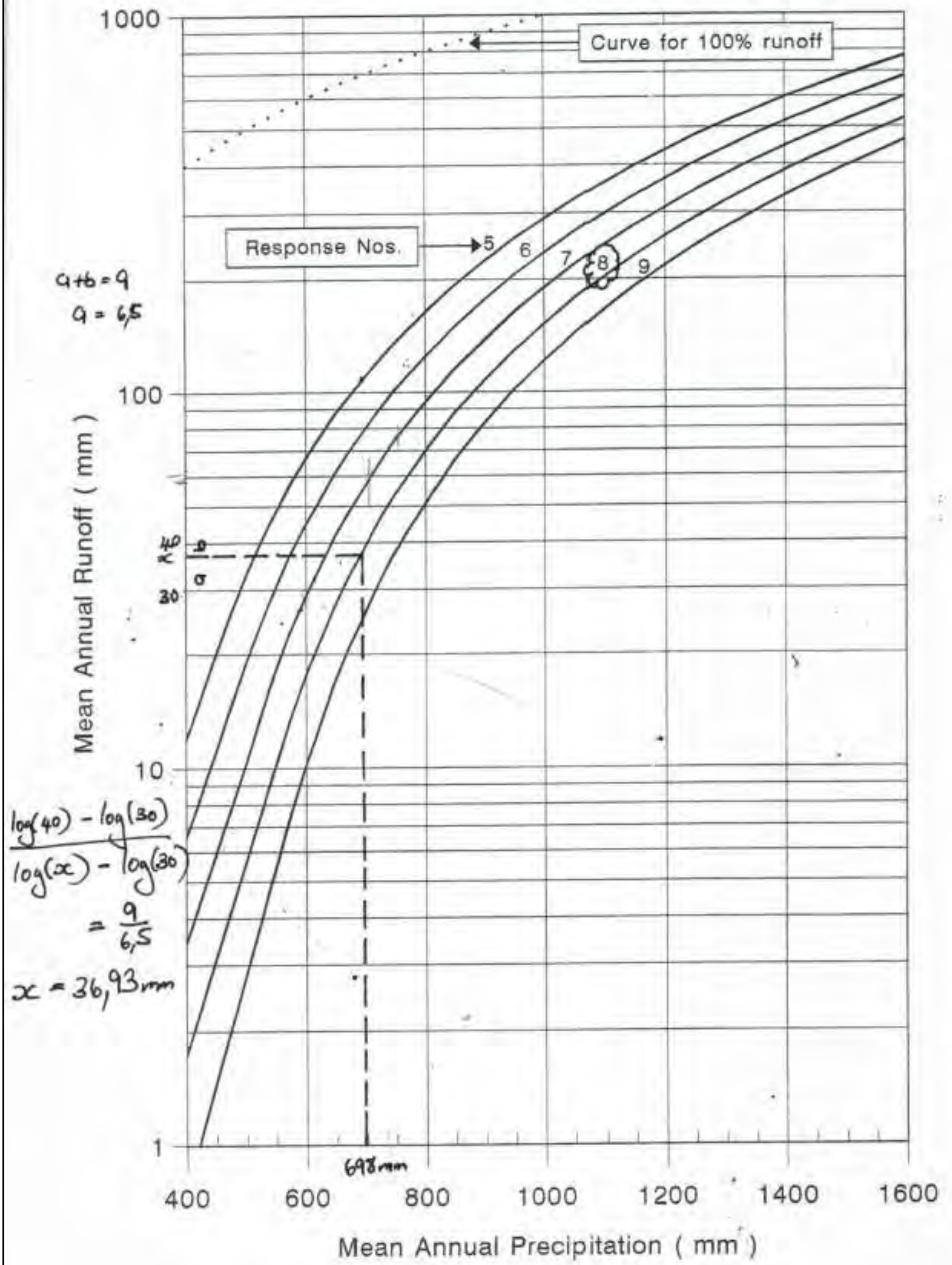
(VOLUME VI) APPENDIX B : QUATERNARY AND TERTIARY CATCHMENT INFORMATION (contd.)

CATCHMENT	GROSS AREA (km²)	NET AREA (km²)	FOREST AREA (km²)	IRRIG AREA (km²)	EVAP ZONE	MAE (mm)	RAIN ZONE	MAP (mm)	MAR (mm)	MAP-MAR RESP.	NET MAR (10^6m^3)	GROSS MAR (10^6m^3)	CV	HYDRO ZONE	DAMS
W57A	593	593		3.6	13A	1400	W5J	824	179	5	106.1	106.1	.704	C	
W57B	434	434		1.1	13A	1450	W5J	784	67	8	28.9	28.9	1.419	Q	
W57C	575	575		.4	13A	1450	W5J	-755	59	8	33.7	33.7	1.463	Q	
W57D	366	366		2.4	13A	1400	W5J	862	197	5	72.0	72.0	.696	C	
W57E	403	403		13.7	13A	1450	W5J	701	46	8	18.4	18.4	1.541	Q	
W57F	223	223		.3	13A	1450	W5J	774	151	5	33.7	33.7	.720	C	
W57G	623	623		1.7	13A	1450	W5J	644	34	8	21.2	21.2	1.612	Q	
W57H	426	426		62.2	13A	1500	W5J	710	45	8	19.4	19.4	1.533	Q	
W57J	522	522		37.1	13A	1500	W5J	628	30	8	15.7	15.7	1.622	Q	
W57K	301	301	3		13A	1500	W5J	628	30	8	9.1	9.1	1.622	Q	
W57	4466	4466	3	122.5		1453		729	80		358.0		1.023		
W60A	172	172	1	1.7	13A	1400	W6A	1156	411	5	70.7	70.7	.406	A	
W60B	143	143		3.4	13A	1400	W6A	1201	439	5	62.8	62.8	.406	A	
W60C	233	233		5.1	13A	1400	W6A	1161	414	5	96.5	96.5	.406	A	
W60D	187	187		6.8	13A	1400	W6B	937	206	6	38.5	38.5	.626	C	
W60E	134	134		.2	13A	1450	W6B	806	73	8	9.8	9.8	1.254	Q	
W60F	418	418		2.2	13A	1450	W6B	801	71	8	29.9	29.9	1.259	Q	
W60G	222	222		.8	13A	1400	W6A	912	187	6	41.5	41.5	.549	C	
W60H	365	365		1.6	13A	1450	W6B	796	70	8	25.5	25.5	1.264	Q	
W60J	447	447			13A	1450	W6B	819	77	8	34.5	34.5	1.241	Q	
W60K	665	665		115.9	13A	1500	W6B	825	75	8	50.1	50.1	1.238	Q	
W60	2986	2986	1	137.7		1445		893	154		459.8		.693		
W70A	2589	589	255		22C	1500	W3E	769	43	9	25.3	111.2	1.049	L	
W70	2589	589	255			1500		769	9.8		25.3		1.049		
X11A	672	672			5A	1450	X1A	682	35	8	23.7	23.7	.900	P	$
* X11B	597	597			5A	1450	X1A	714	44	8	26.2	26.2	.860	P	$
X11C	319	319	5		5A	1450	X1A	716	45	8	14.2	14.2	.857	P	$
X11D	590	590		11.8	5A	1450	X1B	744	88	6	51.8	51.8	.432	B	$
X11E	242	242	1	4.9	5A	1400	X1B	760	98	6	23.8	23.8	.441	B	$
X11F	183	183	1	3.7	5A	1400	X1B	820	120	6	22.0	22.0	.462	B	$
X11G	264	264	39	5.3	5A	1400	X1C	867	180	6	47.6	47.6	.333	B	$
X11H	265	265	42	5.3	5A	1400	X1C	951	222	6	58.8	58.8	.337	B	
X11J	186	186	138		5A	1400	X1C	1040	271	6	50.5	50.5	.334	B	$
X11K	211	211	21	16.3	5A	1400	X1C	895	194	6	40.9	40.9	.334	B	$
X11	3529	3529	247	47.3		1431		779	102		359.6		.410		
X12A	244	244	54	1.3	5A	1400	X1D	802	127	6	31.0	31.0	.446	B	
X12B	155	155	58	.8	5A	1400	X1D	834	140	6	21.8	21.8	.446	B	
X12C	186	186	1	1.1	5A	1400	X1D	876	160	6	29.7	29.7	.442	B	
X12D	223	223	14	8.2	5A	1400	X1D	860	80	8	17.9	17.9	.705	F	
X12E	333	333	113	2.0	5A	1400	X1D	889	91	8	30.3	30.3	.688	F	
X12F	313	313	22	1.9	5A	1400	X1D	870	84	8	26.2	26.2	.699	F	
X12G	239	239	3		5A	1400	X1D	901	96	8	22.9	22.9	.680	F	$
X12H	286	286			5A	1400	X1E	922	121	8	34.6	34.6	.772	F	
X12J	296	296	77		5A	1400	X1E	1158	232	8	68.6	68.6	.553	C	
X12K	286	286	4		5A	1400	X1E	911	116	8	33.2	33.2	.777	F	
X12	2561	2561	346	15.3		1400		910	123		316.2		.580		
X13A	245	245	50		5A	1400	X1E	1200	255	8	62.4	62.4	.549	C	
X13B	237	237	86		5A	1400	X1E	1157	231	8	54.8	54.8	.553	C	
X13C	195	195			5A	1400	X1E	1267	294	8	57.4	57.4	.540	C	
X13D	181	181	7	1.0	5A	1400	X1F	1185	268	8	48.5	48.5	.732	G	
X13E	212	212		1.2	5A	1400	X1F	1019	187	7	39.6	39.6	.746	G	
X13F	217	217	50	1.3	5A	1400	X1F	1007	182	7	39.4	39.4	.745	G	
X13G	335	335	6		5A	1400	X1F	822	82	8	27.4	27.4	1.287	Q	
X13H	306	306			5A	1450	X1F	742	54	8	16.5	16.5	1.429	Q	
X13J	789	789		7.7	5A	1500	X1H	676	32	8	25.4	-25.4	1.796	R	
X13K	621	621		79.4	5A	1550	X1H	609	19	7	11.8	11.8	2.112	C	$
X13L	286	286		36.5	5A	1550	X1H	605	18	7	5.3	5.3	2.126	C	$
X13	3624	3624	199	127.1		1464		842	107		388.5		.777		

$ At least one registered dam situated in the quaternary catchment
# The quaternary has been split into two hydro zones
* The MAP derived from the CCWR isohyetal map has been adjusted

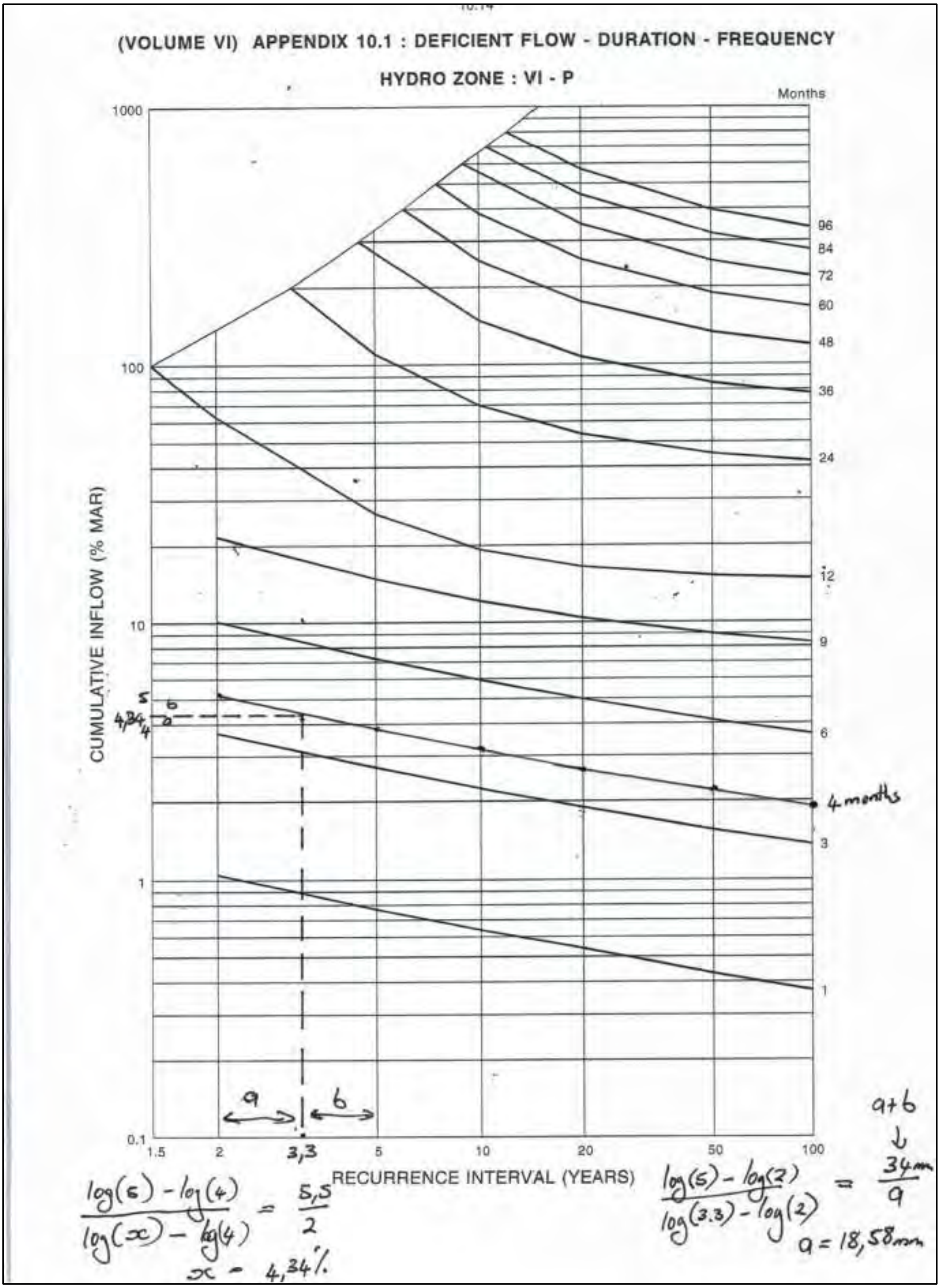
9.1

(VOLUME VI) APPENDIX 9 : RAINFALL - RUNOFF RESPONSE



(VOLUME VI) APPENDIX 10.2 : AVERAGE MONTHLY FLOWS EXPRESSED AS PERCENT MAR

HYDRO ZONE	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
VI-A	4.4	7.3	10.8	14.1	15.8	13.7	9.8	6.9	5.3	4.4	3.9	3.6
VI-B	4.1	9.2	13.6	15.4	15.8	12.3	8.7	6.3	4.7	3.8	3.2	2.9
VI-C	4.3	8.5	12.6	16.1	17.8	14.2	8.8	5.3	3.8	3.1	2.7	2.8
VI-E	4.8	9.3	13.6	17.7	18.8	16.9	8.0	3.3	1.8	1.3	1.5	3.0
VI-D	6.7	11.9	14.0	16.1	15.4	12.6	7.4	4.2	2.8	2.8	2.4	3.7
VI-F	3.5	6.7	11.8	15.6	19.4	14.4	8.2	5.6	4.5	3.8	3.4	3.1
VI-G	2.7	5.6	10.1	16.7	21.7	18.6	9.8	4.5	3.2	2.6	2.3	2.2
VI-H	5.8	12.9	16.6	20.0	17.3	11.5	6.1	3.0	1.7	1.4	1.4	2.3
VI-J	4.1	7.9	11.8	18.2	21.2	18.6	8.6	3.0	1.4	1.0	1.2	3.0
VI-K	6.8	9.3	10.0	10.5	13.1	16.5	10.2	6.2	5.0	3.5	2.9	6.0
VI-L	7.0	6.6	7.0	8.7	11.2	14.6	10.7	8.0	6.9	6.5	5.5	7.3
VI-M	8.5	8.5	9.1	8.3	12.9	14.3	8.9	7.3	5.6	4.9	3.8	7.9
VI-N	6.2	11.0	13.7	17.5	17.5	13.6	6.5	3.2	1.8	2.2	2.1	4.7
* VI-P	4.3	15.6	20.2	18.2	16.3	8.7	5.3	3.8	2.5	1.9	1.5	1.7
VI-Q	3.9	8.7	12.1	20.4	23.3	17.7	6.3	1.8	1.2	1.3	0.9	2.4
VI-R	0.3	3.7	8.9	22.2	35.4	23.1	5.7	0.4	0.0	0.0	0.0	0.3


(VOLUME VI) APPENDIX 10.1 : DEFICIENT FLOW - DURATION - FREQUENCY
HYDRO ZONE : VI - P
Months
96
84
72
60
48
36
24
12
9
6
4 months
3
1
CUMULATIVE INFLOW (% MAR)
1000
100
10
1
0.1
5
4,34
4
RECURRENCE INTERVAL (YEARS)
1.5
2
3,3
5
10
20
50
100
a
b
a+b
log(5) - log(4) / log(x) - log(4) = 5,5 / 2
x = 4,34%
log(5) - log(2) / log(3.3) - log(2) = 34mm / a
a = 18,58mm

APPENDIX B
FLOOD CALCULATIONS

Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	Kranspan - Coal Mine
Analysed by:	HS Peens
Name of river:	N/A
Description of site:	C1
Filename:	S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\C1.fld
Date:	9 January 2019

Printed: 28 January 2019 **Page 1**

Flood Frequency Analysis: Alternative Rational Method

```
Project                                 = Kranspan - Coal Mine
Analysed by                             = HS Peens
Name of river                           = N/A
Description of site                     = C1
Date                                    = 2019/01/09
Area of catchment                       = 15.49 km²
Dolomitic area                          = 0.0 %
Length of longest watercourse           = 3.62 km
Flow of water                           = Defined water course
Height difference along 10-85 slope     = 55.0 m
Area distribution                       = Rural: 92 %,  Urban: 0 %,  Lakes: 8 %

Catchment description - Urban area (%)
Lawns                          Residential and industry Business
Sandy, flat (<2%)       0      Houses            0      City centre       0
Sandy, steep (>7%)      0      Flats             0      Suburban          0
Heavy soil, flat (<2%)  0      Light industry    0      Streets           0
Heavy soil, steep (>7%) 0      Heavy industry    0      Maximum flood     0
Catchment description - Rural area (%)
Surface slopes                 Permeability             Vegetation
Lakes and pans          8      Very permeable    0      Thick bush & forests          0
Flat area               92     Permeable         100    Light bush & cultivated land  40
Hilly                   0      Semi-permeable    0      Grasslands                    60
Steep areas             0      Impermeable       0      Bare                          0
Days on which thunder was heard         = 60 days/year
Weather Services station number         = 480267
Weather Services station location       = KRANSPAN
Mean annual precipitation (MAP)         =  698  mm
Duration 2      5      10     20     50     100    200
1 day    62     82     97     112    135    153    173
2 days   77     102    120    140    167    189    213
3 days   86     115    136    158    188    213    240
7 days   113    151    179    207    246    278    312
The modified recalibrated Hershfield relationship was used to determine point rainfall.
-----------------------------------------------------------------------------------------------
Average slope                           = 0.02026 m/m
Time of concentration                   = 48.1 min
Run-off factor
Rural - C1                              = 0.326
Urban - C2                              = 0.000
Lakes - C3                              = 0.000
Combined - C                            = 0.300
-----------------------------------------------------------------------------------------------
Return   Time of       Point     ARF     Average    Factor   Runoff       Peak
period   concentration rainfall          intensity  Ft       coefficient  flow
(years)  (hours)       (mm)      (%)     (mm/h)              (%)          (m³/s)
-----------------------------------------------------------------------------------------------
1:2      0.80          27.89     97.1    33.81      0.75     22.5         32.72
1:5      0.80          47.05     97.1    57.03      0.80     24.0         58.88
1:10     0.80          61.55     97.1    74.60      0.85     25.5         81.83
1:20     0.80          76.05     97.1    92.17      0.90     27.0         107.05
1:50     0.80          95.21     97.1    115.39     0.95     28.5         141.47
1:100    0.80          109.70    97.1    132.96     1.00     30.0         171.59
1:200    0.80          124.20    97.1    150.53     1.00     30.0         194.26
Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable
catchments

Calculated using Utility Programs for Drainage 1.1.0
```

Utility Programs for Drainage
Flood calculations

Sinotech

Project name: Kranspan - Coal Mine
Analysed by: HS Peens
Name of river: N/A
Description of site: C2
Filename: S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVIL\05 Calculations\Stormwater\C2.fld
Date: 9 January 2019

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C2
Date	= 2019/01/09
Area of catchment	= 2.485 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 1.77 km
Flow of water	= Overland flow
Height difference	= 55.0 m
Value of r for over land flow	= Moderate grass (r=0,4)
Area distribution	= Rural: 88 %, Urban: 0 %, Lakes: 12 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	12	Very permeable	0	Thick bush & forests	0
Flat area	88	Permeable	100	Light bush & cultivated land	36
Hilly	0	Semi-permeable	0	Grasslands	64
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.03107 m/m
Time of concentration	= 1.16 h
Run-off factor	
Rural - C1	= 0.328
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.289

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	1.16	30.84	100.0	26.68	0.75	21.6	3.986
1:5	1.16	52.03	100.0	45.00	0.80	23.1	7.173
1:10	1.16	68.06	100.0	58.86	0.85	24.5	9.969
1:20	1.16	84.09	100.0	72.73	0.90	26.0	13.04
1:50	1.16	105.28	100.0	91.05	0.95	27.4	17.23
1:100	1.16	121.30	100.0	104.92	1.00	28.9	20.90
1:200	1.16	137.33	100.0	118.78	1.00	28.9	23.67

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	**Kranspan - Coal Mine**
Analysed by:	**HS Peens**
Name of river:	**N/A**
Description of site:	**C3**
Filename:	**S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\Kranspan Third.fld**
Date:	**9 January 2019**

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C3
Date	= 2019/01/09
Area of catchment	= 2.222 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 3.37 km
Flow of water	= Overland flow
Height difference	= 25.0 m
Value of r for over land flow	= Moderate grass (r=0,4)
Area distribution	= Rural: 90 %, Urban: 0 %, Lakes: 10 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	10	Very permeable	0	Thick bush & forests	0
Flat area	90	Permeable	100	Light bush & cultivated land	26
Hilly	0	Semi-permeable	0	Grasslands	74
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.00742 m/m
Time of concentration	= 2.18 h
Run-off factor	
Rural - C1	= 0.339
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.305

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	2.18	35.95	100.0	16.48	0.75	22.9	2.327
1:5	2.18	60.65	100.0	27.80	0.80	24.4	4.187
1:10	2.18	79.34	100.0	36.36	0.85	25.9	5.820
1:20	2.18	98.02	100.0	44.92	0.90	27.5	7.613
1:50	2.18	122.73	100.0	56.24	0.95	29.0	10.06
1:100	2.18	141.41	100.0	64.80	1.00	30.5	12.20
1:200	2.18	160.10	100.0	73.37	1.00	30.5	13.82

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	**Kranspan - Coal Mine**
Analysed by:	**HS Peens**
Name of river:	**N/A**
Description of site:	**C4**
Filename:	**S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\C4.fld**
Date:	**9 January 2019**

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C4
Date	= 2019/01/09
Area of catchment	= 11.86 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 5.74 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 40.0 m
Area distribution	= Rural: 90 %, Urban: 0 %, Lakes: 10 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	40	Very permeable	0	Thick bush & forests	0
Flat area	60	Permeable	100	Light bush & cultivated land	53
Hilly	0	Semi-permeable	0	Grasslands	47
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.00929 m/m
Time of concentration	= 1.54 h
Run-off factor	
Rural - C1	= 0.297
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.267

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	1.54	33.16	100.0	21.49	0.75	20.0	14.20
1:5	1.54	55.95	100.0	36.26	0.80	21.4	25.54
1:10	1.54	73.18	100.0	47.43	0.85	22.7	35.50
1:20	1.54	90.42	100.0	58.60	0.90	24.1	46.44
1:50	1.54	113.20	100.0	73.37	0.95	25.4	61.38
1:100	1.54	130.44	100.0	84.54	1.00	26.7	74.44
1:200	1.54	147.67	100.0	95.71	1.00	26.7	84.28

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Sinotech

Project name:	**Kranspan - Coal Mine**
Analysed by:	**HS Peens**
Name of river:	**N/A**
Description of site:	**C5**
Filename:	**S:\Peens and Associates\01 Projects\0155_Kranspan Surface Water\02 CIVL\05 Calculations\Stormwater\CA6.fld**
Date:	**9 January 2019**

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Flood Frequency Analysis: Alternative Rational Method

Project	= Kranspan - Coal Mine
Analysed by	= HS Peens
Name of river	= N/A
Description of site	= C5
Date	= 2019/01/09
Area of catchment	= 16.49 km²
Dolomitic area	= 0.0 %
Length of longest watercourse	= 4.62 km
Flow of water	= Defined water course
Height difference along 10-85 slope	= 40.0 m
Area distribution	= Rural: 90 %, Urban: 0 %, Lakes: 10 %

Catchment description - Urban area (%)

Lawns		Residential and industry		Business	
Sandy, flat (<2%)	0	Houses	0	City centre	0
Sandy, steep (>7%)	0	Flats	0	Suburban	0
Heavy soil, flat (<2%)	0	Light industry	0	Streets	0
Heavy soil, steep (>7%)	0	Heavy industry	0	Maximum flood	0

Catchment description - Rural area (%)

Surface slopes		Permeability		Vegetation	
Lakes and pans	40	Very permeable	0	Thick bush & forests	0
Flat area	60	Permeable	100	Light bush & cultivated land	50
Hilly	0	Semi-permeable	0	Grasslands	50
Steep areas	0	Impermeable	0	Bare	0

Days on which thunder was heard	= 60 days/year
Weather Services station number	= 480267
Weather Services station location	= KRANSPAN
Mean annual precipitation (MAP)	= 698 mm

Duration	2	5	10	20	50	100	200
1 day	62	82	97	112	135	153	173
2 days	77	102	120	140	167	189	213
3 days	86	115	136	158	188	213	240
7 days	113	151	179	207	246	278	312

The modified recalibrated Hershfield relationship was used to determine point rainfall.

Average slope	= 0.01154 m/m
Time of concentration	= 1.20 h
Run-off factor	
Rural - C1	= 0.300
Urban - C2	= 0.000
Lakes - C3	= 0.000
Combined - C	= 0.270

Return period (years)	Time of concentration (hours)	Point rainfall (mm)	ARF (%)	Average intensity (mm/h)	Factor Ft	Runoff coefficient (%)	Peak flow (m³/s)
1:2	1.20	31.15	98.5	25.54	0.75	20.3	23.69
1:5	1.20	52.54	98.5	43.08	0.80	21.6	42.62
1:10	1.20	68.73	98.5	56.35	0.85	23.0	59.24
1:20	1.20	84.92	98.5	69.62	0.90	24.3	77.49
1:50	1.20	106.32	98.5	87.16	0.95	25.7	102.41
1:100	1.20	122.50	98.5	100.43	1.00	27.0	124.21
1:200	1.20	138.69	98.5	113.71	1.00	27.0	140.62

Run-off coefficient percentage includes adjustment saturation factors (Ft) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

ILIMA COAL COMPANY (PTY) LTD

KRANSPAN 49-IT, MPUMALANGA

SURFACE WATER ECOSYSTEMS ECOLOGICAL SURVEYS & IMPACT ASSESSMENT

Prepared for:

ABS Africa (Pty) Ltd

Report authors: Dr Mathew Ross (*Pr Sci Nat*); Dr Tahla Ross
Report Ref: Kranspan_Wet 201903
Date: March 2019
Version: FINAL

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DECLARATION

PROJECT: ILIMA COAL COMPANY: KRANSPAN PROJECT: Surface Water Ecosystem Ecological and Impact surveys.

This report has been prepared according to the requirements of the Environmental Impact Assessments Regulations (GNR 982) in Government Gazette 38282 of 4 December 2014, and DWS (2008) Guidelines for wetland delineations. We (the undersigned) declare the findings of this report free from influence or prejudice.

Report Authors:

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MSc (Aquatic Health) (RAU)
PhD (Aquatic Health), (University of Johannesburg).

Field of expertise:

Fish ecology, fishway evaluations, biomonitoring and wetland evaluations, aquatic ecology, aquatic & terrestrial fauna and flora.

MJRoss

Date: 8 June 2019

Dr M Ross (*Pr Sci Nat*)

Dr Tahla Ross

PhD (Zoology) (RAU)

Field of expertise:

Biomonitoring and wetland evaluations, aquatic ecology, aquatic & terrestrial fauna and flora.

TRoss

Date: 8 June 2019

Dr T Ross

DISCLAIMER, ASSUMPTIONS & LIMITATIONS

The findings of the survey provided within this report, together with the results and general observations, and the conclusions and recommendations provided upon completion of the survey are based on the best scientific and professional knowledge of the field specialists. This is also dependent on the data and resources available at the time. The report is based on survey and assessment techniques that are limited by time and budgetary constraints relevant to the type and level of investigation undertaken.

Although EnviRoss CC and its research staff exercises due care and diligence in rendering services and preparing documents, EnviRoss CC accepts no liability, and the client, by acceptance of this document, indemnifies EnviRoss CC, members and employees against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by EnviRoss CC.

EXECUTIVE SUMMARY

Introduction & Background

Enviross CC was requested to undertake a survey and impact assessment of the surface water ecosystems for the proposed Ilima Coal Kranspan Project, located near Carolina in Mpumalanga Province. This report details the findings of a field survey undertaken during January 2019. The results within the report have been presented following collaboration with other specialists associated with the project, especially the soils and biodiversity specialists. The survey was undertaken to ascertain the overall ecological integrity of the wetland habitat units and watercourses, as well as to delineate ecologically sensitive wetland habitat features associated with the site/area that may be associated with the proposed mining activities, and to assess the possible impacts of the mining activities on the identified habitat units.

Methods & Materials

The methodologies employed for the wetland delineation were those outlined in the DWS (Department of Water and Sanitation) (2008) *Guidelines to identifying riparian zones and wetland boundaries*. These guidelines make use of four indicators of wetland habitats that enable the identification of a wetland. This does not necessarily mean that all four indicators are utilised, but rather that there are four indicators available to be utilised. Aspects such as severely degraded vegetation structures often lead to this indicator not being utilised. In this case, more emphasis is then placed on the other indicators. The four available indicators commonly used are:

- Terrain Unit Indicators (TUI)
- Soil Wetness Indicators (SWI)
- Soil Form Indicators (SFI)
- Vegetation Unit Indicators (VUI)

Consultation of various available mapping (1:50,000 topographical maps, GIS [Geographic Information Systems] databases), aerial photographs and catchment reviews formed part of an initial desktop study. The field survey concentrated on identifying the various wetland indicators by making use of samples taken with a soil auger, the digging of inspection pits, wetland floral species identification and the confirmation of topographical features that would support wetland formation and the observations of any saturated soils and surface water.

The outer edges of the temporary zones of the wetlands were then identified and mapped using a handheld GPS (Global Positioning System) unit. These data were then transformed into GIS (Geographic Information

System) shapefiles that can be incorporated into the construction and layout plans of the proposed development activities.

The ecological integrity of the various wetland units/systems, using the WETLAND-IHI and the ecological importance and sensitivity (EIS) were calculated. These indices take into consideration the water quality, vegetation structures, hydrological and geomorphological characteristics of the wetland units, as well as the wetland ecological services (such as water quality enhancement, flood attenuation, resource provision, etc) that the wetland units provide.

Results & Discussions

The proposed development area falls within the quaternary catchment of X11B, which falls within the Komati/Crocodile primary catchment area. The main watercourse draining X11B to the northeast is Boesmanspruit, which drains into the Nooitgedacht Dam, located at the northern point of the catchment area. Main watercourses within the catchment area are shown to have retained an overall B (largely natural) present ecological state (SANBI, 2010).

The desktop review reiterated by a ground-truthing field survey showed that the proposed development area has an association with relatively large expanses of wetland units. Being located relatively high in the catchment area, valley-head seep zones feeding into unchannelled and channelled valley-bottom wetland units were common. Valley-bottom wetland units were also supplemented by hillslope seepages. Depression wetland units were also noted to be relatively common within the survey area. The main present land use is formal agriculture and much of the outer wetland zones are impacted by cultivation. Impoundments, which have been historically constructed to aid in agricultural practice, are also commonplace and impact all of the watercourses.

The main present pressures and drivers of ecological change were shown to be the formal agriculture (cultivation) that surrounds the majority of the wetland units, and the numerous impoundments along all watercourses. The impact of current mining activities adjacent to the proposed Kranspan Mining Right Area (within the northern part of the survey area), was evident in the altered water quality of the one depression wetland that would be the recipient of runoff water from these areas. The water quality (following laboratory analysis) of the remaining surface waters has retained relatively good status, barring elevation of components that one would expect from the dominant land use being cultivation.

The proposed development area was delineated into three main surface water ecosystem units. The WETLAND-IHI rated all of these units to within a C Present Ecological State (PES) category (moderately modified), with a relatively high ecological importance and sensitivity.

The DWS Risk Assessment Matrix noted a high risk associated with all of the activities that would include wetland habitat units and cause the potential destruction, degradation or transformation thereof.

The impact significance ratings were also calculated, which showed that many impacts are rated as being high (before mitigation), which is largely due to the impacts being associated with wetland habitat units. The significance of the impacts is largely dependent on the extent of wetland habitat to be included in the development footprint and thus to be removed the severity of the associated impacting features if fringing on wetland habitat units. Applying appropriate mitigation measures shows that significance of most of the impacts can be reduced.

It should be noted, however, that much of the wetland complexes, especially peripheral temporary zones and less established wetland areas, have been cultivated and have therefore lost much of their function due to the land use. These areas, although considered to offer a supportive role to the more established wetland units, have largely lost their ecological function.

Conclusions & Recommendations

A field survey was undertaken during January 2019 in order to evaluate the surface water ecosystems associated with the area pertaining to the proposed development of the Ilima Coal Kranspan Project. Following the field survey of the proposed development area and the associated impact assessment, and taking into consideration the results and findings of the soils and biodiversity specialists associated with the project, the following salient recommendations can be proposed to aid in the conservation of the overall ecological integrity of the wetlands within the region:

- The proposed development area was shown to incorporate a relatively high proportion of wetland habitat units, ranging from valleyhead seeps, hillslope seeps, channelled and unchannelled valley-bottom and depression-type wetland units. These units have been delineated and their outer boundaries, together with conservation buffer zones, are presented in Figure 15;
- The wetland units are interspersed amongst formal cultivation, which is considered to be the main pressure and driver of ecological change at present, and much of the peripheral wetland units have

lost functionality and ecological contribution due to cultivation. This was taken into consideration when developing the final buffer zone designation (as indicated in Figure 15);

- The wetland units were shown to all fall within a PES category range of C (moderately modified) to D/E (largely modified), with a high ecological importance and sensitivity;
- Laboratory analysis of water samples showed that the wetlands retain a relatively good water quality, excepting for one depression wetland that is subject to runoff from mining areas located to the north, adjacent to the proposed Kranspan Mining Right Area. Water quality within this wetland unit has been degraded to the point of posing a risk to both human and livestock health;
- The DWS Risk Assessment Matrix indicates that all proposed mining activities that will impact the wetland directly carry a high risk factor. The impact significance ratings also indicate that the potential impacts carry a high significance post mitigation. The significance of the impacts is largely due to the direct involvement of deleterious impacts to wetland habitat units. The significance is, however, largely dependent on the extent of wetland habitat that will be directly affected by mining activities and the severity of those impacts;
- The presented infrastructure layout indicates that some wetland areas are required to be included within the mining area and therefore will be lost. The significance of the ecological loss is dependent on the sensitivity as well as the present functionality of the wetland units. Ultimately, infrastructure layout planning that takes into consideration the wetland delineation mapping, associated conservation buffer zones, as well as the proposed mitigation measures, can greatly reduce the overall significance of the impacts to the wetland systems associated with the site.

It should be noted that, in order to conserve the wetland ecological structures within the area, the wetland needs to be viewed as an interconnected larger system and the individual units should be managed as such. This includes keeping general habitat destruction and construction footprints to an absolute minimum within the terrestrial habitat as well. Conserving the habitat units will ultimately conserve the species communities that depend on it for survival. This can only be achieved by the efforts of the contractor during the construction phase and by strict management during the operations phase.

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1. INTRODUCTION

1.1. Background

Ilima Coal Company (Pty) Ltd has initiated the process of the mining rights application for all of the property portions of the farm Kranspan 49-IT, located to the southwest of the town of Carolina in Mpumalanga Province. EnviRoss CC has been requested by ABS Africa (Pty) Ltd to undertake the necessary ecological surveys and associated impact assessment pertaining to the surface water ecosystems associated with the project area. The locality of the site is presented in Figure 1. This report details the findings of a survey that was undertaken during January 2019.

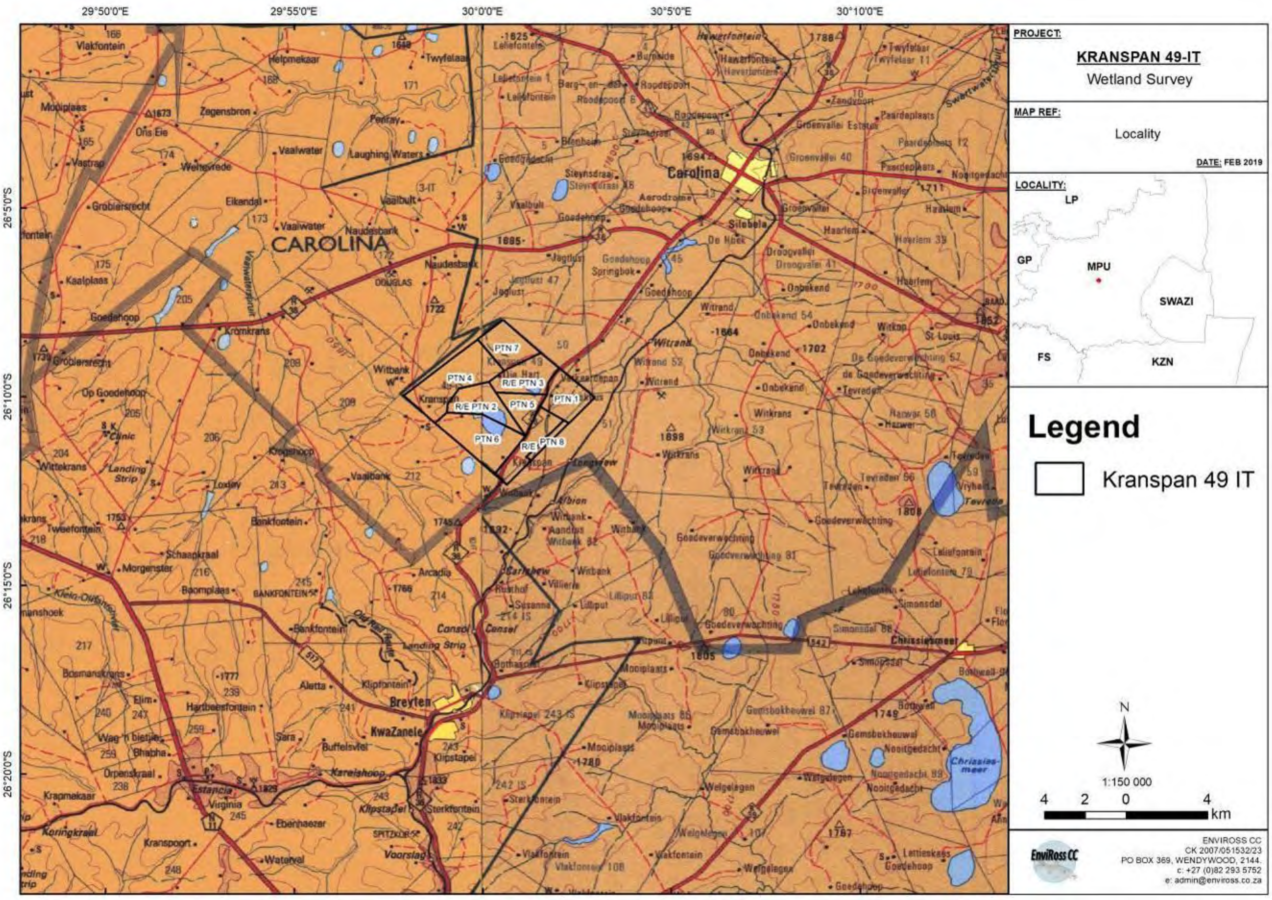


Figure 1: Locality of the survey area.

1.2. Scope of Work

The Scope of Work for the surface water ecosystem survey was to determine the overall ecological integrity and functionality of the surface water ecosystem units that are associated with the development area and to designate appropriate conservation buffers to these units as a protective factor to the wetland units from the terrestrial development activities. The ecological integrity of the wetland habitat units was also to be determined which would allow for the determination of the overall significance of the impacts to the wetland and aquatic habitat units.

Application of the DWS Risk Assessment Matrix was also to be applied to the wetland units associated to the development area as part of the survey.

1.3. Assumptions & Limitations

The conclusions to the overall perceived impacts have been based on a desktop survey that was reiterated by ground-truthing through a single field survey of the area encompassing the proposed development. Even though vegetation structures and some floral species are mentioned within the report, this mention is purely for the purpose of delineating the wetland boundaries and is not meant as an account of the full species lists and ecological potential of the proposed development site.

2. AIMS & OBJECTIVES

The objective of this report is to indicate the present ecological state of the surface water ecosystem units as well as to indicate the limits of the outer boundaries of these units that are associated with the survey area. The survey also aims to offer recommendations to the general management of the wetland units in order to limit the present and potential future deleterious impacts. This information can be utilised as supporting information for the design, construction and management teams of the proposed development activities.

The report was also to be generated as a supporting document according to the requirements of the Environmental Impact Assessments Regulations (GNR 982) in Government Gazette 38282 of 4 December 2014, and DWS (2008) Guidelines for wetland delineations.

3. APPLICABLE LEGISLATION

3.1. National

Conservation of aquatic and wetland habitat units and resources is protected by a myriad of legislature, including the Constitution of South Africa (Act no 108 of 1996), which states that everyone has a right to an environment that is not harmful or detrimental to their health and which is sustainable for future generations. Further to this, South Africa uses environmental-specific legal frameworks based on principles found in the National Environmental Management Act (NEMA) (Act no 107 of 1998). Section 28 (1) states that any person who causes or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment.

The National Water Act (Act no 36 of 1998), which is the main water regulation statute of South Africa, defines what is meant as a "water use" as activities that require authorisation. Sections most applicable to developments impinging upon or within surface water ecosystem boundaries, including wetlands, are section 21(c) *impeding or diverting the flow of water in a watercourse;* and 21(i) *altering the bed, banks, course or characteristics of a watercourse*. As per definition, this means any change affecting the resource quality within the riparian habitat or 1:100 year flood line, whichever is the greater distance. Subsequent to this, DWA issued a Government Notice (GN) within the Government Gazette, No 1199 (18 December 2009), in which Section 6(b) indicates that any development within a 500 m radius of any wetland must seek authority through a Water User Licence Application (WULA) and that authority for these activities through a General Authorisation is no longer applicable (discretionary powers do, however, lie with DWS authorities on a *per project* basis). As the development activities are within a 500 m radial regulatory zone of the surrounding wetlands, authority will have to be sought prior to any development taking place.

4. WETLANDS FORMS AND FUNCTIONS

A wetland is defined as land that is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water and which, under normal circumstances, supports or would support vegetation typically adapted to life in saturated soil (National Water Act 36 of 1998). The identification of a wetland therefore requires a combination of factors, including hydrological (water drainage and movement), geomorphological (soil types, characteristics and inundation) as well as vegetation (identification of hydrophytic species and communities).

4.1. Hydrogeomorphic forms

The classification of the hydrogeomorphic forms of wetlands associated with the proposed development area are based on those defined in Table 1. Wetland units form and are supported by an interplay of various physical and biological features. Underlying soil layering that inhibits percolation through the soils, topographical features, erosive forces and the quantity and origin of the water source all dictates the hydrogeomorphic form of any particular wetland unit.

Table 1: Hydrogeomorphic forms of wetland habitat units.

Hydrogeomorphic types		Description	Source of water maintaining the wetland	
			Surface	Sub-surface
Floodplain		Valley bottom areas with a well-defined stream channel, gently sloped and characterised by floodplain features such as oxbow depressions and natural levees and the alluvial (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*
Valley bottom with a channel		Valley bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterised by the net accumulation of alluvial deposits or may have steeper slopes and be characterised by net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*/***
Valley bottom without a channel		Valley bottom areas with no clearly defined stream channel, usually gently sloped and characterised by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from the channel entering the wetland and also from adjacent slopes.	***	*/***
Hillslope seepage linked to a stream channel		Slopes on hillsides, which are characterised by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and output is usually via a well-defined stream channel connecting the area directly to a stream channel.	*	***
Isolated hillslope seepage		Slopes on hillsides, which are characterised by the colluvial movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a stream channel.	*	***
Depression (includes pans)		A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water. An outlet is usually absent, and therefore this type is usually isolated from the stream channel network.	*/***	*/***

Wetland units also tend to be interconnected, with a seep zone often developing into a valley-bottom wetland, which then often develops into an established aquatic riverine system that then acts as a drainage watercourse for the catchment area.

4.2. Soil types and characteristics

The occurrence of wetland conditions is almost primarily due to a combination of soil conditions (including stratification characteristics), soil type, and a water source (surface water, lateral movement of soil water, or the upwelling of groundwater). Soil forms that are regarded as being always associated with wetland conditions include Champagne, Katspruit, Willowbrook and Rensburg soils. Those soil forms that are *sometimes* associated with wetlands include Inhoek, Klapmunts, Dresden, Bloemdal, Dundee, Longlands, Tukulu, Avalon, Witfontein, Wasbank, Cartref, Pinedene, Sterkspruit, Lamotte, Fernwood, Glencoe, Sepane, Estcourt, Westleigh, Bainsvlei and Valsrivier (DWAF, 1999).

The degree of soil saturation is also important in discerning temporary, seasonal and permanent zones of wetland habitat units, as well as the colour (chroma) and degree of ferrolysis (observable as mottling) within the upper 500 mm of the soil profile. This feature is elaborated on under the section of Wetland Delineation Methods.

A specialist soil survey was undertaken for the site and close interaction between the soil specialist (Earth Science) and Enviross (as the wetland ecologists) was undertake throughout the various phased of the survey. This was also true for the terrestrial biodiversity specialists (Ecorex) assigned to the project.

4.3. Vegetation structures

Wetlands tend to be transitional in nature and therefore a gradual transition of soils, inundation and vegetation structures can be observed from the terrestrial areas, temporary, seasonal and into the permanent zones of a wetland. The ability to identify and differentiate wetland floral species as being obligate wetland species, facultative wetland species, facultative species and facultative dryland species is important in discerning the occurrence of wetland conditions. Vegetation associated with any wetland units within the survey area tended to be facultative wetland species. Due to the arid climate of the region, surface water retention is limited to shortened periods and therefore wetland units tend to be temporary or seasonal in nature.

5. METHODS OF INVESTIGATION

5.1. Desktop survey

Scrutiny of topographical maps, aerial photography and available GIS mapping databases (provincial and national) as well as the latest available literature and online databases (from SANBI, DWS, DEAT, ADU, etc) were used to set the baseline data for the proposed development site.

5.2. Wetland delineation methods

The wetland delineation assessment includes review of topographical maps and aerial photographs and an 'on-site' evaluation of the wetland and associated vegetation structure condition. This includes the general ecological integrity of the wetland itself as well as the identification of any sensitive biota that are potentially dependant on the wetland (if applicable).

The wetland delineation procedure takes into account (according to DWS guidelines for wetland delineations, 2008) the following attributes to determine the limitations of the wetland:

- Terrain Unit Indicator – helps to identify those parts of the landscape where wetlands are more likely to occur (valley-bottoms, depressions, etc);
- Soil Form Indicator – identifies the hydromorphic soil forms, which are associated with prolonged and frequent saturation and associated anoxia and ferrolysis;
- Soil Wetness Indicator – identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation; and,
- Vegetation Indicator – identifies hydrophilic vegetation associated with frequently saturated soils.

According to the wetland definition used in the National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role. The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained (perhaps several centuries) (DWA, 2005).

5.2.1. Terrain Unit Indicator (TUI)

The TUI takes into consideration the topography of the area to determine those areas most likely to support a wetland (DWS, 2008). These include depressions and channels where water would be most likely to accumulate. This is done with the aid of topographical maps, aerial photographs and engineering and town planning diagrams (these are most often used as they offer the highest degree of detail needed to accurately delineate the various zones of the wetland). Seepage zones are also very often characterised by depressions, the identification of which aids in determining the presence of a wetland.

5.2.2. Soil Form Indicator (SFI)

The SFI takes into account the identification of hydromorphic soils that display unique characteristics resulting from prolonged and repeated saturation. This ongoing saturation leads to the soil eventually becoming anaerobic and therefore a change in the chemical characteristics of the soil. Certain soil components, such as iron and manganese, which are insoluble under aerobic conditions, become soluble when the soil becomes anaerobic, and can thus be leached out of the soil profile. Iron is one of the most abundant elements in soils, and is responsible for the red and brown colours of many soils. Once most of the iron has been dissolved out of the soil as a result of the prolonged anaerobic conditions, the soil matrix is left a greyish, greenish or bluish colour, and is said to be “gleyed”. A fluctuating water table, common in wetlands that are seasonally or temporarily saturated, results in alternation between aerobic and anaerobic conditions in the soil. Aerobic conditions in the soil leads to the iron returning to an insoluble state and being deposited in the form of patches or mottles within the soil. Recurrence of this cycle of wetting and drying over many decades concentrates these insoluble iron compounds. Thus, soil that is gleyed and has many mottles may be interpreted as indicating a zone that is seasonally or temporarily saturated (DWS, 2008).

Figure 2: Inspection pits dug to observe *in situ* soil profiles.

Soil samples are taken periodically in a line running perpendicular to the permanent water zone until the outer limits of this zone are identified. This normally coincides with a particular contour level, but transformations and modifications to the landscape often lead to the zone limits not conforming to this theory. Soil samples are taken using a Dutch-type soil auger to a depth of 500 mm. The soil sample is then examined for indications of soils particular to the characteristics described above. Sample pits are also dug periodically as a more thorough and therefore more reliable means of confirming the presence or absence of hydromorphic soil characteristics. These were dug using a garden spade and the profiles thus created were examined for hydromorphic processes within the soil.

5.2.3. Soil Wetness Indicator (SWI)

In practise, this indicator is used as the primary indicator, but can be rendered unreliable during heavy rainfall periods. The colour of various soil components are also often the most diagnostic indicator of hydromorphic soils. Colours of these components are strongly influenced by the frequency and duration of soil saturation. Generally, the higher the duration and frequency of saturation in a soil profile, the more prominent grey colours become in the soil matrix. Coloured mottles, another feature of hydromorphic soils, are usually absent in permanently saturated soils, and are at their most prominent in seasonally saturated soils, becoming less abundant in temporarily saturated soils, until they disappear altogether in dry soils (DWA, 2005). This indicator is also identified by taking a soil sample using a Dutch-type soil auger to a depth of 500 mm. The soil sample is then examined for indications of soils displaying these characteristics.

5.2.4. Vegetation Indicator (VI)

Vegetation is a key component of the wetland definition in the National Water Act (Act 36 of 1998). However, using vegetation as a primary indicator requires undisturbed conditions and expert knowledge (DWA, 2005). As a result of this, greater emphasis is often placed on the SWI and SFI. Nonetheless, plant community structure analyses are still viewed as helpful guides to finding the boundaries of wetlands. Plant communities undergo distinct changes in species composition along the wetness gradient from the centre of the wetland to the edge, and into adjacent terrestrial areas. This change in species composition provides valuable clues for determining the wetland boundary, and wetness zones. When using vegetation indicators for delineation, emphasis is placed on the group of species that dominate the plant community, rather than on individual indicator species (DWA, 2005). In wetlands that have undergone extensive transformation through landscaping, the vegetation unit indicators can potentially be absent.

5.3. Assessing the Present Ecological State (PES) of the wetland habitat units

5.3.1. Wetland Index of Habitat Integrity (WETLAND-IHI)

The WETLAND-IHI (Wetland Index of Habitat Integrity) was a wetland habitat assessment tool used to establish the overall PES of the wetland unit associated with the proposed development site. The WETLAND-IHI was developed as a tool for use in the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP), formerly known as the River Health Programme (RHP). The WETLAND-IHI was developed to allow the NAEHMP to include *floodplain and channelled valley bottom wetland types* to be assessed and the monitoring data incorporated into the national monitoring programme (DWA, 2007). Neither of these wetland hydrogeomorphic units were present at the site and therefore the WETLAND IHI methodologies do not apply. A descriptive analysis based on observations will therefore be provided in terms of hydrological, geomorphological, vegetation and water quality features.

Further observations of general ecological integrity at each site during the routine surveys will also be reported on. These points include:

- Erosion trends;
- Degree of siltation at downstream points;
- Unnecessary vegetation removal;
- Other general impacts on the aquatic system (dumping of rubble, litter, etc).

5.3.2. WET-Ecoservices

WET-Ecoservices was used to assess the goods and services that individual wetlands provide (Kotze et al, 2007). This is taken as a combination of both ecological services and provision of services and resources to users. Through a series of scoring matrices for 15 different goods and service characteristics of a particular wetland, a rating score (out of 4) is provided. This is then compared to the class categories presented in Table 2. This sensitivity categorisation is based on strategic ecological functionality classes typical of environmental scoring systems, with this particular categorisation being based on those established by Wetland Consulting Services (2007).

Table 2: Recommended ecological importance and sensitivity categories (*taken from* WCS, 2007). Interpretation of the median values and categories is also provided.

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very high Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and ≤4	A
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and ≤3	B
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and ≤2	C
Low/marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and ≤1	D

5.3.3. Water quality analysis

Samples from four localities that included persistent surface waters and represented the various main watercourses within the proposed development area were taken and sent to a laboratory for analysis for elemental components and bacterial inclusion.

5.3.4. Mapping, sensitivity analysis and designation of buffer zones

From the field survey observations and delineation procedures, a handheld GPS (Global Positioning System) (Model: *Garmin Montana 650*) was used to mark the outer edges of the various wetland zones. These data are then compared to aerial imagery to generate digital shapefiles (ArcGIS) and maps of the various wetland zones.

National legislature does not specify a distance for buffer zone regulations pertaining to wetland units, but developments that are associated with surface water ecosystems are required to gain permission through the Department of Water and Sanitation (DWS) prior to permission being granted to start the construction phase of the proposed development. The current DWS guidelines allude to an "appropriate buffer zone in accordance to the surrounding land use" (DWAF, 2008). The extent of the buffer zone is determined by taking into consideration the land use, the potential impacts to the surface water ecosystems, the ecological status of the wetland units and the systems that are fed by the water source that comes from the wetland units. Special restrictions should be imposed on construction activities that are to be undertaken within these conservation zones to limit the overall negative ecological impacts of these activities.

Workshop sessions and correspondence between the specialists pertaining to terrestrial biodiversity, soil profiles and wetland ecology were undertaken in order to draft a sensitivity map that indicates the sensitive ecological features of the site. An overall sensitivity map could then be developed for the proposed development area, which takes into consideration the ecologically sensitive features, whilst considering the overall ecological condition of the surrounding area.

5.4. Risk Assessment Matrix

The DWS developed a risk-based analysis matrix (published in Government Gazette 39458, Notice 1180 of 2015, 27 Nov 2015) that stipulates that a Risk Assessment Matrix be applied to water uses in terms of the National Water Act (Act 36 of 1998), which than allows for the categorisation of the severity of the ecological risks pertaining to proposed developments associated with wetland habitat units. Based on the outcome of the Risk Assessment Matrix, *Low* risk activities will be generally authorised with conditions, while *moderate* to *high* risk activities will be required to go through a Water Use Licence Application (WULA) Process. Water use activities that are authorised in terms of the General Authorisations (GA) will still need to be registered with the DWS. The Risk Assessment Matrix has been used in the assessment of the risk posed to the wetland ecosystems for the proposed development in an attempt to better quantify the risk to the resource.

The categories (and interpretations of the scores) are assigned to the final ratings based on the ratings analysis (Table 3).

Table 3: Ratings of the risk and associated management descriptions (DWS, 2015).

RATING	CLASS	MANAGEMENT DESCRIPTION
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.
56 – 169	M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Licence required.
170 – 300	(H) High Risk	Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve. Licence required.

6. RESULTS & DISCUSSIONS

6.1. Study area & catchment characteristics

The survey area falls within the Sabie/Crocodile/Komati (X) Primary catchment, the X1 Secondary catchment and the Inkomati/Usuthu (3) DWS water management area. It falls within the X11B quaternary catchment. The watershed associated with the survey area drains toward the Boesmanspruit, which drains northwards. The Nooitgedacht Dam is located at the northern end of the quaternary catchment, at the confluence of the Boesmanspruit, Vaalwaterspruit and Witkloofspruit. The watercourse from the dam draining toward the northeast is the Komati River. The DWS has designated Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (ES) for all of the catchment areas nationally. The quaternary catchment of X11B has a PES of C (moderately modified), an EI of moderate and an ES of high (DWS, 2014). The Boesmanspruit has retained a PES of B (near natural) up until it drains into Nooitgedacht Dam, after which the Komati River (which is the main watercourse leaving the dam) has a PES of C (moderately modified) (SANBI, 2009 & NFEPA, 2010) (Figure 3). The region is shown to have a relatively low mean annual runoff as well as a relatively low groundwater recharge (Figure 4 and Figure 5). Land use within the region is dominated by formal agriculture and mining and the associated transformation to physical characteristics and degradation of water quality tend to be the main pressures and drivers of ecological change of the surface water ecological features.

Mpumalanga Province conservation authorities have developed a biodiversity spatial conservation plan (Mpumalanga Biodiversity Conservation Plan – MBCP) that details the importance of various regions to the conservation of natural resources throughout the province. Figure 6 shows that much of the site has been categorised as “highly significant”. This is due to the area providing a source of water and the refugia offered and biodiversity supported by the interconnected wetland habitat.

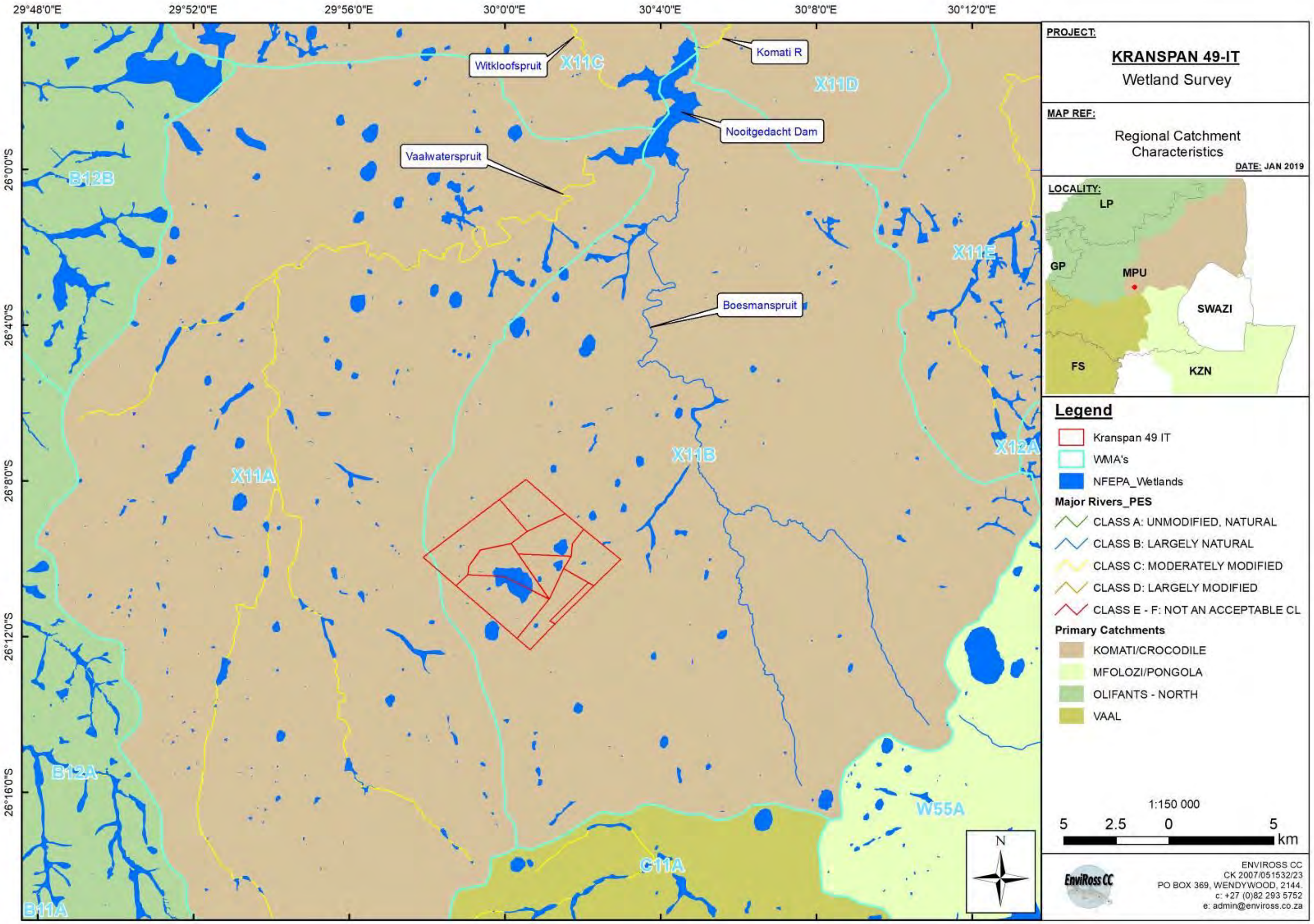


Figure 3: Regional catchment details.

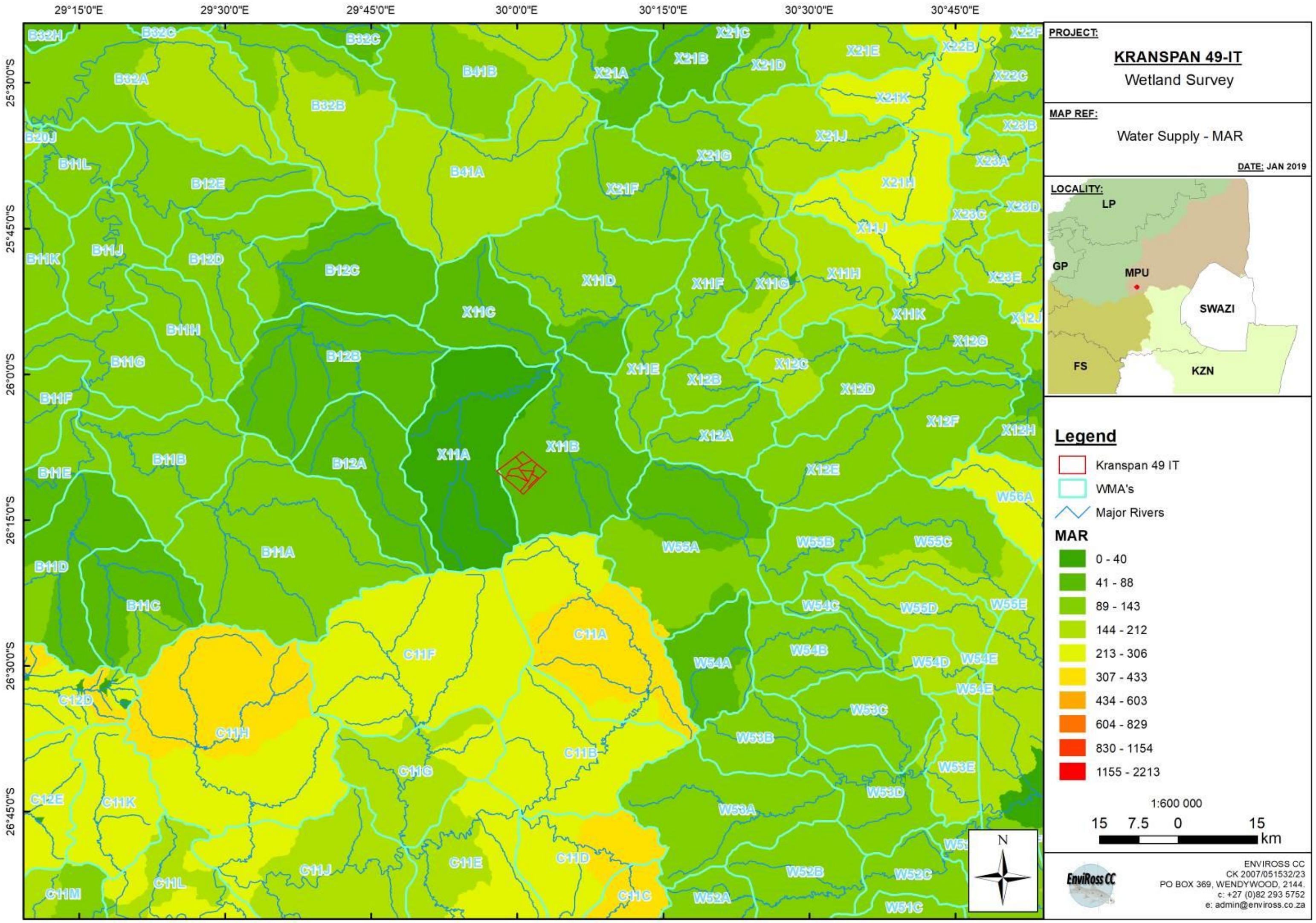


Figure 4: The Mean Annual Runoff (MAR) of the region.

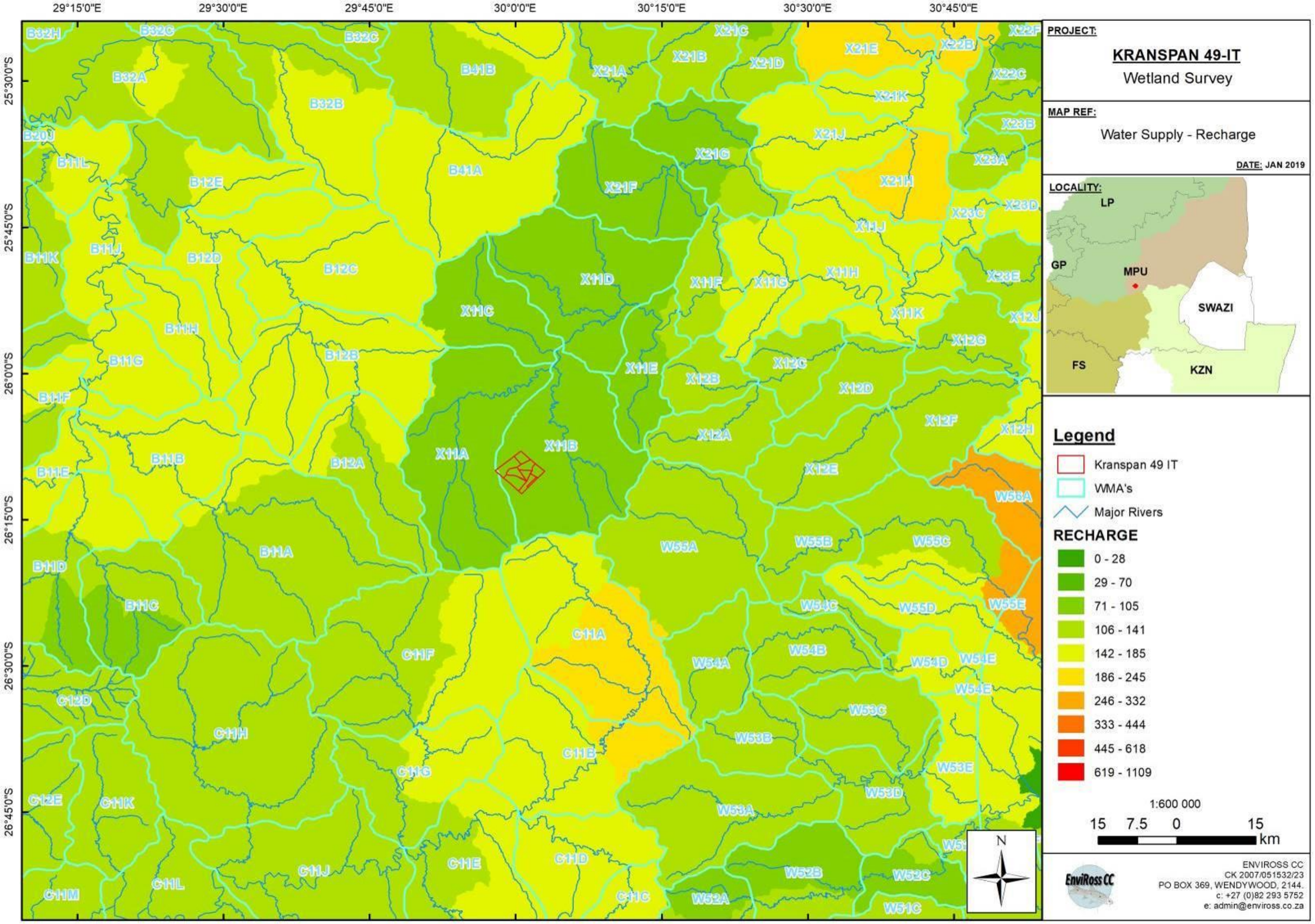


Figure 5: The recharge status of the region.

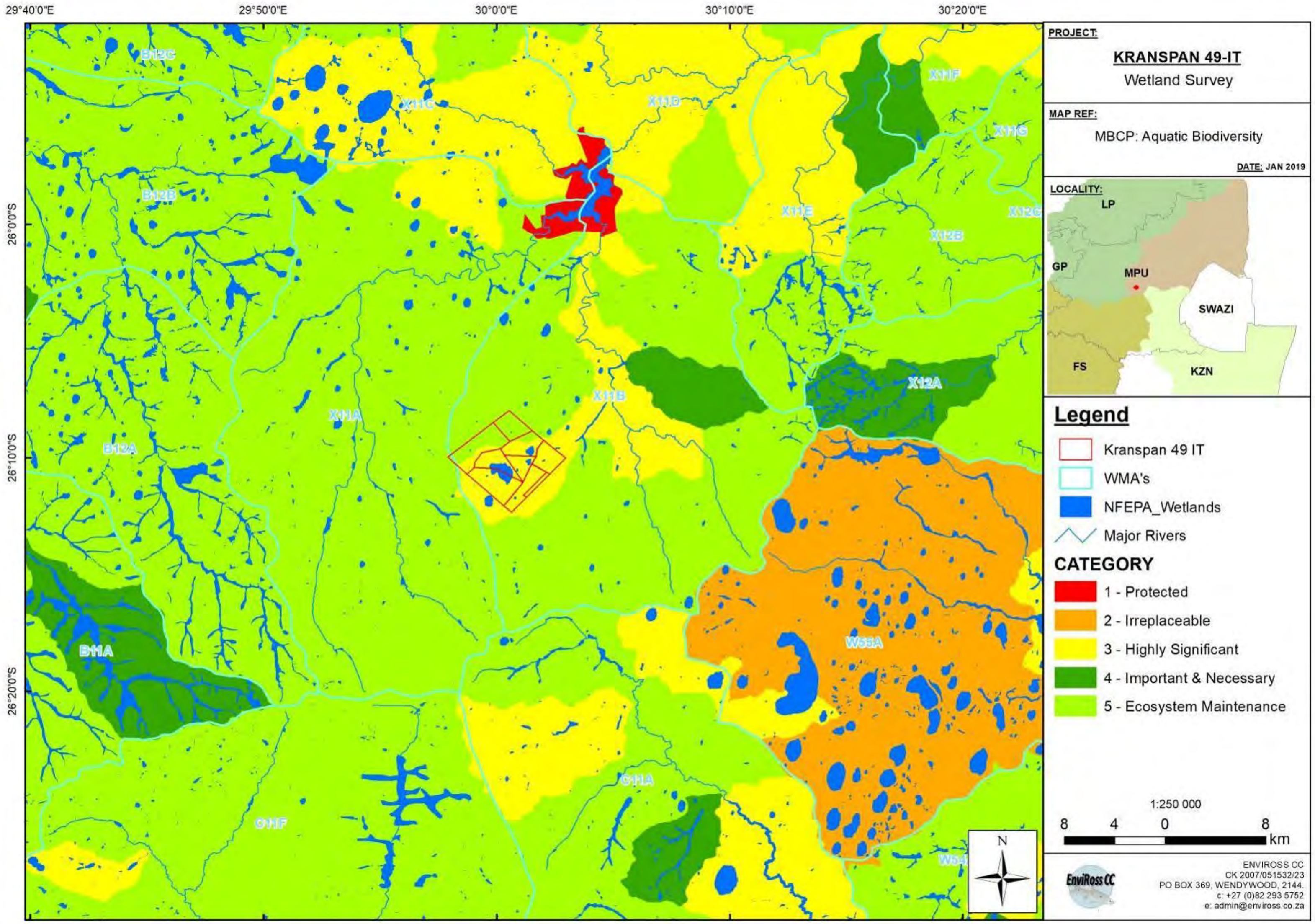


Figure 6: The MBCP for the region associated with the proposed development area pertaining to the protection of the aquatic resources.

The dominant veld type of the surrounding area is Eastern Highveld Grassland, of the Mesic Highveld Grassland bioregion within the Grassland biome. Conservationally, this is regarded as an *endangered* vegetation type, which is largely due to largescale transformation to accommodate the agricultural and mining sectors and the general lack of protection within conservation areas. Well-developed wetlands within the region include the vegetation type of Eastern Temperate Freshwater Wetlands, which is an azonal inland freshwater vegetation type. This is regarded as *Least Threatened* conservationally (Mucina & Rutherford, 2006).

6.2. General local survey area condition

The survey area is dominated by formal agriculture and cultivation seems to have occurred wherever soil and physical characteristics have allowed for it. Waterlogged areas and areas with a steep topography tend to have retained natural features. Formal mining occurs on properties adjacent to the proposed Kranspan Mining Right Area to the nearby north and northeast. The development area has an undulating terrain and valley-bottoms tend to support a well-developed wetland feature and wetland features tend to be commonplace within the area. Small impoundments along watercourses are common. Surface water persists within depression-type wetland units, but the main wetland feature located centrally within the proposed development site (Kranspan) seemingly only retains surface water following exceptional rainfall events.

A view of the largest depression wetland within the site (Kranspan), looking north.

A view of the largest depression wetland within the site (Kranspan), looking south.

 An artificial impoundment constructed within a valley-bottom wetland area, which allows for permanent surface water features to develop.	 Typical grassland habitat that is utilised for livestock grazing in and around wetland units.
 Well-established valley-bottom wetland units occur within the scope of the site.	 Another artificial impoundment constructed within a valley-bottom wetland area, which allows for permanent surface water features to develop.
 Floral zonation indicating a transitional zone of a wetland unit.	 Typical wetland vegetation within a seasonal zone wetland unit. Exotic agricultural weeds are commonly included within these areas.

 The cultivation of maize is regarded as a major land use within the survey site and most wetland units have been encroached upon by cultivation.	 Grassland areas that are suffering from disturbance impacts. Lowered ground cover rate and subsequent destabilisation of soils are the precursors for erosion development.
 Permanent surface water created through artificial impoundments often included a high density of aquatic plants. This is often an indication of an unbalanced nutrient cycle within the system.	 The wall of an artificial impoundment. Kikuyu grass dominates areas such as this, which is often the case following soil disturbances. Kikuyu is also often used as a soil stabiliser species but then does spread further than the intended target site..

Figure 7: Various views of the survey area.

6.3. Wetland hydrogeomorphic (HGM) forms present within the area

The region is characterised by depression-type wetland units, supplemented by hillslope seep wetlands that are often interconnected by valley-bottom wetland types. Valleyhead seeps often are associated at the origin of the valley topographical feature that develops into a valley-bottom wetland feature. The proposed development site includes two watershed zones, with the bulk of the runoff water collecting the southern, central and eastern runoff water and draining it south-eastwards to drain along a watercourse (Boesmanspruit) that flows north-eastwards. Another watershed collects runoff from the central north-western portions and drains it northwards, with the watercourse (Vaalwaterspruit) draining north-eastwards.

Figure 8 presents a digital elevation terrain model of the proposed development site, which is based on 1m contour data. It can be seen that the majority of Portion 4 and Portion 7 drain north-westwards, whereas the remaining portions tend to drain eastwards and northwards.

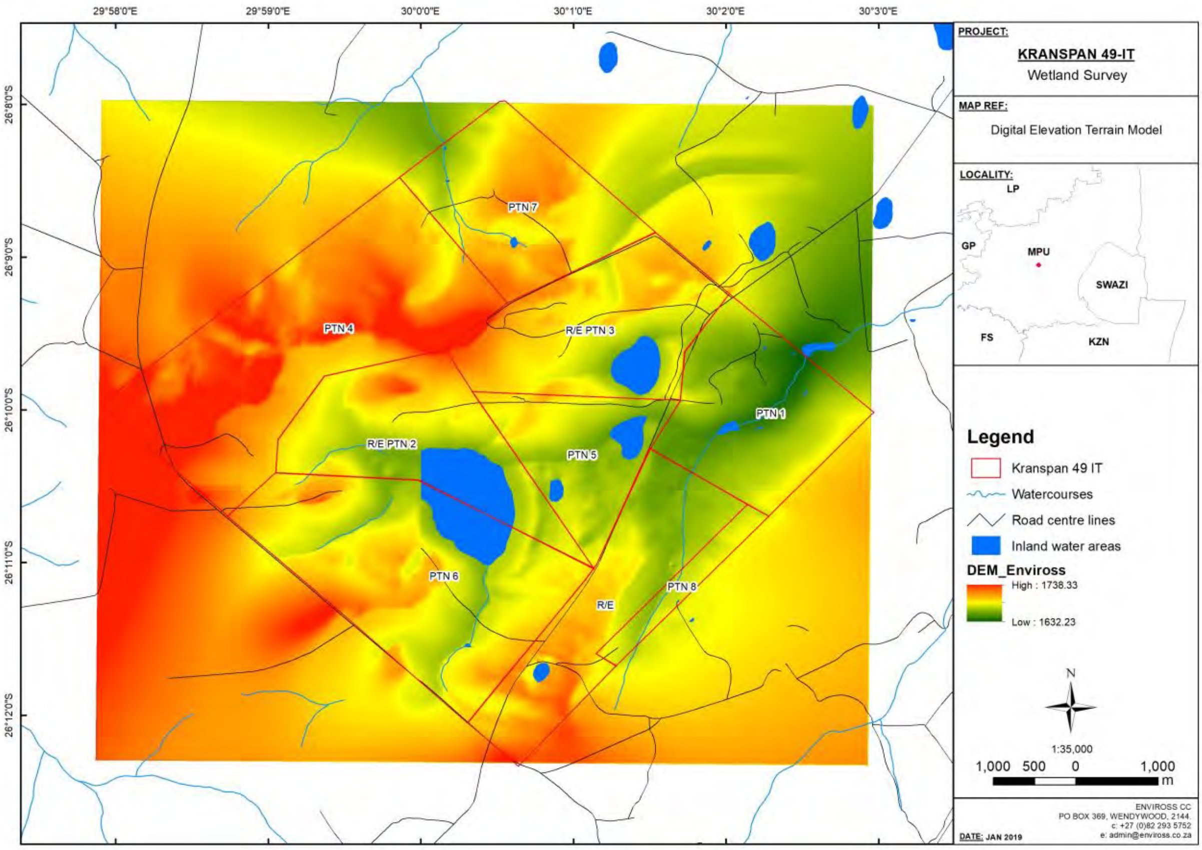


Figure 8: A digital elevation model (DEM) showing the terrain of the proposed development area.

The site is located within the upper reaches of the catchment area and therefore valleyhead seep zones that develop into valley-bottom wetland units are common. Depression wetlands that are either ephemeral (short-lived/seasonal) or more perennial (persistent) in occurrence are common. Kranspan, being the largest wetland unit within the survey area is regarded as a typical ephemeral wetland unit. There are impoundments along the watercourses of the valley-bottom units that induce persistent surface waters. Although the wetland clusters and complexes are largely isolated in terms of surface water flow, overtopping of the wetland units and surface interconnection would happen following exceptional rainfall events. They are, however, also interconnected via subsurface flows and interchanges.

Figure 9: The different HGM wetland units associated with the site. From this it can be seen that many of the peripheral wetland areas have been utilised for cultivation.

Wetland habitat units are regarded as well-established and developed within the area, with underlying soil and geological features that support a high water table and a relatively large ground-surface water interchange and therefore soil characteristics indicate that the majority of the area was historically established wetland areas. Land use that has led to unnatural channelling of valley-bottom wetlands that decreases landscape water retention periods, catchment management practices, as well as cyclic climate changes are all contributing factors that have induced the overall reduction of the functional areas of the wetland units. Hydromorphic soils reminiscent of historical wetland zones therefore tend to indicate larger expanses than what are considered to be functional and active wetland zones (detailed under section 6.6.2.).

6.4. Ecological functionality & ratings

Although there is a relatively high degree of interlinking, the survey area includes three main drainage areas. These areas are subject to similar pressures and drivers of ecological change and all have similar catchment characteristics. There are numerous small impoundments located along all watercourses, cultivation is commonplace within the higher-lying areas and livestock graze generally throughout all of the grassland areas, which are all factors that have deleterious impacts on the overall functionality of the wetland features. Hydrological, vegetation and geomorphological features are therefore generally similar for all units. All of the individual wetland units within these three areas have therefore been grouped in order to evaluate their overall ecological status. These three groups have been further broken down into subunits. If the wetlands within these individual subunits are to be impacted directly by the proposed development, then they have been analysed separately. The three functional systems of the survey area are indicated in Figure 10.

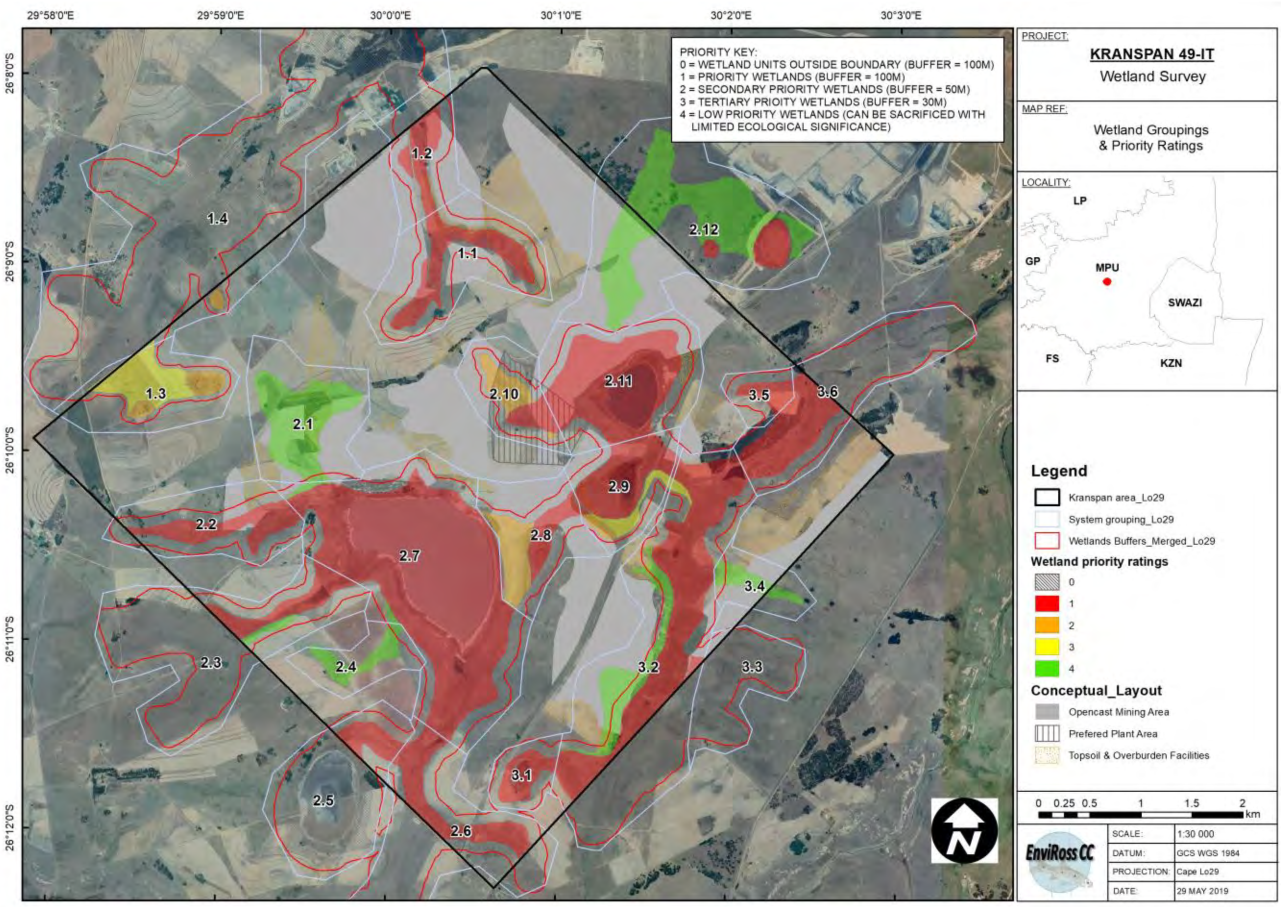


Figure 10: The three major groupings of the main wetland systems within the survey area.

From this figure it can be seen that much of the areas delineated as part of the wetland units have been cultivated and therefore lost their vegetation and other biodiversity support roles. These areas are largely considered to be supportive zones due to hydromorphic soil conditions and add to wetland function as a whole due to having retained soil layering characteristics that allows for a perched water table. Loss of these areas would not have the overall impact significance when compared to the impact significance of losing wetland features that still offer surface water persistence, and which support a community of wetland biodiversity.

6.4.1. WETLAND-IHI

The WETLAND-IHI was applied to the three wetland units associated with the survey area. These scores are presented in Table 4. Due to the largely homogenous land use throughout the catchment area and the similar pressures and drivers of ecological change experienced by the wetland units, there is little variation in scores and ratings within the units themselves. Overall, the wetland units fall within a C PES range. Variations do occur due to differences in vegetation cover, proximity to formal agriculture and mining (where the water quality would be more prone to deleterious effects of agrochemicals and other contaminants), erosion features and proximity to and number of impoundments. All of the wetland units are considered to be classified as 'moderately modified' due to factors outlined above. The depression wetland unit located on R/E Ptn 3 (sub unit 2.11) suffers a higher level of water quality degradation that was not observed within the remaining units. The source of this contamination was not ascertained during the field survey, but it is assumed to originate from the mining activities located to the nearby northern area, a large cattle presence and increased runoff from the immediate surrounding catchment area (formal agriculture and sand winning). In isolation, this wetland unit would be classified as a D/E PES rather, but, as a collective within the greater wetland unit/system, it does not proportionally contribute enough to change the PES of the overall unit. Water quality attributes are discussed in more detail under the relevant section.

Wetland sub unit 2.1 is considered a minor tributary and poorly-developed wetland feature that shows the retention of hydromorphic soil characteristics (reminiscent of historical wetland function) but has since been lost to cultivation and overall reduction of the extent of the source of water that feeds it. This unit, due to its use for cultivation, shows obvious reductions in scores in relation to the wetland unit as a whole. Water quality is shown to be rated higher than the whole wetland unit as potential sources of contamination are from only one source (one land use type) whereas, holistically, wetland unit 2 has a much wider potential source of water contamination.

Sub unit 2.8 includes a cultivated area that is regarded as a linkage between two depression-type wetland units. The PES of this unit calculated to 37.2% due to a diversity of pressures and drivers of ecological change, mostly emanating from cultivation. As this is a linkage zone between two established wetland features, the significance of impact of losing this functionality, although it shows a relatively low PES, would be greater.

Wetland sub unit 2.10 includes a feeder seepage zone that develops into a valley-head seep and unchannelled valley bottom, which feeds into sub unit 2.11, which is a depression wetland with permanent surface waters. The seep zones associated with this depression wetland within sub unit 2.10 were also considered when calculating the PES and evaluating the significance of the impacts. These units were separated due to differences in hydrogeomorphic types. The overall PES of sub unit 2.10 calculated to 44.5% (D), which is again largely due to cultivation through the unit that has led to altered vegetation structures, hydrology and geomorphological features. The PES of sub unit 2.11 calculated to 79.8% (B/C), with the main pressure and driver of ecological change being degraded water quality.

Table 4: Results from the WETLAND-IHI for the wetlands associated with the proposed development area.

Wetland unit	Sub unit	Vegetation	Hydrology	Geomorphology	Water quality	Overall PES
Wetland unit 1	Holistically	72.8%	61.3%	52.7%	72.7%	65.5% (C)
Wetland unit 2	Holistically	87.8%	70.0%	56.4%	72.7%	75.2% (C)
	2.1	43.4%	29.6%	23.6%	85.3%	38.9% (D/E)
	2.8	43.4%	29.6%	23.6%	64.3%	37.2% (E)
	2.10	59.9%%	29.6%	23.6%	64.3%	44.5% (D)
	2.11	83.7%	86.4%	70.0%	62.7%	79.8% (B/C)
	2.12	43.4%	29.6%	23.6%	85.3%	38.9% (D/E)
Wetland unit 3	Holistically	80.4%	66.5%	75.0%	72.7%	75.0% (C)

6.4.2. Ecological Importance-Sensitivity (EIS)

The EIS was undertaken according to the methods outlined in WET-EcoServices (Kotze et al, 2007). The wetland units throughout the survey area are all subject to similar pressures and drivers of ecological change, and all of the units fall within a catchment area that shares a similar land use and are located on private land, so uses of the wetland resources by local inhabitants are limited. Impoundments are located along the vast majority of the watercourses, which is typical of an established agricultural area. The EIS of the wetland units are therefore all similar as they all share similar features. The generalised rating for the EIS is indicated in Table 5.

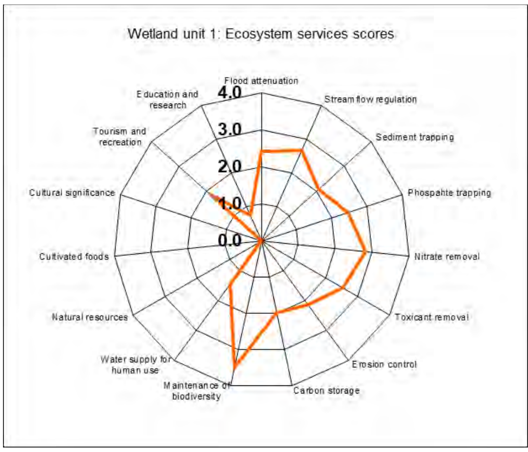
Table 5: The results of the WET-Ecoservices index to determine the EIS of the wetland units.

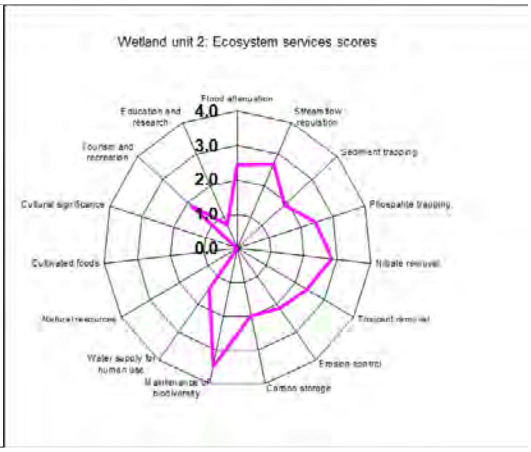
Wetland functional feature	Unit 1	Unit 2	Unit 3
Flood attenuation	2.4	2.4	2.4
Stream flow regulation	2.7	2.7	2.7
Sediment trapping	2.1	1.9	2.3
Phosphate trapping	2.5	2.5	2.5
Nitrate removal	2.8	2.8	2.8
Toxicant removal	2.5	2.4	2.7
Erosion control	2.1	2.1	2.1
Carbon storage	2.0	2.0	2.0

Wetland functional feature	Unit 1	Unit 2	Unit 3
Maintenance of biodiversity	3.5	3.5	3.5
Water supply for human use	1.4	1.4	1.4
Natural resources	0.0	0.0	0.0
Cultivated foods	0.0	0.0	0.0
Cultural significance	0.0	0.0	0.0
Tourism and recreation	1.9	1.9	1.9
Education and research	0.8	0.8	0.8
Runoff intensity from the wetland unit's catchment	2.0	2.0	2.0
Alteration of sediment regime	3.0	1.0	3.0
Alteration of nutrient/toxicant regime	3.0	1.0	3.0
Level of threat	3.0	3.0	3.0
Levels of opportunity	3.0	3.0	3.0
Rating	2.04	1.82	2.06

These scores indicate that the wetlands supply a moderate to high ecological service. The threat level to the habitat units remain as relatively high (3 out of 4), with the levels of opportunity, which could be interpreted as the degree to which the wetland habitat units could perform these services, also scored relatively high as well (3 out of 4) (Table 5).

The various input features and how they scored for the wetland unit are presented in Figure 11. This shows which features (services) that are performed by the wetlands are currently scoring the highest, and which ones are ranked lower. It can be seen that the ecological services supplied by the wetlands are rated as the relative highest. The wetland functionality elements (flood attenuation, and water purification) are also ranked high. Tourism and recreation also ranks relatively high due to the opportunity for birding within these areas, but the area does not fall within a tourist-friendly area, which lowers the relevance of these factors. Low-scoring elements include the dependency of the rural sector on the resources offered by the wetland units (all located on private land) and cultural significance of the wetland units.





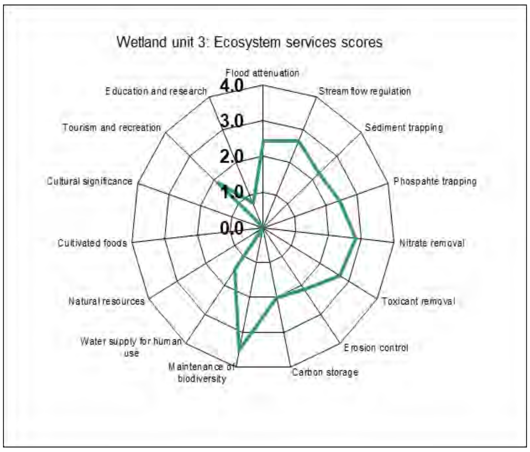


Figure 11: Scoring of the various aspects of ecological services provided for by the wetland habitat units present within the survey area.

Although the wetland units have scored average EIS and PES ratings, they remain ecologically sensitive habitat units, and they do offer value to protecting the water resource, maintenance of biodiversity, as well as provision of water to downstream ecosystems and water users, as well as provision of flood attenuation. The ecological value of such wetland units should therefore not be discounted.

6.5. Water quality analysis

Four water samples were collected during the field survey and sent to an accredited laboratory for analysis. The site localities of the sampling sites are presented in Figure 12. The results are presented in Table 6 and Table 7, with a graphical representation of the site comparative results presented in Figure 13. Results from Table 6 show that site 4 has been subject to external contamination, with relatively higher values for those parameters tested for than other watercourses from within the same catchment area. It is assumed that this is from runoff water emanating from sand winning and mining operations located to the nearby north of the site, which is regarded as a diffuse source of pollution and contamination. This is considered to be relatively more difficult to manage in relation to a point source of pollution. The depression wetland from where the sample was taken showed obvious signs of pollution sources, with a high turbid discoloured water and obvious odour.

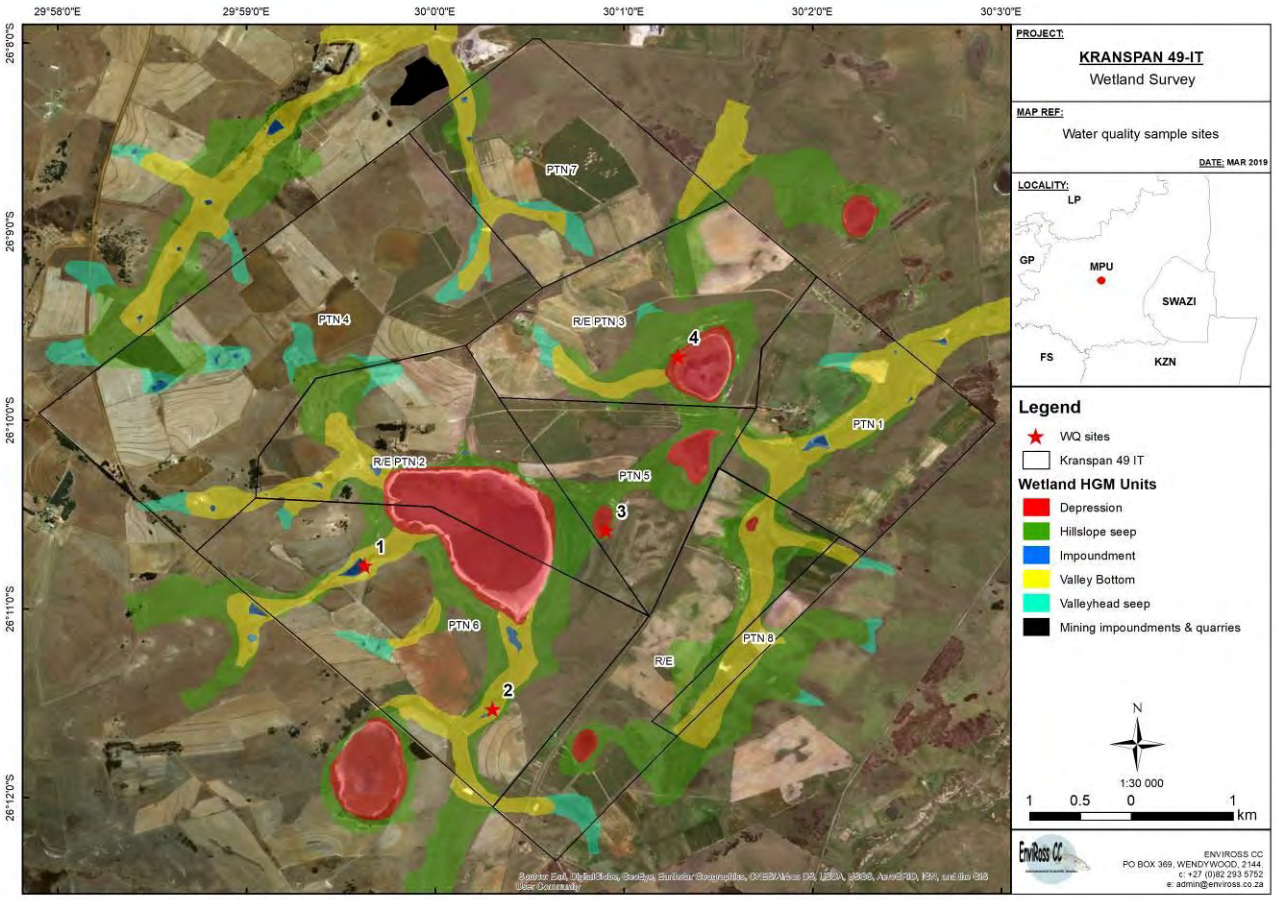


Figure 12: Water quality sampling sites.

Table 6: General water quality parameters for the four sampling sites. Parameters of concern are highlighted.

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification			
		Site 1	Site 2	Site 3	Site 4
Sample Number (Lab ref)		55147	55148	55149	55150
pH – Value at 25°C	WLAB065	6.9	7.4	6.9	7.5
Electrical Conductivity in mS/m at 25°C	WLAB002	30.0	31.6	29.1	203
Total Dissolved Solids at 180°C	WLAB003	184	222	218	1 342
Suspended Solids at 105°C	WLAB004	12.2	6.7	126	1 714
Turbidity in N.T.U	WLAB005	5.5	4.8	38	1 092
Total Alkalinity as $CaCO_3$	WLAB007	24	52	40	556
Chloride as Cl	WLAB046	51	57	57	286
Sulphate as SO_4	WLAB046	26	3	7	147
Fluoride as F	WLAB014	0.4	0.3	0.3	1.0
Nitrate as N	WLAB046	0.1	<0.1	0.1	<0.1
Total Coliform Bacteria / 100 mℓ	WLAB021	58 000	980	1 600	6 200
Faecal Coliform Bacteria / 100 mℓ	WLAB021	0	0	0	340
E. coli / 100 mℓ	WLAB021	0	0	0	280
Free & Saline Ammonia as N	WLAB046	0.4	0.4	0.5	0.5
% Balancing *	---	94.8	92.4	96.8	98.9

Electrical conductivity and total dissolved and suspended solids are all high (as is reiterated by the high positive cation concentrations shown in Table 7). Increased sulphate values indicate that the source of pollution is probably from dewatering opencast pits associated with existing coal mines.

Table 7: Results of the element scan of the four samples. Outlying concentrations (indicating extraordinarily high values are highlighted).

Element	Sample 1	Sample 2	Sample 3	Sample 4		Element	Sample 1	Sample 2	Sample 3	Sample 4
Ag	< 0.010	< 0.010	< 0.010	< 0.010		**Na**	34	36	39	428
Al	0.309	0.449	0.237	3.66		**Nb**	< 0.010	< 0.010	< 0.010	< 0.010
As	< 0.010	< 0.010	< 0.010	< 0.010		**Nd**	< 0.010	< 0.010	< 0.010	< 0.010
Au	< 0.010	< 0.010	< 0.010	< 0.010		**Ni**	< 0.010	< 0.010	< 0.010	< 0.010
B	0.011	< 0.010	0.021	0.029		**Os**	< 0.010	< 0.010	< 0.010	< 0.010
Ba	0.055	0.090	0.080	0.551		**P**	0.058	< 0.010	< 0.010	1.56
Be	< 0.010	< 0.010	< 0.010	< 0.010		**Pb**	< 0.010	< 0.010	< 0.010	0.012
Bi	< 0.010	< 0.010	< 0.010	< 0.010		**Pd**	< 0.010	< 0.010	< 0.010	< 0.010
Ca	8	9	6	21		**Pr**	< 0.010	< 0.010	< 0.010	< 0.010
Cd	< 0.010	< 0.010	< 0.010	< 0.010		**Pt**	< 0.010	< 0.010	< 0.010	< 0.010
Ce	< 0.010	< 0.010	< 0.010	0.014		**Rb**	0.010	0.011	< 0.010	< 0.010
Co	< 0.010	< 0.010	< 0.010	< 0.010		**Rh**	< 0.010	< 0.010	< 0.010	< 0.010
Cr	< 0.010	< 0.010	< 0.010	< 0.010		**Ru**	< 0.010	< 0.010	< 0.010	< 0.010
Cs	< 0.010	< 0.010	< 0.010	< 0.010		**Sb**	< 0.010	< 0.010	< 0.010	< 0.010
Cu	< 0.010	< 0.010	< 0.010	< 0.010		**Sc**	< 0.010	< 0.010	< 0.010	< 0.010
Dy	< 0.010	< 0.010	< 0.010	< 0.010		**Se**	< 0.010	< 0.010	< 0.010	< 0.010
Er	< 0.010	< 0.010	< 0.010	< 0.010		**Si**	0.7	0.7	2.5	18.5
Eu	< 0.010	< 0.010	< 0.010	< 0.010		**Sm**	< 0.010	< 0.010	< 0.010	< 0.010
Fe	1.59	1.25	0.859	2.41		**Sn**	< 0.010	< 0.010	< 0.010	< 0.010
Ga	< 0.010	< 0.010	< 0.010	0.012		**Sr**	0.039	0.049	0.035	0.090
Gd	< 0.010	< 0.010	< 0.010	< 0.010		**Ta**	< 0.010	< 0.010	< 0.010	< 0.010
Ge	< 0.010	< 0.010	< 0.010	< 0.010		**Tb**	< 0.010	< 0.010	< 0.010	< 0.010
Hf	< 0.010	< 0.010	< 0.010	< 0.010		**Te**	< 0.010	< 0.010	< 0.010	< 0.010
Hg	< 0.010	< 0.010	< 0.010	< 0.010		**Th**	< 0.010	< 0.010	< 0.010	< 0.010
Ho	< 0.010	< 0.010	< 0.010	< 0.010		**Ti**	< 0.010	< 0.010	< 0.010	0.095
In	< 0.010	< 0.010	< 0.010	< 0.010		**Tl**	< 0.010	< 0.010	< 0.010	< 0.010
Ir	< 0.010	< 0.010	< 0.010	< 0.010		**Tm**	< 0.010	< 0.010	< 0.010	< 0.010
K	11.3	11.9	12.3	43		**U**	< 0.010	< 0.010	< 0.010	< 0.010
La	< 0.010	< 0.010	< 0.010	< 0.010		**V**	< 0.010	< 0.010	< 0.010	0.010
Li	< 0.010	< 0.010	< 0.010	< 0.010		**W**	< 0.010	< 0.010	< 0.010	< 0.010
Lu	< 0.010	< 0.010	< 0.010	< 0.010		**Y**	< 0.010	< 0.010	< 0.010	< 0.010
Mg	7	10	5	12		**Yb**	< 0.010	< 0.010	< 0.010	< 0.010
Mn	0.061	0.042	0.050	0.281		**Zn**	0.028	0.016	0.017	0.010
Mo	< 0.010	< 0.010	< 0.010	< 0.010		**Zr**	< 0.010	< 0.010	< 0.010	< 0.010

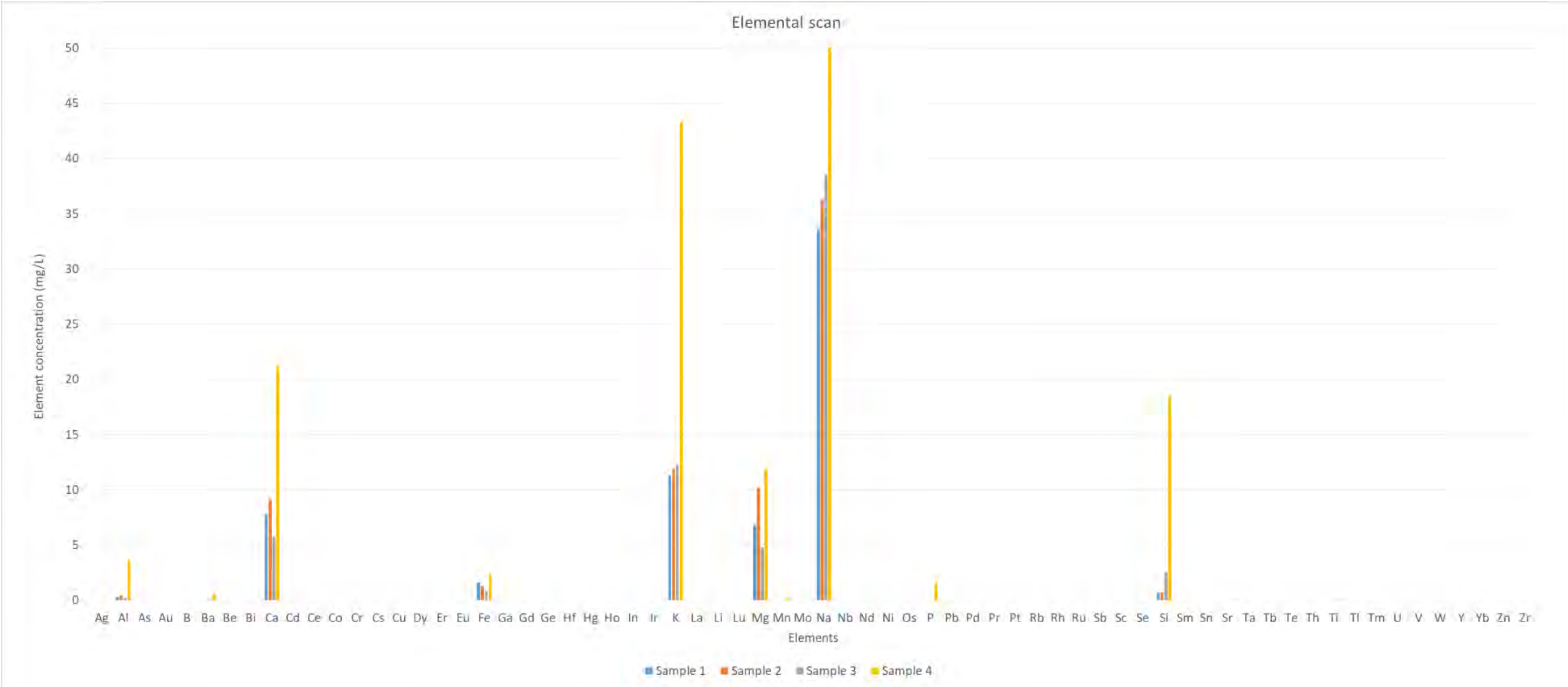


Figure 13: Elemental scan results for the four sampling sites (showing site comparisons).

The presence of *E. coli* is an indication of contamination from untreated sewerage, which would emanate from failing or inadequate sewerage infrastructure or disposal of sewerage into the system and requires urgent rectification as this poses a risk to human and livestock health.

Results of the water quality analysis shows that the surface waters have generally retained good water quality. This is what would be expected from wetland units located high up within the catchment area. The dominant surrounding land use is formal agriculture (cultivation) and therefore elements typical of fertilizers (nitrates, phosphates and trace elements such as potassium, iron, calcium, magnesium, etc) are expected to show elevated levels (pesticide contamination was not tested for). This is what was observed throughout all of the samples. Sample 4, however, has been subject to diffuse contamination by runoff from sand winning and mining activities located to the north, which is apparent by relatively higher elemental concentrations (as graphically represented in Figure 13). High levels of aluminium, calcium, potassium, sodium and silicone are all apparent within this sample. Detectable levels of lead are also shown to occur, which poses a threat to human and livestock health.

6.6. Standard Wetland Delineation Indicators

It is important to note that not all of the four wetland indicators will necessarily be present at any particular site. Disturbance factors and landscaping often lead to the vegetation indicators being largely transformed and unreliable. Landscaping also often diverts surface water flow that often dries certain areas of the wetlands, leading to the loss of the soil wetness indicators, or an arid climate could mean that limited soil moisture occurs if the survey takes place outside of the wet season. Therefore, the combination of all four unit indicators should be taken into consideration as well as a certain degree of “intuitive rationalisation” gained through experience when assessing the existence of wetland zones. Analysis of aerial imagery also is a very useful tool in analysing wetland drainage and flow patterns, especially for projects that span over a relatively large area.

6.6.1. Terrain Unit Indicator (TUI)

The TUI (taken from topographical maps, GIS data and visual observations at the site) indicated that the terrain is topographically conducive to supporting wetlands. The topography of the survey area supports a west-east watershed that then drains northwards. The application of the other indicators was therefore applied to facilitate the determination of the limits of the wetland zones if applicable.

Depression wetlands were noted to be the most abundant wetland unit throughout the survey area. Depression wetlands within this area are thought to be created through aeolian (wind) action, where livestock and wildlife favoured particular areas (a shallow water table would support better grazing and therefore concentrate it within a small area for a longer period of time). The resulting trampling would loosen the soil, making it vulnerable to dispersion from wind action when dry.

6.6.2. Soil Form Indicator (SFI)

Sampling pits were dug using a garden spade at strategic points in order to observe soil profiles *in situ*. Iron nodules were readily observed on the surface and some Laterite formation was also observed (examples of ferrolysis are shown in Figure 14). The survey area was dominated by deep, iron-rich, red soils of the Rensburg form. Observations of bleached soils associated with shallow and fluctuating water tables typical of wetland units were positive indications of ferrolysis within soils. This is where iron is leached out due to a cyclic fluctuation of a shallow water table. The soil form indicator therefore was strongly supported throughout the survey area, indicating wetland (hydromorphic) soils.

Figure 14: Examples of indications of ferrolysis (mottling) within the soils is a positive indication of hydromorphic conditions. These are samples taken within the seasonal zones and the degree of mottling is typical of seasonal wetland zonation.

During periods when the water table recedes and oxygen is able to penetrate the soil, the iron undergoes reduction to iron oxide. This remains localised and tends to be visible in the form of reddish mottles within the soil profile. Iron deposits in the form of nodules were also readily observed throughout the wetland zones.

6.6.3. Soil Wetness Indicator (SWI)

Soil wetness indicators were not strongly supported for delineation purposes due to the temporary nature of the wetland units.

6.6.4. Vegetation Indicator (VI)

Wetland-dependent (hydrophytic) vegetation has a floral species community structure that is dominated by species specifically adapted to inhabiting soils of varying degrees of water-logging, and what can flourish in oxygen-poor (hypoxic) soils. Various species are adapted to survive under varying periods of prolonged water saturated soils and therefore form distinct communities. This is largely true for undisturbed floral community structures associated with wetlands. The outer limits of the various wetland zones can therefore very often be determined by the changes in floral community structures. This unit indicator was found to be a useful tool as floral species indicative of the various wetland zones were observed. The wetland units were regarded as being well-developed, with structures typical of floral zonation being readily observed. The vegetation indicator was regarded as a reliable indicator of discerning the limits of the various zones of the wetland units. Table 8 presents the dominant floral species pertaining to the wetland units noted during the field survey.

Table 8: Dominant floral species noted within the wetland zones pertaining to the survey area.

Family	Species	Zonal indicator
Cyperaceae	*Alinula paradoxa*	Seasonal & outer permanent zones
	Ascolepis capensis	Seasonal & outer permanent zones
	Bulbostylis hispidula	Seasonal & outer permanent zones
	Carex austro-africana	Seasonal & outer permanent zones
	Cyperus compressus	Seasonal & outer permanent zones
	Cyperus congestus	Seasonal & outer permanent zones
	Cyperus denudatus	Seasonal & outer permanent zones
	Cyperus laevigatus	Seasonal & outer permanent zones
	Cyperus longus var. tenuiflorus	Seasonal & outer permanent zones
	Cyperus sexangularis	Seasonal & outer permanent zones
	Eleocharis acutangula	Seasonal & outer permanent zones
	Eleocharis dregeana	Seasonal & outer permanent zones
	Fimbristylis dichotoma	Seasonal & outer permanent zones
	Fuirena pubescens	Seasonal & outer permanent zones
	Fuirena stricta	Seasonal & outer permanent zones
	Isolepis fluitans	Seasonal & outer permanent zones
	Isolepis sepulcralis	Seasonal & outer permanent zones
	Kyllinga erecta	Seasonal & outer permanent zones
	Pycreus nitidus	Seasonal & outer permanent zones
	Schoenoplectus brachyceras	Seasonal & outer permanent zones
	Schoenoplectus corymbosus	Seasonal & outer permanent zones
Juncaceae	*Juncus dregeaus*	Seasonal & outer permanent zones
	Juncus lamatophyllus	Seasonal & outer permanent zones

Family	Species	Zonal indicator
Poaceae	*Hemarthria altissima*	Seasonal zones
	Agrostis lachnantha	Seasonal zones
	Arudinella nepalensis	Seasonal zones
	Imperata cylindrica	Seasonal to temporary zones
	Leersia hexandra	Seasonal to permanent zones
	Sporobolus pyramidalis	Seasonal to temporary zones
	Andropogon eucomus	Seasonal to temporary zones
	Ischaemum fasciculatum	Seasonal to temporary zones
	Paspalum distichum	Seasonal to permanent zones
	Andropogon appendiculatus	Seasonal zones
	Paspalum dilitatum	Seasonal zones
	Paspalum scrobiculatum	Seasonal zones
	Setaria sphacelata var. sphacelata	Seasonal zones
Potamogetonacaea	*Potamogeton thunbergii*	Permanent zones
Apiaceae	*Centella asiatica*	Exotic (seasonal zones)
Menyanthaceae	*Nymphoides thunbergiana*	Permanent zones
Iridaceae	*Watsonia densiflora*	Seasonal to temporary zones
Scrophulariaceae	*Cycnium tubulosum*	Seasonal to temporary zones

6.7. Buffer Zones

The proposed development does have an association with wetland habitat units and therefore conservation buffer zones are applicable. The wetland habitat units associated with the proposed development area perform vital functions within the landscape and should be regarded as being ecologically sensitive features. Conservation of this habitat unit forms an integral part of the conservation of the surface water resources throughout the catchment area. The proposed development is also regarded as being of a relatively high impact to the wetland units associated with it. The wetlands that are regarded as priority (high value) features have been designated a 100 m buffer zone. Those units and areas that perform lesser functions and are not regarded as priority features have been designated 50 m buffer zones, whilst those features regarded as being peripheral in both their development and ecological role have been designated a 30 m buffer zone. This is in accordance to the industry norms. The buffer zones are indicated in Figure 15.

6.8. DWS risk assessment matrix

The Department of Water and Sanitation (DWS) has developed a risk assessment matrix for development activities within a wetland or watercourse. The wetland units associated to the project have all been delineated and the appropriate conservation buffer zones have been designated to the units. The risk assessment matrix is aimed at activities that are to take place within these areas. As infrastructure is planned for within wetland areas and wetland zones will be impacted, many ratings are defaulted to having a high risk. After calculation of the various impacts, all of the impacts were rated as having a ***high*** risk to the present ecological integrity of the surface water ecosystems and associated habitat units. The significance of the impacts is largely related to the scale and intensity of the wetland habitat that will be impacted, and therefore can be greatly reduced by taking into consideration that wetland delineation mapping and associated conservation buffer zones. The calculations of the DWS Risk Assessment, detailing of the impacts and outline of the mitigation measures are provided as an Addendum to this report.

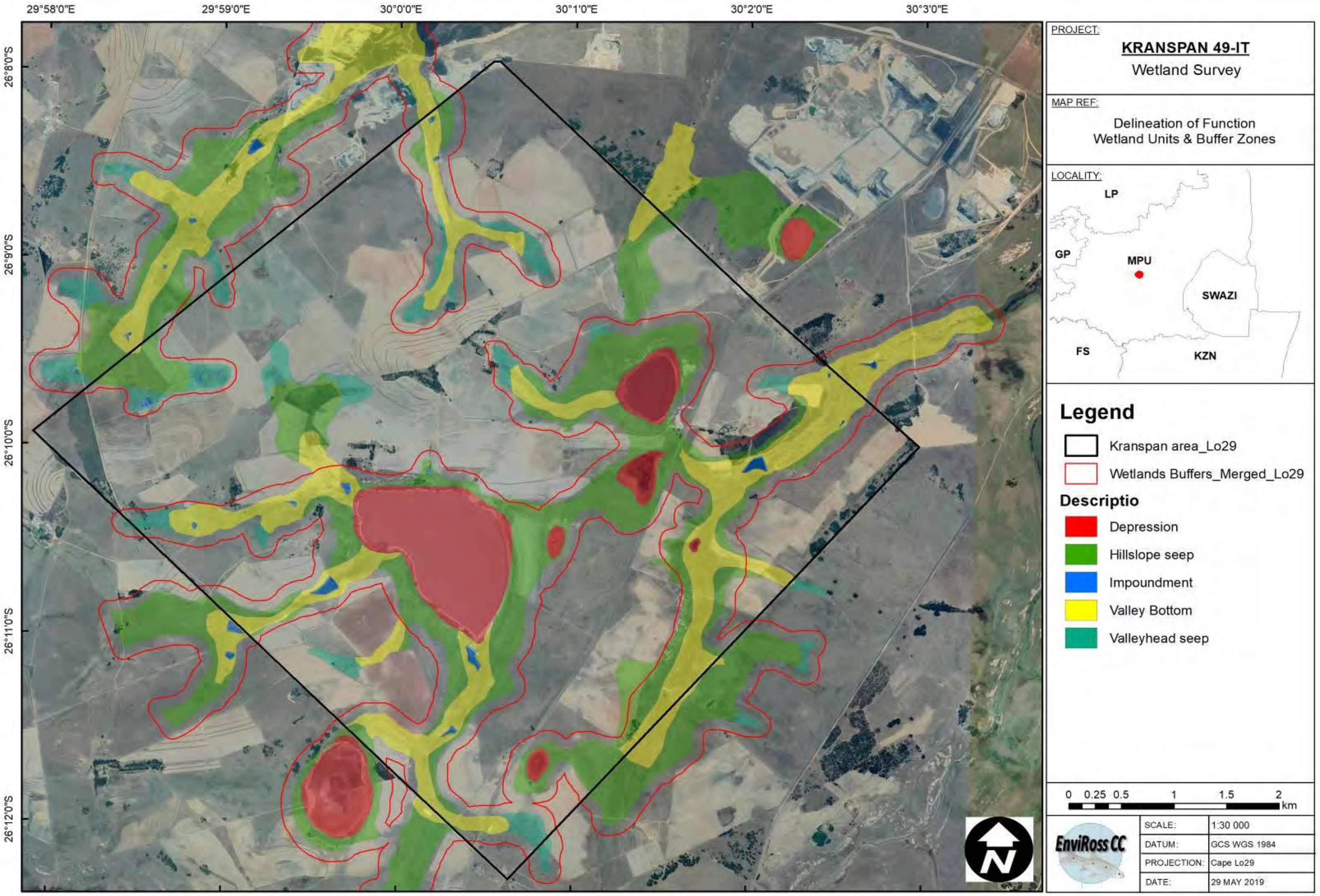


Figure 15: The delineation of functional wetland units and conservation buffer zones for the site.

7. SIGNIFICANCE RATINGS OF PERCEIVED ENVIRONMENTAL IMPACTS

The proposed development activities include the development of processes and infrastructure to aid in the establishment of the mining operations. The development area has been historically utilised for formal agriculture and therefore all mining infrastructure will be newly-established. Therefore planning of infrastructure layout, which is largely dependent on physical and geological factors, will also have to take ecological features into account to reduce overall negative ecological impacts. With mitigation measures in place, the overall ecological impacts that will persist beyond the construction and rehabilitation phases can be reduced in terms of conservation of the surface water ecosystems within the region. Table 12 presents the significance ratings of the potential ecological impacts for the *pre-construction and construction* as well as the *management phases* of the proposed development activities. The ratings are calculated for the scenarios of both before and after the implementation of mitigation measures. This was done in order to show how the degree of impacts can be reduced by careful planning and the following of relatively simple mitigation measures.

7.1. Introduction

The first phase of impact assessment is the identification of the various project activities which may impact upon the identified environmental aspects. The identification of significant project activities is supported by the identification of the various receiving environmental receptors and resources. These receptors and resources allow for an understanding of the impact pathways and assessment of the sensitivity of the receiving environment to change. The significance of the impact is then assessed by rating each variable numerically, according to defined criteria as provided in .

7.2. Impact significance rating

The purpose of the significance rating of the identified impacts is to develop a clear understanding of the influences and processes associated with each impact. The severity (magnitude), spatial scope and duration of the impact together comprise the consequence of the impact; and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact, and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read from a significance rating matrix as shown in Table 10 and Table 11.

The model outcome of the impacts is then assessed in terms of impact certainty and consideration of available information. The Precautionary Principle is applied in instances of uncertainty or lack of information by increasing assigned ratings or adjusting final model outcomes. In certain instances where a variable or outcome requires rational adjustment due to model limitations, the model outcomes are adjusted. Arguments and descriptions for such adjustments, as well as arguments for each specific impact assessments are presented in the text and encapsulated in the assessment summary table linked to each impact discussion.

Table 9: Criteria for Assessing the Significance of Impacts.

SEVERITY OF IMPACT	RATING	
Insignificant / non-harmful	1	
Small / potentially harmful	2	
Significant / slightly harmful	3	
Great / harmful	4	
Disastrous / extremely harmful	5	
SPATIAL SCOPE OF IMPACT	**RATING**	
Activity specific	1	
Area specific	2	
Whole project site / local area	3	CONSEQUENCE
Regional	4	
National	5	
DURATION OF IMPACT	**RATING**	
One day to one month	1	
One month to one year	2	
One year to ten years	3	
Life of operation	4	
Post closure / permanent	5	
FREQUENCY OF ACTIVITY / DURATION OF ASPECT	**RATING**	
Annually or less / low	1	
6 monthly / temporary	2	
Monthly / infrequent	3	
Weekly / life of operation / regularly / likely	4	
Daily / permanent / high	5	LIKELIHOOD
FREQUENCY OF IMPACT	**RATING**	
Almost never / almost impossible	1	
Very seldom / highly unlikely	2	
Infrequent / unlikely / seldom	3	
Often / regularly / likely / possible	4	
Daily / highly likely / definitely	5	

Activity: a distinct process or task undertaken by an organisation for which a responsibility can be assigned.

Environmental aspect: an element of an organisation's activities, products or services which can interact with the environment.

Environmental impacts: consequences of these aspects on environmental resources or receptors.

Receptors: comprise, but are not limited to people or man-made structures.

Resources: include components of the biophysical environment.

Frequency of activity: refers to how often the proposed activity will take place.

Frequency of impact: refers to the frequency with which a stressor will impact on the receptor.

Severity: refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.

Spatial scope: refers to the geographical scale of the impact.

Duration: refers to the length of time over which the stressor will cause a change in the resource or receptor.

Table 10: Significance Rating Matrix

	CONSEQUENCE (SEVERITY + SPATIAL SCOPE + DURATION)														
LIKELIHOOD (FREQUENCY OF ACTIVITY + FREQUENCY OF IMPACT)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Table 11: Positive/Negative mitigation rating

Colour Code	Significance Rating	Value	Negative Impact Management Recommendation	Positive Impact Management Recommendation
	Very High	126-150	Improve current management	Maintain current management
	High	101-125	Improve current management	Maintain current management
	Medium-High	76-100	Improve current management	Maintain current management
	Low-Medium	51-75	Maintain current management	Improve current management
	Low	26-50	Maintain current management	Improve current management
	Very Low	1-25	Maintain current management	Improve current management

7.3. Activities having an impact

The key project activities for the Project upon which the impact assessment was based are described in the EIS. These activities are summarised below per project phase.

7.3.1. Construction Phase Activities

- Clearing and grubbing of vegetation;
- Site perimeter fencing and internal fencing of different sections of the mine;
- Removal and stockpiling of topsoil;
- Delivery and storage of vehicles, equipment, machinery and materials;
- Construction of access roads, platforms and drainage structures;
- Construction of process plant infrastructure and installation of required equipment and machinery;
- Construction of the main mine administration complex; and
- Installation of power and water supply infrastructure.

7.3.2. Operational Phase Activities

- Clearing and grubbing of vegetation;
- Dewatering;
- Open-cast mining of two pits through a combination of excavation and blasting;
- Construction and operation of the soil and overburden stockpiles;
- Hauling of raw materials to the process plant;
- Management of clean and dirty water runoff;
- Raw materials processing at the process plant;
- Concurrent rehabilitation of exposed areas (as is practicable); and
- Delivery and storage of vehicles, equipment, machinery and materials.

7.3.3. Closure and Decommissioning Phase Activities

- Dismantling and removal of all identified above-ground infrastructure;
- Rehabilitation of the open-cast pits and overburden stockpiles; and placement of topsoil and re-vegetation of exposed areas.

Table 12: A generalised significance rating both before and after implementation of mitigation measures of the main potential ecological impacts perceived to be associated to the proposed development activities.

Ecologically sensitive habitat (Wetland units)								
Project Activity		Destruction of sensitive habitat	Likelihood		Consequence			Significance Rating
Destruction of wetland units during all construction phase activities due to heavy machinery and indiscriminate habitat destruction.	Phase of Project	Construction Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Destruction of wetland habitat during construction phase if buffer zones are not taken into consideration	4	4	4	3	5	96 (MH)
			Significance Post-Mitigation					
			1	1	2	2	1	10 (VL)
Project Activity		Destruction of sensitive habitat	Likelihood		Consequence			Significance Rating
Impacts to wetland units during the operations phase from runoff pollution, siltation, habitat smothering and vegetation alteration.	Phase of Project	Operations Phase	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Direct Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Everyday operations that will impact on wetland habitat integrity.	4	4	4	4	5	104 (H)
			Significance Post-Mitigation					
			3	3	3	2	4	54 (LM)
Fragmentation of interconnected wetland units (watercourses) that would otherwise offer migratory corridors.	Phase of Project	Construction/Operations phases	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Secondary Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Fragmentation of interconnected habitat	5	5	3	3	4	100 (MH)
			Significance Post-Mitigation					
			2	2	2	1	1	16 (VL)
Project Activity		Destruction of sensitive habitat	Likelihood		Consequence			Significance Rating
Wetland vegetation alteration following disturbances that will enhance exotic vegetation encroachment.	Phase of Project	All phases of project	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Secondary & Cumulative Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Disturbances that induce invasion of exotic flora	5	5	3	2	5	100 (MH)
			Significance Post-Mitigation					
			1	1	2	1	1	8 (VL)

Soils								
Project Activity		Soil erosion that impacts watercourses and wetland habitat	Likelihood		Consequence			Significance Rating
All construction phase activities	Phase of Project	All phases of project	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	
	Impact Classification	Secondary & Cumulative Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Soil erosion will impact watercourses both locally as well as downstream within more established habitat.	4	4	4	4	5	104 (H)
			Significance Post-Mitigation					
			2	2	2	1	1	16 (VL)

Water quality								
Project Activity		Water quality	Likelihood		Consequence			
All construction phase and operations phase activities associated with water contamination	Phase of Project	All phases of project	Frequency of Activity	Frequency of Impact	Severity	Spatial Scope	Duration	Significance Rating
	Impact Classification	Direct, Secondary & Cumulative Impact	Significance Pre-Mitigation					
	Resulting Impact from Activity	Contamination of surface water will impact integrity of all surface water resources and will reach further downstream to the greater aquatic system.	4	4	4	4	5	104 (H)
			Significance Post-Mitigation					
			3	3	3	2	4	54 (LM)

7.4. Mitigation measures pertaining to impact features

7.4.1. Destruction of sensitive habitat features

Wetlands and surface water ecosystems are regarded as inherently ecologically sensitive features due to a variety of reasons, the main ones being that they provide a source of water, provide flood management of watercourses and support a wide biodiversity. Therefore, regardless of ecological state, wetland and aquatic units are statutorily protected and subject to their own unique environmental legislature. The survey area falls within a region that is rich in wetland habitat units, which coincides with suitable agricultural areas and rich mining deposits. The main land use within the region is therefore dominated by formal agriculture and mining (with the dominant form of mining being opencast coal mining). These are two high-impact land uses that have had deleterious impacts on the existence as well as functioning of wetland units within the region and also therefore impacts on the aquatic habitat located further downstream within the catchment areas. Historically, cultivation has been confined to higher-lying areas as inundated (wetland / hydromorphic) soils tend to be unpractical to cultivate. The main wetland linear units have therefore often been retained within the landscape. The outer edges (outer temporary zones) have often, however, been included within the cultivated areas and therefore wetland units have lost a degree of functionality. Impoundments along the watercourses for practical agricultural usage as well as aesthetic value within the landscape are also commonplace throughout all of the watercourses within the region. Historically there has been a level of cumulative loss of wetland habitat throughout the region due to agriculture. More recently, mining is gaining ground in displacing agriculture as a more lucrative land use, with the consequence of the wetland units suffering higher ecological degradation and relatively higher cumulative loss of physical presence and/or ecological functionality.

It is regarded as inevitable that wetland habitat units will be lost if the mining development is undertaken. The significance of the impacting features that will affect the wetland units within the survey area is dependent on to what level the unit will lose functionality. This can be anywhere from total loss (both physical and functional) to barely perceptible marginal losses that do not alter functioning within the landscape. The significance of the impact on ecologically sensitive habitat (i.e. wetland units) is therefore largely dependent on the overall loss of habitat through transformation to accommodate the mining infrastructure. It is therefore recommended that the mining infrastructure layout be planned to accommodate as much of the wetland habitat functioning areas as possible.

Vegetation and extent of groundcover plays an important role in preserving wetland functionality. It binds soils to protect from erosion, reduces the scouring potential of runoff water through the reduction of velocity and energy dissipation and also provides the micro-habitat and refuge for supporting a greater array of wetland-dependent biodiversity. Indiscriminate destruction of vegetation layers from wetland areas that fall outside of the ultimate infrastructure footprint should be avoided. A delineation map has been presented (Figure 15), which indicates the extent of the 100 m conservation buffer zones. It is recommended that these buffer zones be fenced off within applicable areas to avoid indiscriminate habitat destruction and treated as "no-go" areas. This includes using these areas for soil stockpiling, equipment storage, fuelling areas, etc.

Erosion is regarded as a major driver of ecological change of wetland habitat. Sediments and silts that are transported to lower-lying valley-bottoms and depressions during rainfall events via stormwater runoff will impact functionality through smothering of habitat, and will displace surface water volume and dependent biodiversity. Silts that enter into the aquatic systems increases turbidity and smothers substrates, also leading to displacement of biodiversity and loss of overall function. Erosion sedimentation must therefore be managed as an ongoing concern throughout all the phases of the development activities. This includes protection of stockpiled soils, rock dumps and other stored materials. Stormwater management must ensure erosion protection at the outfall points into the receiving environment.

Disturbance of soils will often lead to enhancing the encroachment of opportunistic alien vegetation. Wetland areas provide ideal conditions for supporting rapidly-growing exotic and invasive floral species, which quickly out-compete and displace natural vegetation. This will lead to displacement of biodiversity in general, an increase in water consumption and destabilisation of soils. This is an aspect that is readily managed and a management strategy should be in place and in practice throughout all phases of the development.

7.4.2. Soil impacting features

Wetland functionality largely depends on the integrity of the layered characteristics of the underlying soils. It is this layering of the underlying soils that ensures the persistence of inundated soils near the surface and the existence of a wetland feature. Trenching and excavations that alter the characteristics of these layers and/or compaction of the layers through (for example) the movement of heavy vehicles on hydromorphic soils will impact the natural hydrological functioning of the wetland units. Impacting features that intercept soil water and either diverts it away or into areas will all have impacts on the functionality of the soils and the ultimate functionality of the wetland units. Trenching near a wetland unit will often lead to desiccation of the soils and the loss of the wetland unit. Trenching within wetland soils is, however, often necessary from infrastructure developments (especially linear infrastructure such as entrenched pipelines of roads) and therefore some guidelines to mitigate the impacts have been offered. With proper mitigation, the deleterious impacts of trenching within wetlands to accommodate pipelines (etc) can be successfully abated.

As mentioned, wetland functionality is largely governed by a perched water table that occurs due to the stratification characteristics of the underlying soils, including an impermeable base layer that inhibits percolation to deeper groundwater. Retention of wetland functionality through the preservation of lateral water movement through the soils is dependent on correct soil layering and profiling. Therefore any soil that is removed for trenching purposes must be stored in their respective layers and returned to the excavation in reverse order. The soils must be stored outside of the wetland and buffer zones in order not to smother established wetland vegetation. Adequate site reinstatement must be implemented in order to abate the formation of erosion through modification of the surface water hydrology. Silt traps and fencing should be used in areas of steeper topography (if applicable). The movement of heavy machinery within wetland zones should be limited to only single access roadways. Upon completion of the construction phase, this roadway should be ripped and/or disk ploughed to loosen the compacted soils and to allow for the establishment of vegetation within the affected areas, which should be a mixture of veld grasses typical of the surrounding area within similar habitat units. Indiscriminate habitat destruction should be avoided and the construction footprint, including service and support areas should be kept to a minimum.

7.4.3. Water quality

Another impacting feature pertaining to the proposed development is contamination of surface water resources. Water quality degradation will displace dependent biodiversity and will have an impact that will perpetuate throughout the system for a long way downstream as well. Possible sources of contamination include hydrocarbons (from poorly-designed and managed fuelling stations and/or workshop and maintenance areas), and runoff water from processing areas that should be kept separate from clean water runoff with a suitable stormwater management system, and general surface water runoff that should be treated prior to release into the environment. Erosion management also plays an important role in preventing water quality degradation.

7.5. Offset mitigation strategy to compensate for loss of wetland units within the site

In order to retain the viability of the proposed mining operation, the Client has indicated that some areas originally delineated as wetland features are required to be sacrificed. When looking to mitigate for a particular ecological impact there is a stepwise hierarchy of impact mitigation that is considered. These steps include the following (Lukey & Paras, 2017):

- Avoid or prevent: Avoidance or prevention refers to the consideration of options in project location, sitting, scale, layout, technology and phasing to avoid impacts on biodiversity, associated ecosystem services, and people. This is referred to as 'the best option', but it is acknowledged that avoidance or prevention is not always possible.
- Minimize: Minimization refers to the consideration of alternatives in the project location, sitting, scale, layout, technology and phasing that would minimize impacts on biodiversity and ecosystem services.
- Rehabilitate: Rehabilitation refers to the consideration of the rehabilitation of areas where impacts are unavoidable and measures are provided to return impacted areas to a near-natural state or an agreed land use.
- Offset: Offsetting refers to the consideration of measures over and above rehabilitation to compensate for the residual negative effects on biodiversity, after every effort has been made to minimize and then rehabilitate impacts.

The first two points have been exhaustively explored and the initial proposed infrastructure layout was reduced considerably to accommodate the ecologically sensitive features, but some wetland features remained within the prescribed infrastructure and impact footprint areas. The nature of the proposed mining development is such as rehabilitation measures to pre-development status is not practically viable as it requires deep excavations and removal of the unearthed materials. Prescribed rehabilitation measures for large open cast operations at present is to slope the steeper sides, line the pit with topsoil and wither re-vegetate, or allow the pit to naturally fill with water. Considering that the functionality of the present wetland features largely rely on soil layering characteristics at relatively shallow depths, the deep excavations will remove the historical functionality of the wetland unit. This cannot be practically mitigated and therefore an offset mitigation may be the only viable means of mitigating for the loss of wetland features within the survey area. If this is indicated as a requirement by the relevant conservation authorities, then a prescribed method for offset mitigation procedures is followed according to relevant guidelines (MacFarlane et al., 2016), which outlines the best practice guidelines for wetland offsets.

The focus of biodiversity offsets as a mitigation option is to provide a "like for like" area of the same ecosystem type, species composition and ecological function to fully remedy that which is lost (DEA, 2017).

In terms of designing and locating an offset, the following procedural guideline should be followed (DEA, 2017):

1. Obtain a measure of the residual loss of biodiversity (i.e. residual negative impacts) as a consequence of the proposed development. The measure at minimum relates to the area and condition of affected ecosystem/habitat;
2. Determine the best type of offset;
3. Determine the required size of the offset and, where applicable, its optimum location;
4. Investigate candidate offset site(s) in the landscape that could meet the offset requirements. Check whether and any eligible offset receiving area is suitable;
5. Decide on the best way to secure the offset, and ensure that the offset option would be acceptable to the relevant conservation authorities.
6. Prepare an Offsets Report or dedicated section within the EIA report; and
7. Conclude agreements on offsets (between the applicant and an implementing agent) and develop an Offset Management Programme, where applicable.

A guideline document that was drafted as a collaboration between SANBI and DWS entitled Wetland offsets: A best practice guideline for South Africa (MacFarlane et al., 2016) would be utilised to address the offset process. This gives an indication of the extent of the wetland: offset area ratio for the offset mitigation option.

The loss of wetland unit habitat following the presentation of the final proposed infrastructure and mining development layout plan is presented in Table 13. The isolated wetland units that are referred to within Table 13 are presented in section 6.4, where a description of the wetland units that would be included within the proposed infrastructure layout plan, as well as a map, are presented.

Table 13: The wetland unit areas to be lost due to the proposed development, together with the respective PES ratings.

Wetland units category	Total area (within survey site)	Total area to be sacrificed - ha (% of unit)	Total area to be retained – ha (% of unit)	PES of areas to be lost	General notes
1	833.030	133.84 (16.1%)	699.190 (83.9%)	Ranging from C to D/E	Priority wetlands with high functional value. These areas maintain wetland biodiversity as they fall within the main and developed watercourses of the wetland units. These areas also contribute in terms of water source and most include permanent wetland zones.
2	55.902	40.675 (72.8%)	15.227 (27.2%)	Ranging from C to D/E	Secondary wetlands are the temporary wetland areas that act as interlinking corridors between established wetland units and fall within an area with obvious soil water interaction zones. Majority of these areas are, however, cultivated and therefore have suffered a lower PES. Regarded as supportive wetland areas. Loss of these units will constitute a loss of a level of function of the priority wetland areas as it will result in fragmentation of the complex.
3	44.398	0.000 (0.0%)	44.398 (100.0%)	Ranging from C to D/E	Tertiary wetland areas include peripheral zones of established and high priority wetland units. They provide a supportive role in maintaining the function of priority wetland areas. Cultivation is common within these areas, however.
4	168.957	131.673 (77.9%)	37.283 (22.1%)	Ranging from C to D/E	Limited functionality wetland areas. These are temporary wetland areas and most include upland minor tributary that have been actively cultivated. Loss of these areas is considered to have no significant impact to functional and established wetland units.

8. PROPOSED STORMWATER MANAGEMENT PRACTICES & MONITORING MEASURES

8.1. Stormwater management

The purpose of a stormwater management plan is largely to (from *City of Cape Town Management of Urban Stormwater Impacts Policy*):

- Improve on the quality of stormwater runoff.

The development of an area calls for unearthing of underlying geologies that would otherwise not have been exposed to weathering, which may create oxidising agents and/or changes in pH and other pollutants within the runoff water that would otherwise been immobile within the environment. The development of an area also brings in various pollution sources (hydro carbons, chemicals, nutrient and biological contaminants) that would not have been present under natural and undisturbed scenarios. It should be the aim of the stormwater management plan to ensure that the stormwater remains within a target water quality range prior to any release into the environment (DWS target water quality guidelines, 1996).

- Control the quantity and rate of stormwater runoff.

Under natural conditions, varying topography, unconsolidated soils and vegetation features would naturally slow down the runoff by retaining the water within the landscape. This would ensure a slow release into the environment. The development of an area typically strips off the vegetation and topsoil, unearthing a hardened layer of soil. Landscaping also often ensures that surfaces are harder than before the development, which decreases the percolation rate. The rate of discharge is then increased, which often leads to erosion impacts and flooding of the local watercourses.

- Encourage natural groundwater recharge.

As mentioned, by increasing the rate of runoff through the various abovementioned factors, the retention time of the stormwater within the landscape is reduced. This means that the surface water is not given chance to percolate within the soils to recharge the groundwater levels.

Government Notice (GN) 704 from the water Quality Management Series, operational Guideline No. M6.1 (DWAF, 2000) is a comprehensive document outlying the requirements of stormwater management in terms of a mining activity. This document should be consulted when designing a stormwater management system for the *quarry site. The points below highlight points from this document (and other sources) that are thought to be pertinent from an ecological impact and management perspective.*

Section 26(1) of the National Water Act, 1998 (Act 36 of 1998) provides for the development of regulations to, amongst others (from GN 704, DWAF [2000]):

- require that the use of water from a water resource be monitored, measured and recorded;
- regulate or prohibit any activity in order to protect a water resource or in-stream or riparian habitat; and
- prescribe the outcome or effect which must be achieved through management practices for the treatment of waste, or any class of waste, before it is discharged or deposited into or allowed to enter a water resource.

When making regulations, the need for the following must be taken into account (section 26(4) of the National Water Act):

- promoting economic and sustainable use of water;
- conserving and protecting water resources or, in-stream and riparian habitat;
- preventing wasteful water use;
- facilitating the management of water use; and
- facilitating the monitoring of water use and water resources.

8.1.1. Separation of clean and dirty water

One of the ways to achieve these objectives is to isolate clean (unpolluted) water from any dirty (polluted) water and/or area. The distinction between clean and dirty water relies on the specific requirements of a water resource, and should therefore be determined on a catchment specific basis. The quality of water as per definition of “clean water” should be gauged against the DWAF (1996) target water quality guidelines for freshwater aquatic ecosystems (vol 7). Further to this, the water quality of the receiving environment (Orange River in this case) should be monitored over an extended period in order to determine water quality trend data. Many of the parameters defined within the water quality guidelines stipulate a limitation of the range of the parameter that should not be altered. This will be different for every watercourse and therefore background data and trend analysis of the receiving watercourse should be gained.

In order to separate polluted from unpolluted water, any clean water system operating on the quarry site should be designed, constructed and maintained so that it is not likely to spill into any dirty water system more than once in 50 years.

The containment of unpolluted water should only occur if the volumes pose a risk, the water couldn't be diverted to a watercourse by gravitation, or for attenuation purposes. The unpolluted water should as far as possible be released into natural watercourses under controlled conditions. As the storage of water is defined as a water use in section 21 of the National Water Act, the person in control of a mining or related activity need to apply for a water use licence, unless covered under a General Authorisation (DWAF, 2000).

When designing a dam, the emphasis should be placed on *at all time capable of handling the 1:50 year flood-event*. How this is calculated and complied with will be determined by the specific circumstances and processes involved. It is proposed that acceptable engineering principles be used during the design of a water system. Therefore, a suitably qualified person must be responsible for the design of a water system and the construction thereof should take place under the supervision of that person.

8.1.2. Reuse and reticulation of dirty water

Another component is to collect the water arising within any dirty area, including water seeping from mining operations, outcrops or any other activity, into a dirty water system. Any water arising from an area, which causes, has caused or is likely to cause pollution of a water resource, including polluted stormwater, must be contained within a dirty water system. In order to reduce the volume of polluted water, contaminated areas should be minimised. While clean water should be diverted to natural watercourses, polluted water should be re-used wherever possible, thereby reducing the use of clean water.

The ultimate aim of any stormwater management plan is the protection of the water resource. In order to achieve this, it is the responsibility of the quarry management to prevent water containing waste or any substance which causes or is likely to cause pollution of a water resource from entering any water resource, either by natural flow or by seepage, and must retain or collect such substance or water containing waste for use, re-use, evaporation or for purification and disposal in terms of the Act (National Water Act no 36 of 1998). Any water containing waste should be diverted to a dirty water system and prevented from entering and polluting a water resource. This requirement is in line with section 19 of the National Water Act and subscribes to the principle of *pro-active pollution control.*

The intention of this is not to prohibit the discharge or disposal of water containing waste, but only to control such aspects. The person in control of a mining or related activity could apply for a water use licence in terms of section 40 of the National Water Act for the disposal or discharge of any water containing waste. The conditions for the specific disposal or discharge of water containing waste should be based on the site-specific circumstances, and stipulated within the water use licence.

It is also the responsibility of the quarry management to design, modify, locate, construct and maintain all water systems, including residue deposits, in any area so as to prevent the pollution of any water resource through the operation or use thereof and to restrict the possibility of damage to the riparian or in-stream habitat through erosion or sedimentation, or the disturbance of vegetation, or the alteration of flow characteristics.

8.1.3. Prevention of flow through mining areas

Measures should be in place to minimise the flow of any surface water or floodwater into mine workings, opencast workings, other workings or subterranean caverns, through cracked or fissured formations, subsided ground, sinkholes, outcrop excavations, adits, entrances or any other openings. The intention of this regulation is mainly the following:

- to prevent the flooding of mine workings, both underground and opencast, that could cause the loss of life or the sterilisation of the mineral resource;
- to minimise the quantity of clean water contaminated by either the mixing with dirty water or the contamination thereof by the activity. In this way the volume of clean water that can be diverted to the natural resource is maximised; and
- to prevent the pollution of the groundwater resource.

8.1.4. Maintenance and management of operational systems

Another measure to protect the water resource is to design, modify, construct, maintain and use any dam or any residue deposit or stockpile used for the disposal or storage of mineral tailings, slimes, ash or other hydraulic transported substances, so that the water or waste therein, or falling therein, will not result in the failure thereof or impair the stability thereof. The failure of such structures can result in in major pollution of a water resource. This regulation requires that such a structure be designed, constructed and maintained in such a way as to prevent the failure thereof. A suitably qualified person, e.g. civil engineer, who can professionally be held liable in the case of a disaster (loss of human life, extreme water pollution, etc.) or a failure, should design the dam or residue deposit.

8.1.5. Avoidance of leaching from stockpiles and protection of receiving environment

The erosion or leaching of materials from any residue deposit or stockpile from any area and contain material or substances so eroded or leached in such area by providing suitable barrier dams, evaporation dams or any other effective measures to prevent this material or substance from entering and polluting any water resources must also be prevented. Erosion of a residue deposit or stockpile should be prevented through proper management thereof, with inspection and maintenance done on such structures on a regular basis. The dual objectives of this requirement are firstly to prevent the eroded material from entering and polluting a water resource, and secondly to prevent structural failure thereof.

8.1.6. Recycling of dirty water

Another aspect of protection of the water resource is to ensure that water used in any process at a mine or activity is recycled as far as practicable, and any facility, sump, pumping installation, catchment dam or other impoundment used for recycling water, is of adequate design and capacity to prevent the spillage, seepage or release of water containing waste at any time. Dirty water must be re-used as far as possible on the premises of a mining or related activity, thereby minimising the use of clean water and the disposal or discharge of polluted water. Any operations facilities utilised in the management of polluted water must be maintained and operated in a manner that will ensure functionality as infrastructure failure can result in contamination of the receiving environment.

8.1.7. Management of wastewater emanating from domestic use

It is not only dirty water that occurs as a result of mining operations that can create a pollution source to the receiving environment. Water for domestic use (wash water, water-borne sewerage, etc) that cannot be disposed of directly into a municipal sewerage system is to be disposed of in terms of authorisation under the National Water Act. In terms of section 40 of the National Water Act, a person in control of a mining or related activity needs to apply for a water use licence for the disposal of domestic waste and wash-water if not disposed of in a municipal sewage system. The site-specific conditions need to be stipulated within the water use licence.

8.1.8. Further aspects to consider

The opencast areas, for the large part, are subterranean and therefore surface runoff from the pits does not occur, but runoff will occur from surface processing, processing and transport facilities. If large volumes of water do accumulate within the quarry pit, then it is assumed that it would be drained through pumping it to the surface or to an unused/inactive part of the pit where it must be managed as part of the polluted / dirty water system. Inflow of clean runoff stormwater into the pit should be avoided through creating embankments that surround the pits area that will divert clean stormwater toward a clean water management system. It is assumed that stormwater accumulation will be limited in extent and that most of it would be utilised through the routine dust suppression activities that would take place throughout the site (i.e. spraying of roads, sand/rock piles, etc.). It does need to be acknowledged, however, that transformation of the landscape through vegetation removal and surface hardening will increase the surface water runoff and therefore it is recommended that an attenuation pond be established. It is not advised that polluted water be used for dust suppression outside of the quarry pit area as this will merely lead to contamination of clean water areas from runoff.

Points to consider during the planning and construction of such an attenuation pond follow:

- This should be placed at the lowest point of the development area for practical purposes as stormwater runoff is gravity driven (outside of the quarry pit), but not within the riparian zones or associated buffer areas;
- It should be of sufficient volume in order to capture the magnitude of a reasonable flood event. This should be calculated by a suitably qualified engineer;
- It should be protected from other pollution sources (i.e. placed away from any area where fuel and/or oils are stored and completely separate from any dirty water storage or reticulation);
- This pond should be constructed of a material that will allow for practical usage of the water (e.g. pumping into water tanks for road irrigation for the purpose of dust suppression), but should also be designed in a way to allow for slow seepage into soils or for slow release into the receiving environment;
- The overflow outfall of the pond should be designed in a way that will protect the receiving environment from the impacts of erosion. High velocity water being directed onto loose soils will create erosion and impact the aquatic environment that it will eventually enter into. Energy dissipation mechanisms should be in place to slow down the velocity of the flowing water;
- Quarry water that is pumped to the surface should be routinely monitored for quality prior to release into the pond. If it is found that the quality falls outside of guideline values, then further treatment may be required prior to release of usage throughout the site;
- It is not thought that the stormwater release into the environment, however, will create a significant impact to the receiving environment.

Further recommendations to improve stormwater management is to use permeable paving wherever paving is required to stabilise road and/or building surfaces and for dust suppression within the service area (administration areas, etc). This will enhance percolation of water into the soils for groundwater recharge.

8.2. Proposed monitoring plan

The monitoring of ongoing wetland ecological function and overall health and integrity is aimed at monitoring the same points that are utilised in assessing overall wetland health initially, viz vegetation status, hydrology and geomorphology. Water quality should also be monitored for at least every six months (biennially) during normal operations, but will increase in response to accidental spillages or other incidences that warrant more frequent monitoring.

Site photographs from set points at all of the monitoring stations should be taken for all monitoring periods for reference and comparative purposes. These will be useful when undertaking trend analyses of the various monitoring aspects.

The following points should be included in the monitoring:

8.2.1. Vegetation features

- Extent of vegetation cover and the trend of increasing or decreasing extent of cover should be monitored for;
- Species composition and analysis of indigenous versus exotic species communities. Grass species composition should be analysed in terms of status (pioneering, decreaser of increaser species) as an indication of succession;
- Exotic vegetation must be monitored for to enable early detection of exotic invasive species so that this can be timeously managed;
- A change in floral species communities will also indicate the extent of the wetland functioning areas. A decrease or increase in facultative of obligatory wetland species over time will alert to this change.

8.2.2. Hydrological features

- The changes in baseflows will be most noticeable if the water levels within the instream impoundments are monitored. Cumulative data will indicate trending data over time and allow for the trends pertaining to seasonal variation to be accounted for during data interpretation;
- Increases of flow volumes emanating from the stormwater/clean water runoff from the site should be monitored to determine if the increase capacity is creating scouring impacts within the receiving environment;
- Decreases in water volume should also be monitored and areas of wetland desiccation should be flagged for increased monitoring frequency. This is due to the impact that desiccation has on hydromorphic soil structures, which exposes them to structural failure and subsequent erodibility.

8.2.3. Geomorphological features

- Geomorphological features pertain to the sediment load and the sediment transport capacity of the wetland feature. Soil erosion within the wetland unit falls within this category and is perhaps the primary and most pertinent monitoring aspect that warrants active and ongoing management;
- Lowered vegetation cover, increased exotic vegetation invasion, increased water volumes and velocity within a channel and modification of soil features are all interplaying aspects that manifest in modification of geomorphological features of a wetland unit;
- Emerging erosion, in all forms, must be routinely monitored for throughout all areas of the wetland units and management intervention must be undertaken immediately once a problem area has been identified. Erosion is relatively simple to rectify if caught early but increases in scale and complexity with time. Early intervention also allows for the use of natural features (natural vegetation to stabilise soils, etc), whereas a perpetuating erosion impact will eventually require costly civil structure intervention;
- One of the single most important driving factors behind wetland ecological integrity and functionality is erosion control, which is a function of vegetation structure and balanced hydrological features.

8.2.4. Water quality monitoring

- A functioning wetland unit provides a water quality remediation process and therefore adds a protection factor to perhaps more sensitive aquatic habitat located downstream within the system. The capacity for water purification has an obvious limit and is different from one wetland unit to the next. Preserving the overall ecological integrity and functionality of a wetland unit will enhance its capacity for water purification;
- The quality of the water that is being discharged into the wetland units (be it clean stormwater runoff, dirty process water or just the water the flows within the wetland zones) needs to be monitored and the results compared to target water quality guideline values. General water quality parameters, elemental scans and bacteriological counts should be part of routine analysis, undertaken at least every six months;
- If an incident occurs on site, such as an accidental spill, chemical leaks, sewerage contamination and the like, then a water quality monitoring schedule, targeting specifically the offensive pollutant, must be implemented at a frequency recommended by the ECO designated to the site;
- If poor or deteriorating water quality trends are observed, then the source of the pollutants must be identified and remedied appropriately, according to the type of pollution impacts identified;

- Water quality monitoring should be undertaken at the same site each time and the sampled analysed at an accredited laboratory;
- Water samples were taken during the baseline survey and these same sampling points should be considered for the routine monitoring. This can be modified at the discretion of the plant management if necessary;
- Monitoring should be undertaken within watercourses prior to the impact zones as well as within the same watercourses as they leave the impact zones. As it is dependent on the presence of surface waters, the inclusion of all of all of the recommended points may not be practical (see Figure 16);
- Monitoring points must also include as many of the local catchments within the site as possible to gain an overall understanding of the impacts to water quality, how those contaminants are being transported and to where they are being transported to. Managing a local catchment that has a single draining watercourse is then easier to manage, should the need arise.

Figure 16: Recommended points to be utilised for routine water quality monitoring.

9. CONCLUSIONS & RECOMMENDATIONS

A field survey was undertaken during January 2019 in order to evaluate the surface water ecosystems associated with the area pertaining to the proposed development of the Ilima Coal Kranspan Project. Following the field survey of the proposed development area, analyses of the data, and collaboration with the soils and groundwater specialists, the following salient recommendations can be proposed to aid in the conservation of the overall ecological integrity of the wetlands within the region:

- The proposed development area was shown to incorporate a relatively high proportion of wetland habitat units, ranging from valleyhead seeps, hillslope seeps, channelled and unchannelled valley-bottom and depression-type wetland units. These units have been delineated and their outer boundaries, together with conservation buffer zones, are presented in Figure 15;
- The wetland units are interspersed amongst formal cultivation, which is considered to be the main pressure and driver of ecological change at present, and much of the peripheral wetland units have lost functionality and ecological contribution due to cultivation. This was taken into consideration when developing the final buffer zone designation (as indicated in Figure 15);
- The wetland units were shown to all fall within a PES category range of C (moderately modified) to D/E (largely modified), with a high ecological importance and sensitivity;
- Laboratory analysis of water samples showed that the wetlands retain a relatively good water quality, excepting for one depression wetland that is subject to runoff from mining areas located to the north, adjacent to the proposed Kranspan Mining Right Area. Water quality within this wetland unit has been degraded to the point of posing a risk to both human and livestock health;
- The DWS Risk Assessment Matrix indicates that all proposed mining activities that will impact the wetland directly carry a high risk factor. The impact significance ratings also indicate that the potential impacts carry a high significance post mitigation. The significance of the impacts is largely due to the direct involvement of deleterious impacts to wetland habitat units. The significance is, however, largely dependent on the extent of wetland habitat that will be directly affected by mining activities and the severity of those impacts;
- The presented infrastructure layout indicates that some wetland areas are required to be included within the mining area and therefore will be lost. The significance of the ecological loss is dependent on the sensitivity as well as the present functionality of the wetland units. Ultimately, infrastructure layout planning that takes into consideration the wetland delineation mapping, associated conservation buffer zones, as well as the proposed mitigation measures, can greatly reduce the overall significance of the impacts to the wetland systems associated with the site.

It should be noted that, in order to conserve the wetland ecological structures within the area, the wetland needs to be viewed as an interconnected larger system and the individual units should be managed as such. This includes keeping general habitat destruction and construction footprints to an absolute minimum within the terrestrial habitat as well. Conserving the habitat units will ultimately conserve the species communities that depend on it for survival. This can only be achieved by the efforts of the contractor during the construction phase and by strict management during the operations phase.

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IRENE LEA ENVIRONMENTAL & HYDROGEOLOGY

GEOHYDROLOGICAL IMPACT PREDICTION REPORT FOR THE PROPOSED KRANSPAN COLLIERY

FINAL REPORT

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PROJECT DETAILS

PROJECT:	**GEOHYDROLOGICAL IMPACT PREDICTION REPORT FOR THE PROPOSED KRANSPAN COLLIERY**
Report Title:	Geohydrological Impact Prediction Report for the proposed Kranspan Colliery
Client:	ABS Africa
Client Contact	Paul Furniss
Project Number	ILEH-ABS ILI 10-18
Date Submitted	9 May 2019
Author	Irene Lea (M. Sc. *Pri. Sci. Nat*)

INDEMNITY AND CONDITIONS RELATING TO THIS REPORT

The findings, results, observations, conclusions and recommendations given in this report are based on the author's best scientific and professional knowledge as well as available information. The report is based on assessment techniques, which are limited by information available, time and budgetary constraints relevant to the type and level of investigation undertaken, and Irene Lea Environmental and Hydrogeology cc reserve the right to modify aspects of the report including the recommendations if and when new information may become available from on-going research, monitoring and further work in this field pertaining to the investigation.

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9 May 2019

EXECUTIVE SUMMARY

A geohydrological specialist study was completed for the proposed Ilima Kranspan project with the objective of evaluating the risks to groundwater availability and quality associated with the proposed mining activities. The project will entail opencast and underground coal mining of the E Seam in the Ermelo Coal Field. The coal will be washed and processed on site. Discard generated at the plant may either be backfilled to mined-out opencast pits or be placed on surface on a discard stockpile. The impact of both of these discard management measures was assessed as part of the specialist study, the details of which are discussed below.

In order to complete the geohydrological specialist study, eight pairs of shallow and deep monitoring boreholes were drilled and tested to obtain information to characterise the aquifer present. The borehole locations were determined with the aid of surface geophysical methods. Two northeast-southwest striking lineaments transect the proposed mining area. One of these lineaments is located underneath the largest pan present on site. The geophysical surface was used to pinpoint the locations of these and monitoring boreholes were used to characterise aquifer conditions associated with the lineaments. The results indicate that the lineaments have enhanced aquifer characteristics and will act as preferential flow paths to groundwater. Groundwater samples were taken from the monitoring boreholes for chemical analysis to establish ambient groundwater quality conditions.

The information obtained from the monitoring boreholes indicates that there are two aquifers present, namely a shallow weathered aquifer that extends to a depth of 10m and a deeper fractured rock aquifer.

The average depth to groundwater in the weathered aquifer is 4m. In low-lying areas, the groundwater table is however shallower and springs occur in the area. The aquifer is not considered significant in terms of water supply due to its limited thickness. It does however play an important role in terms of the recharge of rainwater and baseflow to streams and pans, especially during the dry season.

The weathered aquifer is underlain by a deeper fractured rock aquifer. The fractured rock aquifer is most prominent along the two lineaments identified, which have higher permeabilities compared to the unfractured rocks. The average depth to groundwater in the fractured rock aquifer is 9,7m.

A hydrocensus of private groundwater use was also completed as part of the study. A total of 26 private boreholes and springs were identified during the hydrocensus. Groundwater level measurements could be taken in 7 of these boreholes. Seven groundwater samples were furthermore taken from selected hydrocensus boreholes for chemical analysis and to establish baseline conditions. The weathered aquifer is not isolated from the fractured rock aquifer and aquifer tests confirmed that there is interaction between the two aquifers.

Groundwater flow patterns that were established from the data obtained from the monitoring and hydrocensus boreholes indicate that groundwater flow is mainly towards the largest of the pans present on site. Local variations in groundwater flow occur and groundwater also flows towards the smaller pans.

The results of the chemical analysis of groundwater samples taken from the monitoring and private boreholes indicate that groundwater quality is generally good and complies with South African drinking water standards. The dominant cations are sodium and potassium and the dominant anions are bicarbonate and to a lesser extent chloride. The groundwater is however naturally hard, which can result in scaling and has a so-called “soap destroying” nature. Elevated concentrations of iron and aluminium and to a lesser extent of fluoride were also recorded. At the concentrations recorded, staining in plumbing may be expected. Groundwater with elevated iron concentrations may also result in adverse health effects in young children and sensitive individuals and may promote the proliferation of iron-oxidizing bacteria, which may manifest as slimy coatings in plumbing.

The geohydrological impact assessment was completed with the aid of a numerical groundwater flow and contaminant transport model, which was calibrated with data obtained from the monitoring and private boreholes. In order to ensure that boundary conditions do not affect the outcome of the assessment, a modelled area was created that is much larger than the project site, covering an area of 270 km^2. The results of model calibration indicate that the calibration criteria set for the project were met. The model is therefore considered suitable to complete the impact assessment with the available dataset. The outcome of the assessment indicates that the model is sensitive to large fluctuations in the rate of recharge to the aquifers as well as to the storage coefficient and specific yield of the aquifers. Model calibration and confidence levels can be improved once additional monitoring information becomes available from the site. Model verification should therefore be undertaken once mining starts and the groundwater monitoring programme results are available.

The calibrated model was used to complete the impact assessment for the project. During simulations, the opencast and underground mine plans made available by Ilima was incorporated into the model. Opencast mining will be completed over a period of 14 years and underground mining over 12 years. The impact of mining on wetlands was a specific focus during the assessment. The extent of the wetlands and associated buffer zones as identified as part of the Scoping Phase of this project were used during the assessment.

Based on the outcome of provisional geochemical tests completed on waste rock and discard material sourced from the project site, the main source of contamination associated with the site is leachate from the discard. The study indicates that the waste rock samples poses a low environmental risk with only one out of twenty samples pointing to acidification of water in the long-term. The discard material on the other hand has a high probability of becoming acid generating if stored in a surface discard dump for a significant amount of time. There is however a level of uncertainty regarding the magnitude of the acid generating potential from the provisional geochemical tests. Greater clarity is expected once more sophisticated kinetic tests are completed. These are currently underway. The geochemical study confirms that sulphate is an indicator element associated with the project. Increased sulphate concentrations result from the oxidation of pyrite and other sulphide minerals in the coal, overburden and discard material. In the absence of the results of the kinetic tests, medium and long-term sulphate concentrations were inferred from literature-based values during the assessment.

The impact assessments associated with discard management included three alternative disposal options. The first and preferred option is the placement of discard into mined-out pits. The second was placing the discard on surface on an unlined stockpile. The third option evaluated was to assess the impact of lining the discard stockpile with a Class C liner. It is noted that the final liner design will be determined by the professional engineer who will design the facility. During simulations, the rate of recharge to un-rehabilitated and rehabilitated mining areas was varied, according to rates described in literature.

The results of the impact assessment are summarised as follows:

- **Impact on groundwater availability during the construction and operational phases of mining:**
    - The rate of groundwater seepage during the construction and operational phases of mining was calculated. Due to the anticipated heterogeneous nature of the fractured rock aquifer, a range of seepage rates is provided. Under average conditions, the total volume of groundwater seepage to the box cut and adit may be around 125m^3/d during the construction phase. It is further recommended that provision is made for 18 000 m^3 of groundwater per year in the pollution control dam that will be constructed during this phase of mining. During the operational phase of mining,

groundwater seepage rates may vary according to many factors that influence the seepage rate. On average, the total volume of groundwater seepage may vary between 100 and 340 m^3/d. Maximum flow rates are expected during Year 10 due to the depth and extent of mining at this stage. It is further recommended that provision is made for a total of 50 400 m^3/a of groundwater in all the pollution control dams. This is equivalent to 8 400 m^3/a for each of the six planned dams.

- It is anticipated that mining activities will have a negative impact on groundwater availability in private boreholes and springs. The following boreholes and springs, only one of which is currently in use (KR_Spring5), will in all likelihood be destroyed during mining:

BH ID	Owner	Current use
KR5	Jaco Papenfus	Open hole not in use
KR6	Jaco Papenfus	Open hole not in use
KR7	Jaco Papenfus	Submersible pump (not operational): supply to house and animals
KR8	Jaco Papenfus	Windpump not in use
KR_Spring5	Koos Jordaan	Fenced in: supply to animals

- In addition to the boreholes that may be destroyed, groundwater levels may also be lowered in private boreholes as a result of mine dewatering. Even though the boreholes and spring listed above will be destroyed, they are included in the assessment presented below for comparison. The impact of mine dewatering on private boreholes is listed below. It is noted that groundwater is one of the only water resources available to farmers in the area. Whether or not the estimated lowering in groundwater levels will have a negative impact on current groundwater use will depend on the depth and construction of the boreholes. This information is not available for the private boreholes. It is however likely that boreholes in which groundwater levels are lowered by more than 10m will be lost Two boreholes (KR7 and KR8) could be lost in this regard. Neither of these were recorded to be in use during the hydrocensus:

Affected BH	Owner Current Use	Current abstraction volume (l/hr)	Anticipated lowering in groundwater level (m)	Timing of impact (year of mining)
KR3	Rudi Prinsloo Windpump: supply to animals	Not available	<2	Year 3 – 5
KR4	Rudi Prinsloo Open borehole: not in use	Not available	<2	Year 3 – 5
KR5	Jaco Papenfus Open borehole: not in use	Not available	<10	Year 6 – 11
KR6	Jaco Papenfus Open borehole: not in use	Not available	<10	Year 6 - 11
KR7	Jaco Papenfus Submersible pump (not operational): supply to house and animals	Not available	<25	Year 1 - 14
KR8	Jaco Papenfus Windpump: not in use	Not available	<25	Year 1 - 14
KR10	Gysbert Klein Windpump: supply to animals	Not available	<5	Year 10 - 14
KR11	Rudi Prinsloo Windpump: supply to house and animals	Not available	<5	Year 1 – 5
KR12	Koos Jordaan Submersible pump: supply to house and animals	Not available	<2	Year 14

- **Impact on groundwater quality during the construction and operational phases of mining:**
  - Under average conditions and based on the results of preliminary geochemical analyses, modelling suggests that sulphate concentrations may increase to above 150 mg/l within the mining area during the operational phase. This assessment excludes the placing of discard in pits or on surface. The contamination is not expected to move significant distances from the mining areas due to the impact of mine dewatering and the reversal of groundwater flow towards the mining areas during the operational phase.
  - The most significant impact on private boreholes is expected to occur in the vicinity of KR7 and KR8, which are situated near the proposed plant. The increase in sulphate concentrations is however not expected to pose a health or aesthetic risk.
- **Long-term impacts on groundwater - rate of groundwater level recovery:**
  - Regional groundwater levels are expected to take 30 – 50 years to recover around the mining areas after mining and mine dewatering ceases.
- **Long-term impacts on groundwater - risk of decant:**
  - The risk of decant depends on several factors, which are discussed in more detail in this report. The main factor that controls the risk of decant is the rate of recharge of rainwater to the disturbed areas. It is unlikely that the opencast mining areas could be rehabilitated to natural recharge conditions and for this reason, decant is likely from all the pits. The most likely decant point at each pit is associated with the lowest topographical elevation and a total of 20 possible decant locations are listed below for the thirteen planned pits. The locations of the decant points are indicated on a map presented in this report. The static test results indicate that there is an acid generating potential for some of the material that will be handled on site, specifically the coal and discard material. For this reason, the quality of decant is not expected to be suitable for discharge to the environment. The decant is expected to be acidic (pH<5), with elevated salt and trace metal concentrations.

Decant No	Pit	Decant elevation (mamsl)	Time to possible decant (yrs)	Possible decant volume (m^3/a)
1	Pit 1	1659	26	21873
2		1672		
3		1656		
4	Pit 2	1665	16	7849
5		1665		
6	Pit 3	1666	14	2848
7	Pit 4	1671	17	2257
8	Pit 5	1661	19	23431
9		1664		
10		1667		
11	Pit 6	1666	19	11732
12		1668		
13	Pit 7	1653	32	5118
14	Pit 8	1652	39	15014
15	Pit 9	1654	13	11908
16		1653		
17	Pit 10	1656	10	8078
18	Pit 11	1655	6	1724
19	Pit 12	1671	32	1635
20	Pit 13	1663	13	1159

  - The most significant impact of decant will be on wetland functioning. As the decant points are all associated with low-lying areas, they are typically associated with wetlands. If the decant is not contained, the acidic pH conditions and high salt and trace metal concentrations are expected to kill the wetland fauna and flora. These impacts would most probably be irreversible in the long-term.
  - In addition to impacting negatively on wetlands, the unmanaged decant will also flow across land to the pans and non-perennial streams that drain the project area. As

with the wetlands, the decant will negatively affect water quality in these surface water bodies and will most probably result in irreversible acidification and unacceptable salt loads.

- o If no subsidence takes place over the underground mining areas, it is unlikely that the underground workings would decant in the long-term.

- **Long-term impacts on groundwater quality:**
  - o As mentioned previously, various scenarios were tested to determine the long-term impact of mining on groundwater quality. These are:
    - Scenario 1: the long-term impact if all rehabilitation measures are implemented and deterioration in groundwater quality does not take place during the operational phase of mining. This option does not take the impact of discard disposal on site into consideration.
    - Scenario 2: tests the impact of placing discard material into the mined-out pits. Although it is acknowledged that this will not take place in all of the pits as the volume of discard generated will be less than the void space available in all the pits, the model was used to see the impact of backfilling all the pits with discard. This will allow identification of pits that may be more suitable for backfill with discard. In order to complete this scenario, it was assumed that the discard material will acidify during the operational phase as well as post-closure resulting in an increase in sulphate concentrations.
    - Scenario 3: evaluates the impact of placing discard in a stockpile on surface within the plant area. The scenario assumes that the discard stockpile will not be lined and the rate of seepage would be governed by the permeability of the weathered aquifer.
    - Scenario 4: test the effect of lining the discard stockpile with a Class C liner. As noted previously the final liner design will be determined by the professional engineer appointed to design the facility. In order to complete this simulation, literature-based liner leakage volumes were applied.
  - o The outcome of each scenario is discussed in detail in the report. A summary of the simulations is presented below in terms of the estimated salt loads resulting from each scenario on receptors identified. It is shown that backfilling the pits with discard will result in the most significant impact. It is however noted that the information presented is an over-estimation, as not all pits would be backfilled with discard. The calculations further indicate that a Class C liner (or a liner described in the design of the facility by a professional engineer) installed at a surface discard stockpile would result in a 9% decrease in salt load.

Description	Average SO_4 (mg/l)				Estimated volume (m^3/a)	Salt load (t/a)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4		Scenario 1	Scenario 2	Scenario 3	Scenario 4
Pans and streams									
Largest pan	275	450	325	275	41245	11,3	18,6	13,4	11,3
Smallest pan	200	350	200	200	657	0,1	0,2	0,1	0,1
Smallest NE pan	100	300	100	100	3778	0,4	1,1	0,4	0,4
Largest NE pan	225	300	225	225	3869	0,9	1,2	0,9	0,9
Non-perrenial stream Pit 10	50	70	50	50	5400	0,3	0,4	0,3	0,3
Non-perrenial stream Pit 7 & 8	300	450	300	300	4500	1,4	2,0	1,4	1,4
Non-perennial stream Largest Pan	50	70	50	50	900	0,05	0,06	0,05	0,05
Wetlands									
Largest pan	650	800	750	650	9736	6,3	7,8	7,3	6,3
Pits 7 & 8	400	675	400	400	6912	2,8	4,7	2,8	2,8
Pit 5	650	800	650	650	4702	3,1	3,8	3,1	3,1
Pit 11	600	600	600	600	2822	1,7	1,7	1,7	1,7
Pit 10	550	625	550	550	4748	2,6	3,0	2,6	2,6
Pit 9	650	725	650	650	2030	1,3	1,5	1,3	1,3

- The result of the simulations indicates that not all of the pits are suitable for backfilling with discard. It is noted that this option would result in a negative impact on decant quality in the long-term and that sulphate concentrations may increase by up to 30% inside the pits. As the discard is expected to acidify in the long-term, the impact on groundwater quality, wetlands and private boreholes may therefore be more significant.
- Due to the increased risk of decant and deterioration in groundwater quality, pits around the largest of the pans should not be backfilled with discard. Pits that are located along the two lineaments should also not be backfilled with discard, as these would preferentially transmit contaminated water. Pits that are situated immediately adjacent to streams should also not be backfilled with discard due to the increased negative risks associated with decant and the groundwater component of baseflow to the streams. Based on the criteria used during the evaluation, it is concluded that only one pit is suitable for discard disposal, as detailed in the report. Mining from this pit is scheduled from Year 6.
- Two scenarios were evaluated for the placement of discard on a surface stockpile, namely an unlined and a lined facility. As expected, an unlined facility will result in a significant increase in sulphate concentrations in the immediate vicinity of the discard stockpile in the long-term. Sulphate concentrations may increase to above 2500 mg/l in the weathered aquifer in the immediate vicinity of the discard facility in this case. It is further possible that the plume may reach the lineament to the west of the discard stockpile and that contamination from the discard stockpile may flow preferentially along the fault towards the largest pan in the southwest. It is expected that leachate from the unlined discard stockpile will be captured in the backfilled pit situated down gradient of it and will to a certain extent be contained in the pit until such time that it is flooded. This is however expected to have a negative impact on decant quality in the long-term. Due to the proximity to the largest pan and the wetlands associated with it, this is expected to result in significant negative impacts in the long-term.
- If the discard dump is lined with a Class C liner the most significant positive impact on sulphate concentrations is expected in the immediate vicinity of the site. For this scenario, sulphate concentrations are expected to remain below 900 mg/l at the stockpile. Groundwater quality will however still be affected by the mining activities in this area and lining of the facility will not mitigate the regional impact of mining on groundwater quality. For this scenario, the discard facility is not expected to have a noticeable impact on pitwater and decant quality.

A groundwater management plan was developed, based on the outcome of the impact assessment presented. The management plan is based on objectives and targets set for the project. Over-arching groundwater management measures are provided, which are aimed at planning for groundwater management from the start of the project and installing good house-keeping measures. All dirty water must be contained in suitably sized and designed facilities and clean water must be diverted around the mining area back into the catchment. Mine design must consider the results of this study, specifically relating to underground mine stability (to prevent subsidence) and the concurrent backfilling and rehabilitation of opencast pits.

Geochemical static leach tests on Kranspan discard samples indicate low concentrations of sulphate in leachate from the discard under the conditions of the test. Kinetic leach tests and geochemical modelling are currently underway, which will improve the understanding of long-term leachate quality. Available information however suggests that the discard material is likely to acidify with time, which will result in a deterioration in leachate quality. For this reason, the groundwater impact assessment is based on a worse case scenario (oxidation of the discard material), in line with the precautionary principle. Ilima is committed to implementing measures to reduce the risk of groundwater contamination associated with the handling of the discard material. For example, for the preferred option of in-pit discard disposal, restrictions are placed on the pit location and depth to which the discard can be backfilled. With these management measures, the rate and extent to which the discard could oxidise will be reduced. The resultant discard leachate could therefore be of better quality than what was used in this report, resulting in a reduced impact on groundwater quality. For this reason, it is recommended that the groundwater quality impact assessment is revised once the results of the kinetic tests and geochemical modelling are available.

Specific groundwater management measures are proposed for each of the impacts identified. These include measures to minimise the impact of mine dewatering as well as of the long-term impact of decant and deteriorating groundwater qualities. It is important that additional information is obtained to characterise borehole depth, construction and yield of private boreholes that fall inside the delineated zones of impact prior to the commencement of mining. This information must be used as a basis for discussions and negotiations with private borehole owners that may be negatively impacted during mining. It is important that the mine provides feedback to private borehole owners on a regular basis regarding mining, rehabilitation and monitoring activities.

The impact on groundwater and decant quality can be minimised by positioning surface infrastructure off the two lineaments, which are preferential flow paths to groundwater. Strict measures must be implemented if discard is backfilled into the pit identified as most suitable. This includes requirements regarding the placement of discard, the extent of mining and monitoring requirements. If discard is to be placed on a surface stockpile, it is recommended that at least a compacted clay liner is considered. This facility must be designed according to legal requirements.

A dedicated groundwater monitoring programme must be implemented during the construction phase of mining and maintained throughout the life of mine. Additional monitoring boreholes that may be required are discussed and specified in the report. The monitoring information must be used to measure the short and long-term impact of mining on groundwater levels and quality. Should adverse impacts be identified, the monitoring programme must trigger the necessary response and implementation of additional management measures, as required. This information must further be used to update, verify and re-calibrate the numerical groundwater flow and contaminant transport model prepared as part of the assessment. This will increase the level of confidence in the impact prediction results.

The assessment presented in this report must be updated once the results of the kinetic geochemistry results are available to ensure that all simulations are based on the best possible dataset. The model should also be updated on a regular basis, once the monitoring programme results become available.

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LIST OF ACRONYMS USED

BH	Borehole
BPG	Best Practice Guideline
CDT	Constant Discharge Test
DTM	Digital Terrain Model
DWS	Department of Water and Sanitation
DWAF	Former Department of Water Affairs and Forestry
iLEH	Irene Lea Environmental and Hydrogeology cc
HDPE	High Density Polyethylene
K	Hydraulic conductivity or permeability (unit: m/d)
L/h	Litre per hour
LOM	Life of Mine
LOW	Limit of weathering
mamsl	Metres above mean sea level
MAP	Mean Annual Precipitation
m bgl	Metres below ground level
Ml/d	Megalitres per day
MRP	Metals Recovery Plant
NA	Not applicable
NS	Not specified
PCD	Pollution Control Dam
RMSE	Root mean square error
S	Storage coefficient (-)
S_y	Specific yield (-)
S&EIR	Social and Environmental Impact Assessment Report
SANAS	South African National Accreditation System
SANS	South African National Standards
SDT	Step Drawdown Test
SWL	Static Water Level
T	Transmissivity (unit: m^2/d)
WL	Water level
WMA	Water Management Area
WML	Waste Management License

1 PROJECT BACKGROUND

1.1 Project Description

The study area is approximately 15 kilometres south of Carolina, Mpumalanga situated along the R36 road between Carolina and Breyten town, on the Mpumalanga Highveld. It is the intention of Ilima to mine the E Coal Seam that forms part of the Ermelo Coalfield. Both surface and underground mining is planned at the proposed colliery. Surface mining is planned for Portion RE, 2, 3, 5 and 7 of the farm Kranspan. Underground mining is planned for Portion 4, the northern section of Portion 2, the northwestern section of Portion 3 and the southern section of Portion 7 of the farm Kranspan.

The existing land uses include cultivated fields, farm roads, private groundwater abstraction, cattle farming and farm steads (ABS Africa, 2018). Two coalmines are located on land surrounding the Kranspan project area, namely Msobo and Northern Coal Mine.

According to the Scoping Report (ABS Africa, 2018), the project will include the following activities that are relevant to the groundwater specialist study presented in this report. It is noted that the broad placement of mining and surface infrastructure was informed by an environmental sensitivity plan, which considered the location of all known sensitive physical, social and environmental features within the application area. In addition, a consultation process is underway following the completion of the scoping phase of the project. Input from the public and authorities will be taken into consideration during final site selection for the project. The locations of the areas listed are indicated on Figure 1.

- Opencast mining over an area of 1 054ha, focussing on the E Seam. The roll over mining method (strip mining) will be implemented to ensure that mined-out areas are concurrently rehabilitated as mining progresses. Overburden and topsoil will be placed back into mined-out voids in the former stratigraphic sequence. The final re-instated surface is anticipated to be approximately 0,52m above the original surface level to ensure a free-draining surface. Upon completion of pit backfilling, each strip will be re-vegetated with suitable pasture grass species.
- Mine production will ramp up over a period of 11 months, with full production planned to commence in Year 2 of mining (Ilima, 2018). The estimated life of mine (LOM) is 12 years, producing 2,256 million tonnes per annum.
- Underground mining over an area of 392ha, using the conventional board and pillar method. The underground mine will be designed for the maximum extraction, but no pillar extraction will take place. In order to gain access to the underground workings, a mine access shaft and a ventilation shaft will be constructed.
- Dry crushing and screening of the coal prior to putting the coal through a wash plant (coal processing plant). The plant will cover an area of 1,7ha. The planned raw coal feed to the plant is 4,24 Mt/a, with an efficiency of 87,6% and a plant yield of 70,8%. Coal will be processed at a rate of 670 t/hr.
- Plant waste material will be disposed of into mined-out opencast pits. Alternatively, the construction of an engineered surface discard dump, covering an area of 26,94ha, may be considered. The selection of the preferred option for discard disposal will be informed by the findings of the geohydrological modelling presented in this report. The results of the geochemistry specialist study will be used to complete this assessment.
- Washed coal will be placed on a coal product stockpile with an anticipated area of 5,3ha in the loading area from where it will be transported off site for sale.
- The placement of overburden and topsoil stockpiles. These will be temporary stockpiles, as opencast mining areas will be concurrently rehabilitated during the operational phase of

mining. Topsoil and soft overburden will be removed in two strips in advance of the working strip and will either be stockpiled or placed directly on rehabilitated areas behind the advancing strip. Hard overburden will be blasted and dozed or hauled to the spoil strip side of the current strip from where it can be backfilled into mined-out areas.

- All dirty runoff will be separated form clean water with the use of cut-off drains. Polluted runoff will be contained in high-density polyethylene (HDPE) lined pollution control dams (PCD). These will be situated adjacent to the processing plant and in the proximity of the opencast pits. This water will be used for dust suppression and in the processing plant.
- For both mining methods, mine dewatering is anticipated over the life of mine (LOM). Water removed from the pits will be stored in the PCDs.
- Ancillary services and activities, like the construction of haul and internal roads; construction of overland conveyors in the pit loading area; construction of a mine contractors camp and a mine support and administration block; the creation of a fuel storage area with a back-up power generator and the construction of an explosives storage area.
- It is anticipated that boreholes will be established to supply potable water to mine staff. It is estimated that approximately 40 m^3/d of water will be required per day to meet the demand at the mine. A small water treatment plant will be constructed at the mine to produce potable water from the boreholes.
- Process water will be used at the processing plant, for dust suppression and for underground cooling. It is anticipated that the processing plant will require around 986m^3/d. Process water may be sourced from ground- or surface water resources available to the mine, or from the dirty water containment facilities.
- Sewage handling and management is not expected to impact on groundwater, as modular sewage package plants and chemical toilets will be used.
- No solid waste disposal facility will be constructed at the mine. Waste will be segregated into general and hazardous waste and will be removed off site by contractors. An oil recycling company will also be appointed to remove waste oil off site. The on-site waste storage area will be located at the processing plant. Medical waste will also be removed by a contractor. Based on the available information, it is not anticipated that solid waste disposal will impact on groundwater at the operations.

1.2 Details of the Specialists

The project was managed by Irene Lea. She has 27 years experience in the field of geohydrology. She has a M.Sc. degree in Geohydrology and is a registered Professional Natural Scientist (400278/06). Her focus includes numerical groundwater flow and contaminant transport modelling, water treatment, integrated water and waste management strategies, rehabilitation and closure projects, environmental management systems and risk assessments.

The fieldwork programme was managed and undertaken by Lucas Smith of Groundwater Abstract. Lucas has 26 years experience in the field of geohydrology. He also has a M.Sc. degree in Geohydrology and is a registered Professional Natural Scientist.

Both consultants that completed the project have no direct or indirect beneficial interest or contingent in the Ilima Kranspan Project at present or in the past. They will be paid a fee by ABS Africa, the environmental consultants appointed to the project for coordinating the groundwater specialist study, numerical groundwater flow and contaminant transport modelling within normal professional consulting practice. Payment of these fees is in no way contingent upon the conclusions or opinions expressed in this report.

1.3 Compliance Framework

This study is submitted as part of the requirements for the application for a mining right, waste management license and a water use license, currently undertaken by ABS Africa. The listed activities that will be included and assessed as part of the groundwater specialist study are listed in Table 1. These are based on information presented in the project Scoping Report (ABS Africa, 2018).

The application is made for a duration of 30 years.

Table 1 Activities applicable to the geohydrological specialist study

Regulation	Description
Mineral and Petroleum Resources Development Act , 2002 (Act No 28 of 2002) (MPRDA)	Ilima is applying for a mining right in terms of section 22 of the MRPDA.
National Environmental Management: Waste Act, 2008 (Act No 59 of 2008) (NEM:WA)	The project will require a waste management license (WML) for the planned PCDs, mineral stockpiles and mine residue stockpiles, in addition to non-mineral waste (the latter is not expected to impact on groundwater).
National Environmental Management Act, 1998 (Act No 107 of 1998) (NEMA)	The proposed mining activities fall within the ambit of various listed activities in Listing Notice 1, 2 and 3, as detailed below. A Social and Environmental Impact Assessment Report (S&EIR) will therefore be compiled and submitted as part of the application.
NEMA: GN 983, 8 December 2014 (as amended on 7 April 2017): Listing Notice 1	The placement of PCDs and material stockpiles within a watercourse, or if no development setback exists, within 32m of a watercourse. It is noted that avoidance of such areas is prioritised as part of the environmental sensitivity planning for the project.
	The planned PDCs may exceed a combined capacity of 50 000 m^3.
	The establishment of borrow pits and other small-scale mining of minerals within the project area.
	The operation of facilities to treat effluent, wastewater or sewage with a daily throughput capacity of between 2000 and 15000m^3. Although the sewage treatment facility will be self-contained, the installation of a treatment facility for contaminated water may be necessary.
NEMA: GN 983, 8 December 2014 (as amended on 7 April 2017): Listing Notice 2	The development and submission of a water use license application in terms of the requirements of the NWA.
	The project will require a mining right according to the requirements of the MPRDA.
NEMA: GN 983, 8 December 2014 (as amended on 7 April 2017): Listing Notice 3	The placement of PCDs and material stockpiles within a watercourse, or if no development setback exists, within 32m of a watercourse. It is noted that avoidance of such areas is prioritised as part of the environmental sensitivity planning for the project.
GN R921, 29 November 2013 Categories A and B	The need and construction of the PCDs, which are categorised as the storage of general waste in lagoons.
	The construction of the mine residue stockpiles.
	The reclamation of residue stockpiles or deposits as part of mining activities, specifically the process of backfilling and rehabilitating the opencast mining voids with topsoil and overburden stockpiles as well as the possible in-pit disposal of discard.
The National Water Act, 1998 (Act No 36 of 1998) (NWA)	The proposed mining activities will require a water use licence for the activities detailed below. An integrated water use license application will be submitted in this regard.
Water Uses in terms of Section 21 of the NWA	Section 21 (a): taking water from a resource Section 21 (b): storing of water Section 21 (c): Impeding or diverting the flow of water in a water course Section 21 (i): Altering the beds, banks, course or characteristics of a water course Section 21 (g): Disposing of waste in a manner which may impact on a water resource Section 21 (j): Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of any activity, or for the safety of people

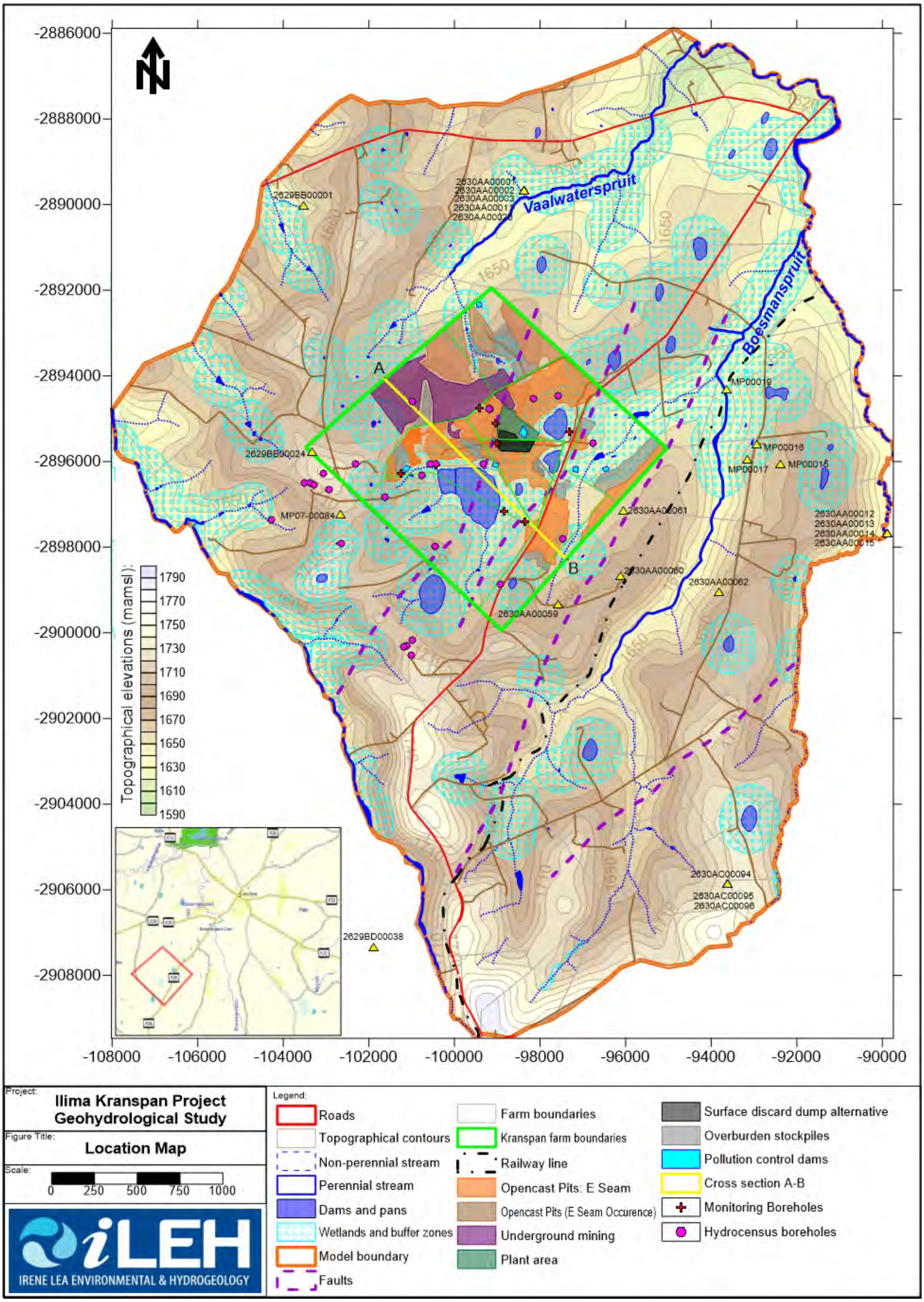

Figure 1 Location map

1.4 Date and season of investigation

The fieldwork component of the project was undertaken between December 2018 and February 2019. The information presented therefore represents groundwater conditions during the wet season.

1.5 Project methodology

The geohydrological impact assessment was completed with information obtained from ABS Africa, Ilima as well as from a dedicated fieldwork programme.

Information made available by ABS Africa and included in this assessment includes:

- A copy of the Scoping Report submitted as part of the mining right application (ABS Africa, 2018).
- Certificates of analyses on various rock samples completed as part of the geochemistry specialist study for the project.
- A copy of the surface water study completed by Peens & Associates (2019).
- Various maps indicating the surface and mining layouts applicable to the project.

Ilima made the results of their exploration programme available in order to conceptualise the coal seam roof and floor elevations in the geohydrological modelling context.

The fieldwork programme was completed by Groundwater Abstract in consultation with iLEH. The fieldwork included a hydrocensus to identify private groundwater use in the region. Ground geophysics were used to site eight dedicated groundwater monitoring boreholes. These boreholes were drilled using percussion methods and aquifer tests were completed to calculate aquifer parameters. Both shallow and deep boreholes were drilled to obtain information on the two main aquifers that are expected on site. Groundwater samples were taken from some of the hydrocensus and all of the monitoring boreholes for chemical analysis in order to characterise ambient groundwater quality conditions.

The geohydrological impact assessment was completed based on the outcome of simulations with a numerical groundwater flow and contaminant transport model. The model was calibrated with the available groundwater monitoring dataset. Details regarding model construction and calibration are discussed later in this report.

The numerical model was used to complete the geohydrological impact assessment presented in this report.

1.6 Geohydrological Study Objectives

The groundwater impact assessment has the following objectives:

- Define the current groundwater use in the project area;
- Define potential receptors in the project area, for example wetlands and private groundwater use;
- Define the aquifers underlying the project, as well as current groundwater table depth, groundwater quality, and flow characteristics;
- Develop a numerical model to define groundwater related impacts and groundwater inflow into the proposed mining areas;
- Define the radius of influence that will be created by mine dewatering, plus the extent of possible contamination originating from the proposed mining areas and mine infrastructure;
- Assess whether decant will occur during the operational phase or post closure; and
- Recommend a groundwater monitoring network that will initiate monitoring of groundwater quality and level changes; pre-mining and into the operational phases.

1.7 Affected catchments

The Kranspan project area is in the Komati River catchment, in the X11B quaternary catchment, forming part of the Inkomati-Usuthu Water Management Area (WMA:3). The main drainage is the Boesmanspruit and it is located approximately 5 km east of the project area. The Boesmanspruit discharges into the Nooitgedacht Dam approximately 17 km north of the project area.

The far western corner of the farm Kranspan is in the X11A quaternary catchment; drained by the Vaalwaterspruit. The Vaalwaterspruit also discharges into the Nooitgedacht Dam.

1.8 Wetlands

At least three wetland types are represented in the study area, namely Endorheic Pans, Valley-bottom Wetlands and Hillslope Seeps (ABS Africa, 2018). The wetlands cover approximately 330 ha of the project area. The extent of the wetlands is indicated on Figure 2.

Satellite imagery indicates several circular to sub-circular permanent or seasonal pans in the study area, of which Kranspan is the most significant, with a size of approximately 125 ha (see Figure 2). Kranspan and a second pan to the north-east are likely to support significant numbers of congregatory waterbirds at certain times of the year.

While wetlands typically have lower species diversity than adjacent undisturbed grassland, a high proportion of habitat specialist plants are usually present and likelihood of fauna species of conservation concern being present is moderate to high.

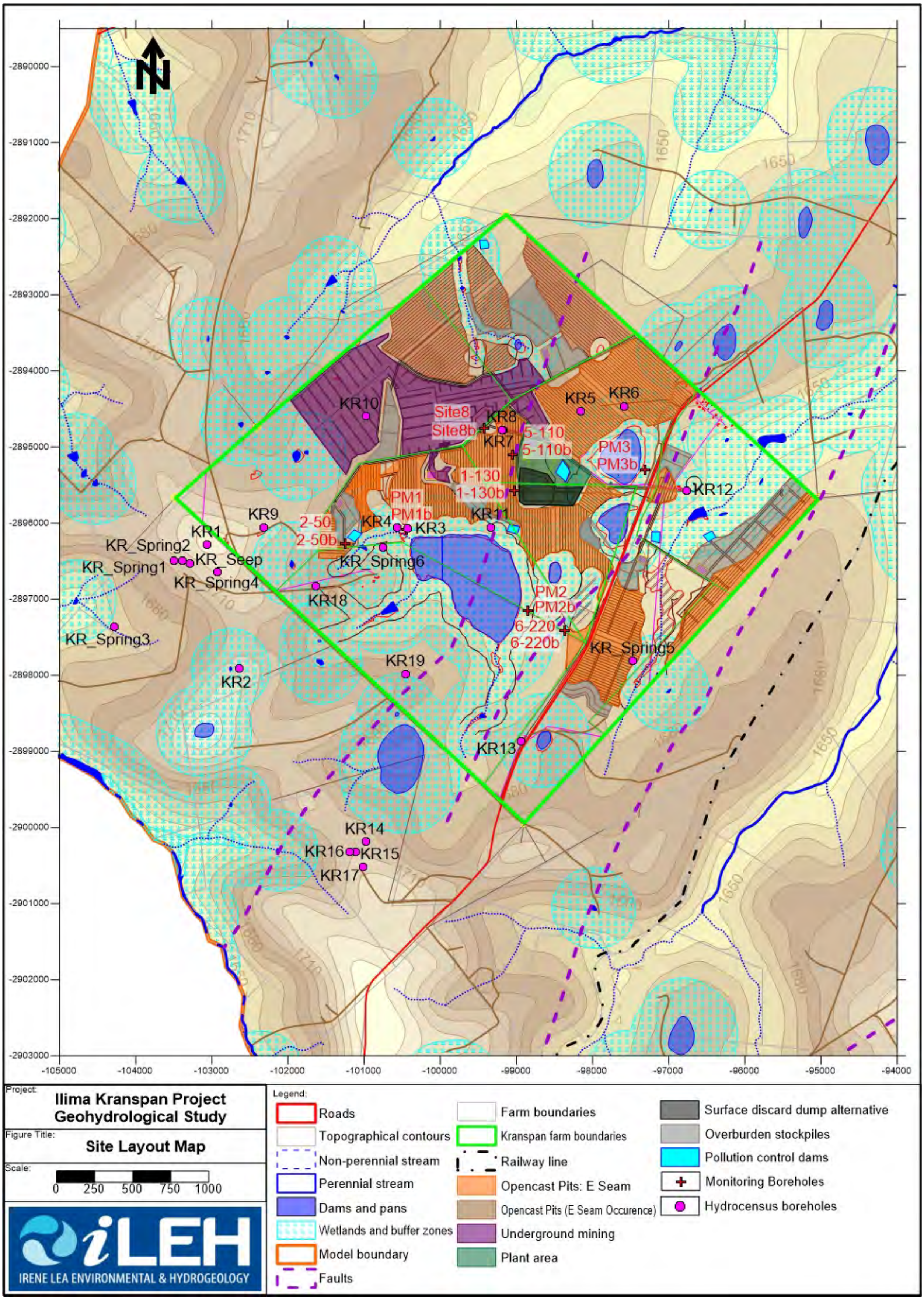

Figure 2 Site layout map

1.9 Climate and rainfall

The climate of the project area is mild to warm during the summer and cool to cold during the winter. During the rainy season it is sub-humid, but during the cold dry season it is mildly sub-arid.

Rain occurs as mild to heavy showers and thunderstorms during the summer months between November and February, with an average of 500 to 750mm per year (ABS Africa, 2018). The winter months are dry. Heavy falls (>100mm) in a single 24-hour period do not occur.

The mean annual precipitation (MAP) for the mining area is 698mm/a (Peens & Associates, 2019). In comparison, the mean annual evaporation (MAE) for the area is 1 450mm/a, which is twice as high as the rainfall.

1.10 Alternatives considered

All project alternatives available to the Kranspan Project were evaluated by ABS Africa as part of the Scoping Phase of the project. The outcome of this assessment was an environmental sensitivity map, which was used to develop optimal surface and mining layouts.

The only project alternative that will be considered as part of this impact assessment is that of discard management. As mentioned previously, two options are under consideration:

- The preferred alternative is to backfill the discard material into mined-out opencast voids. The numerical groundwater model will be used to assess the impact of this option and to identify the most suitable pits for discard backfilling, if any.
- The alternative that will be considered entails an engineered surface discard dump, covering an area of 26,94ha. The location of the discard dump alternative is indicated on Figure 2.

2 GEOHYDROLOGICAL ASSESSMENT

2.1 Geological setting

The Kranspan project is located in the Ermelo Coal Field. Compared to the adjacent Witbank and Highveld Coal Fields, the Ermelo Coal Field hosts thinner seams, is sedimentologically and structurally more complex and is not as well studied or understood (Ilima, 2018). The coalfield is underlain by glacial pre-Karoo rock formations, including the Dwyka tillite. The Karoo Supergroup hosts all the South African coal deposits. The coal in the Carolina area occurs within the Vryheid Formation of the Ecca Group, which forms part of the Karoo Supergroup. Five coal seams are recognised within an 80 – 90m thick sedimentary succession. These are, from the top down, the A to E Seams. The regional geological setting for the project is indicated on Figure 3.

The A Seam, although present in the project area, is too thin to be of economic interest (Ilima, 2018). The B Seam varies from 1 – 2,7m in thickness and splits into two units, referred to as the B Lower and B Upper Seams. It is thought that the quality of the B Seam is often inferior to that of the C Seam, which makes it uneconomical. Normally the C Seam is the main economic coal deposit in the Ermelo Coal Field. Unfortunately it is not economically mineable in the Kranspan area. The D Seam is of good quality, but is generally too thin (0,1 – 0,4m) to be of economic importance. The E Seam is the main mining target in the Kranspan project area. The coal is mostly bright and banded and has a competent sandstone roof and floor. It is sometimes split by a thin sandstone or carbonaceous fines parting

The overall coal seam dip is around 1.5° to the southwest, which is consistent with the regional characteristics. The immediate roof is a hard and competent material.

A dolerite sill occurs in the area, usually above the C-seam and has been identified towards the west and north of the big pan, on the farm Kranspan. The intrusion has resulted in the devolatisation of the coal in certain areas in the south of the project area. No significant structural faults have been identified (Ilima, 2018).

There are two (2) major structural geological features which may have an impact on groundwater flow and possibly mining. These possible dyke structures extend from north to south, with the one structure underlying the big pan on the farm Kranspan and the second roughly following the R36 road.

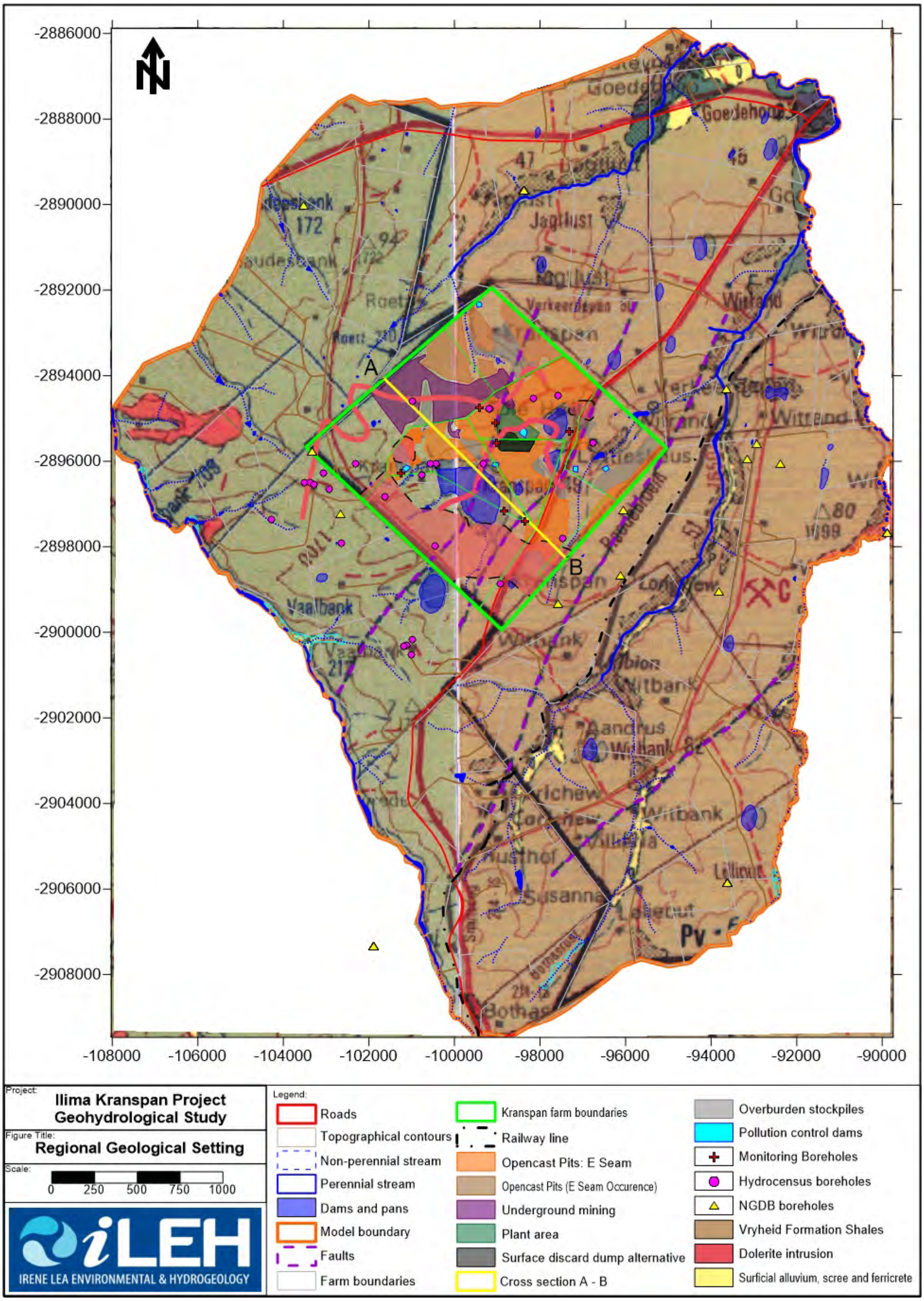

Figure 3 Geological setting

2.2 Geohydrology

2.2.1 Current groundwater use

Groundwater Abstract conducted a hydrocensus across the proposed Kranspan mining area during January 2019. The survey included the proposed mining footprint areas as well as the adjacent properties. The hydrocensus focussed on identifying existing private boreholes and private groundwater use and to enhance the knowledge of the aquifers present.

During the hydrocensus 26 groundwater sites (boreholes and springs) were identified, as detailed in Appendix 1. Farms surveyed included:

- Kranspan 49 IT; and
- Vaalbank 212 IS.

During the hydrocensus the following information was collected for each site:

- Borehole position (X, Y, Z-coordinates);
- Information relating to equipment installed;
- Borehole construction details;
- Borehole yield, if known;
- Groundwater level, if possible; and
- Current use.

The 26 sites included 19 boreholes and 7 springs. In terms of private groundwater use, the following information was obtained:

- 12 boreholes are in use:
    - o 3 boreholes fitted with submersible pumps;
    - o 8 boreholes fitted with windpumps;
    - o 1 borehole fitted with solar submersible pump;
- 2 boreholes are equipped, but not in use (old windpumps); and
- 5 open boreholes are not currently in use.

Groundwater level measurements were possible in 7 hydrocensus boreholes. Pumping equipment blocked the remaining boreholes visited. Seven groundwater samples were collected for water quality analysis during the hydrocensus.

Water levels were measured by using a dip meter to measure the distance from the mouth of the borehole (borehole collar elevation) to the groundwater table depth in the borehole. The height of the borehole collar was subtracted from the measured water level to define a water level below surface, the details of which are presented in Appendix A.

The depth to groundwater level varied between a maximum depth of 22.38 m bgl (borehole KR7), and the surface elevation for the springs where the water table daylights. The average depth to groundwater in the hydrocensus boreholes is 14,7m, if the springs and seeps are excluded from the calculation.

Based on communication with the landowners the springs in the area are seasonal, with the exception of KR-Spring3 and KR-Spring5 that flow throughout the year. The springs serve as water supply to livestock and wildlife in the area. KR-Spring3 is the most prominent spring identified during the hydrocensus (based on flow rate). During the hydrocensus the discharge rate was approximately 86m^3/d (3,600 L/h) and the water quality is good.

Detailed information in terms of borehole construction and yields are not available for the identified private boreholes. The information provided by the landowners indicated low borehole yields for most of the Kranspan project area.

2.2.2 Groundwater monitoring boreholes

2.2.2.1 Geophysical Survey

A ground geophysical investigation was conducted to identify linear geological structures, which could act as preferential groundwater flow paths and potentially be high water yielding aquifers. The geophysical survey has been used in conjunction with the available remote sensing images and geological maps. The two linear north-south geological structures were one of the key targets. Others included the dolerite sill and potential deep weathered zones across the study area.

The geophysical investigation was conducted during November 2018. The following techniques were applied:

- EM 34–3 electromagnetic (EM) system, with a coil spacing of 20 m, and a station spacing of 10 m; and
- Magnetic survey.

The survey included 8 survey lines, and line and station coordinates were marked in the field using a Garmin hand-held GPS. The geophysical data is presented in Appendix 2. The geophysical survey was successful in identifying the dolerite sill contact, as well as the north-south lineaments indicated on Figure 3.

2.2.2.2 Drilling Programme

Based on the geophysical survey results and an understanding of the local geology, Groundwater Abstract identified 8 suitable drilling positions for groundwater characterisation purposes. The information pertaining to the drilling programme is presented in Table 2. The drilling sites were chosen from the geophysical surveys undertaken, but where possible, were placed outside the planned mining areas to ensure that they are not destroyed during mining. This was however not possible in all instances.

WJ Water Drilling carried out the percussion drilling programme during December 2018. The Client was responsible for the drilling supervision. A pair of groundwater characterisation and monitoring boreholes was drilled at each of the eight targets in order to target the shallow and deep aquifers through to be present. The first borehole was therefore drilled to a depth of 50 m below surface, with the aim of characterising and monitoring the deeper fractured aquifer. The second borehole was drilled to a depth of 20m, to monitor the shallow weathered aquifer and to establish whether there is a hydraulic connection between the two aquifers. These two aquifers are often separated by a less permeable dolerite sill in the area.

The boreholes were positioned relatively close to the proposed mining areas, as well as to the large natural pans in the area. The boreholes closer to the pans (boreholes PM1, PM2 and PM3) aim to define surface water- groundwater interaction close to the pan structures.

Data collected include the recording of geological formations at 1 metre intervals, water strike depths, the cumulative final blow yield and final rest water level. A summary of the results is presented in Table 2.

The borehole construction details are as follows:

- Deep boreholes (50 m) – the diameter of the casing is 177 mm, which goes down to 24 m below surface. Beyond this depth the diameter of the borehole is 165 mm.
- Shallow boreholes (20 m) – the diameter of the casing is 152 mm and cased across the total depth to the borehole. The bottom 6m of the casing in the shallow boreholes is perforated.

The geological profiles intercepted by the percussion and core drilling programmes are presented in Appendix 3.

The new Kranspan percussion boreholes produced blow yields between zero litres per hour (L/h) (thus dry) and 10,000 L/h, as detailed in Table 2. In general, borehole yields throughout the project area are low, indicating minor aquifer systems.

From the information presented in Table 2 it can be concluded that the majority of the water strikes are associated with the soil and sub-soil horizons and the upper fractured aquifer. The weathered zone, the fractures in the coal seams and the geological contacts yielded low quantities of water (borehole yields of 800 to 1,000 L/h).

The fractured aquifers in the area can be classified as confined aquifers based on an assessment of the rest groundwater level depths versus water strike depths. All rest water levels were at a shallower depth compared to the water strike depths.

The base of the weathered zone yielded some water, but in very low quantities. Most water strikes produced low yields (1,000 to 2,000 L/h). The highest yielding water strike (>10,000 L/h) is associated with one of the north-south lineaments (borehole PM3). The water yielding zones can be classified as follows:

- Weathered sandstone – 1,000 to 2,000 L/h.
- Fractures in sandstone – 2,500 to 10,000 L/h.
- Dolerite top contact – 1,500 L/h.
- Dolerite bottom contact – 1,000 L/h.
- Sandstone shale contact 1,000 L/h.

Based on the percussion drilling results coal was found in borehole 1-130 only.

The depth of weathering varies between 3 and 50 m bgl; mostly around 7 to 9 metres below surface.

Table 2 Drilling summary of new deep monitoring boreholes

		Borehole ID	1-130	2-50	5-110	6-220	Site8	PM1	PM2	PM3
Borehole Location	WGS84	Latitude	26° 9'56.79"S	26°10'18.91"S	26° 9'41.29"S	26°10'56.51"S	26° 9'29.79"S	26°10'12.94"S	26°10'48.15"S	26° 9'48.17"S
		Longitude	30° 0'34.46"E	29°59'14.14"E	30° 0'33.81"E	30° 0'57.79"E	30° 0'20.37"E	29°59'43.45"E	30° 0'40.43"E	30° 1'36.13"E
		Elevation	1688	1680	1692	1669	1713	1666	1664	1664
Borehole Data	Borehole Depth (m)		50	50	50	50	50	50	50	50
	Blow Yield (L/h)		Seepage	1000	10000	2500	1000	2000	Seepage	>10000
	Water Strike depth (m)		None	5m - seep 35m – 1000L	15m – 1500L 35m – 10000L	15m – 1000L 45m – 2500L	35m – 1000L	30m – 2000L	None	---
	Main Strike Geology		---	Sandstone	Dolerite upper contact; Fracture in sandstone	Shale/sandstone contact; Fracture in sandstone	Base dolerite contact / coal contact	Sandstone	---	---
	Borehole Geology		Laterite, sandstone, carbonaceous shale / coal	Laterite, clay, sandstone / shale	Sandstone, shale, dolerite	Sandstone, carbonaceous shale	Sandstone, shale, dolerite, coal	Clay, sandstone, shale, dolerite	Clay, sandstone	Sand, shale, sandstone
	Static Water Level (m bgl)		5.54	4.22	4.99	5.30	9.71	0.90	1.91	4.98
	Depth of Weathering (m)		3	25	7	5	9	47	50	50,

Table 3 Drilling summary of new shallow monitoring boreholes

		Borehole ID	1-130b	2-50b	5-110b	6-220b	Site8b	PM1b	PM2b	PM3b
Borehole Location	WGS84	Latitude	26° 9'56.79"S	26°10'18.91"S	26° 9'41.29"S	26°10'56.51"S	26° 9'29.79"S	26°10'12.94"S	26°10'48.15"S	26° 9'48.17"S
		Longitude	30° 0'34.46"E	29°59'14.14"E	30° 0'33.81"E	30° 0'57.79"E	30° 0'20.37"E	29°59'43.45"E	30° 0'40.43"E	30° 1'36.13"E
		Elevation	1688	1680	1692	1669	1713	1666	1664	1664
Borehole Data	Borehole Depth (m)		20	20	20	20	20	20	20	20
	Blow Yield (L/h)		Dry	Dry	Dry	Dry	5000	Dry	Dry	Dry
	Water Strike depth (m)		None	None	None	None	13	None	None	None
	Static Water Level (m bgl)		---	4.52	6.44	3.13	5.54	1.04	---	5.54

2.2.2.3 Aquifer Testing

Following completion of the drilling programme, an aquifer test programme was initiated to determine the hydrogeological characteristics of the local aquifers. This includes defining:

- Borehole drawdown and recovery characteristics.
- Aquifer hydraulic parameters:
    - Transmissivity (T) defined as the product of the average hydraulic conductivity (K) and the saturated aquifer thickness. It is a measure of the rate of flow under a unit hydraulic gradient through a cross-section of unit width over the whole saturated thickness of the aquifer. The unit of measurement is m^2/day.
- Characterisation of aquifer flow boundaries such as low permeable, no-flow or recharge boundaries. No-flow or low permeable boundaries refer to a lower transmissive structure (e.g. fracture with a lower conductance or low permeable dyke) or aquifer boundary (limit of aquifer – no-flow boundary) that results in an increase in groundwater drawdown during borehole abstraction. Recharge boundaries relate often to leakage from surface water bodies.

In Situ Groundwater Services was subcontracted to carry out the aquifer testing during January 2019. Aquifer testing was undertaken on the following boreholes, as presented in Table 4:

- 12-hour constant drawdown test on 6 new boreholes:
    - 2-50
    - 5-110
    - 6-220
    - Site8
    - PM1
    - PM3
- Slug test on 2 new boreholes:
    - PM2
    - 1-130.

Prior to each aquifer test, static groundwater levels are measured in the pumping and observation boreholes to enable drawdown calculations during test pumping. Pumped water was released via a discharge pipe at least 100 m from the test borehole, to avoid rapid recharge from the discharged water. During the test, the abstraction rate is continuously monitored by means of electronic flow meters and calibrated by manually measuring the time it takes to fill a container of known volume, with a stopwatch and drum.

The pumping test programme included the following different tests:

- Firstly, a step drawdown test (SDT) is performed. During the SDT the borehole is pumped at a constant discharge rate for 60 minutes, where after the step is repeated at a progressively higher discharge rate. During the SDT the drawdown over time is recorded in pumping and observation boreholes. The advantage of this test is that the pumping rate for any specific drawdown can easily be determined from the relationship between laminar and turbulent flow. After the test stopped, residual drawdown is measured until approximately 90% recovery of the water level has been reached. The discharge rate for the constant discharge test (see below) is calculated from the interpretation of the time drawdown data generated during the SDT.

- The constant discharge test (CDT) follows the SDT. During a CDT a borehole is pumped for a predetermined time at a constant rate. During the CDT test the drawdown over time is recorded in the pumping and observation boreholes. Discharge measurements are taken at predetermined time intervals to ensure that the constant discharge rate is maintained throughout the test period. Any changes in discharge rate are recorded. The duration of CDT at Kranspan was 12-hours. During CDT, the aquifer needs to be stressed sufficiently to identify boundary effects that may impact on long-term aquifer utilization. At each CDT on the deep monitoring boreholes, groundwater levels were monitored in the shallow boreholes in order to determine whether there is an interaction between the two aquifers under stressed conditions.
- Eight (8) groundwater samples were collected at the end of each of the CDTs for chemical analysis.
- The recovery test (RT) follows directly after pump shut down, at the end of the SDT and CDT. The residual drawdown over time (water level recovery) is measured in production and observation boreholes until approximately 90% recovery is reached. Aquifer parameters and sustainable borehole yields can be derived from the time drawdown data of the CDT and recovery tests by application of a variety of analytical methods.

The following software was used for test pumping data analysis:

- The Flow Characteristic Method or FC Method. The FC method uses the first and second order derivatives interpreted from time drawdown data (during test pumping), available drawdown, boundary conditions and recharge to derive sustainable borehole yields. The method is suited for characterising fractured rock aquifers.

A summary of the test programme is given in Table 4.

Five of the 8 boreholes tested indicate a slow recovery, this includes low and high yielding boreholes. The recovery of the groundwater table after abstraction normally provides a good indication of the aquifer yield potential. The volume of abstracted water should not exceed the rate of recovery of the system, to ensure that the aquifer is not over-utilised, which might have a negative impact on other groundwater users within the same hydrogeological system.

The recovery test data for the monitoring boreholes indicate that the recovery is slow and that full recovery (100%) is often not achieved within the predetermined testing timeframe, as detailed in Table 4. An obvious link was not identified in the aquifer test and recovery data in terms of specific geology structures such as lineaments.

The low borehole yields, fast water level drawdown and slow recovery observed during the aquifer testing indicate low transmissivity (T) aquifers, with low groundwater flow conditions in the surrounding aquifers. The mean T-value calculated from the test data was 1.7 m^2/d. The highest T-values (18.8 m^2/d to 26.1 m^2/d) were observed at boreholes that intercepted the main north-south linear structures. This suggests that these lineaments act as preferential flow paths to groundwater. The slug tests yielded average hydraulic conductivity values of approximately 0.2 m/d.

The following has been concluded from the aquifer test data:

- Two of the 6 boreholes tested showed a connection between the shallow and the deep borehole during the 12-hour aquifer testing. These are boreholes 6-220 and PM3. Both boreholes are located along the eastern boundary of the study area and on, or close to the north-south lineament. It appears that these north-south lineaments are possibly fault zones, possibly intruded by dolerite and with secondary fracturing, which as mentioned act as preferential flow paths to groundwater in the horizontal and vertical directions.

- The north-south lineaments are preferred groundwater flow paths, with higher T-values compared to the dolerite sills and sandstone or shale.
- The three sets of boreholes drilled close to the large pans indicate slow groundwater level recovery after pumping stopped. The exception is borehole PM1, where the borehole recovered to 100% of the original rest water level within 40 minutes after pump shut-down.
- The dolerite sill yielded water along the top and bottom contact; in the order of 1,000 L/h.
- Clay was only observed in the boreholes close to the largest pan, in boreholes PM1, PM2 and 2-50.
- The two boreholes with the highest blow yield and constant pump rate (5-110 and PM3) indicate very slow water level recovery after pumping. This suggests that the fractures into which these boreholes were drilled carry water, but that once these fractures are dewatered, the rate at which groundwater flows towards the boreholes from the surrounding aquifers is low.
- The shallow monitoring borehole at Site 8b yielded approximately 5,000 L/h (blow yield) and the deeper borehole only 1,000 L/h. During the aquifer test conducted on borehole Site 8 (deeper borehole) there was no response in the shallow, high yielding borehole. This suggests that the stress imposed on the fractured aquifer during the pumping test was not large enough or the aquifer test not long enough to induce vertical flow.

Table 4 Aquifer test programme summary

		Borehole ID	2-50	5-110	6-220	site8	PM1	PM3	PM2	1-130
Location	WGS84	Lat	S 26.171920°	S 26.161470°	S 26.182365°	S 26.158275°	S 26.170262°	S 26.163380°	S 26.180042°	S 26.165775°
		Long	E 29.987260°	E 30.009393°	E 30.016054°	E 30.005659°	E 29.995403°	E 30.026703°	E 30.011232°	E 30.009571°
		Elevation	1679	1692	1669	1713	1666	1664	1664	1688
Aquifer Test Data	Available Drawdown (m)		39,96	39,19	38,88	34,47	26,98	39,2	---	---
	Step 1 (L/s) / Drawdown (m)		0,21 / 9,19	1,04 / 7,57	0,39 / 4,95	0,2 / 10,35	0,28 / 6,99	1,04 / 2,9	---	---
	Step 2 (L/s) / Drawdown (m)		0,41 / 19,41	2,12 / 13,31	0,61 / 14,11	0,4 / 29,23	0,41 / 26,8	2,12 / 4,72	---	---
	Step 3 (L/s) / Drawdown (m)		0,61 / 40,95	3,54 / 18,47	0,91 / 38,4	0,6 / 44,18	---	3,57 / 25,14	---	---
	Step 4 (L/s) / Drawdown (m)		---	5,60 / 22,44	---	---	---	4,6 / 39,04	---	---
	Step Recovery - % (time)		92% (6hrs)	56% (4hrs)	97% (3hrs)	98% (3hrs)	98% (1,5hrs)	100% (40 min)	---	---
	Constant Discharge (L/s)		0,22	5,1	0,53	0,21	0,23	3,2	slug test	slug test
	Duration (min)		720	300	720	720	720	720	---	---
	Available Drawdown (m)		36,55	29,29	37,72	33,87	26,42	39,2	---	---
	Final Drawdown (m)		10,53	29,19	15,77	17,47	9,92	17,5	---	---
	Observation boreholes (20m deep)		Rest water level 4,52m no response during test	Rest water level 6,44m no response during test	Rest water level 3,13m 0,25m drawdown, slow recovery to 0,09m	water level Rest 5,54m no response during test	Rest water level 1,04m no response during test	Rest water level 4,98m 3,29m drawdown, recovery to 0,1m	---	---
	Recovery - % vs time		87% (10hrs)	63% (12hrs)	100% (40 min)	98% (5hrs)	100% (40 min)	39% (12hrs)	---	recovered very little
	FC Method									
	T - m^2/day		3,5 to 4,6	26,1 (fracture) 6,95 (formations)	1,3 to 3,1	0,3 to 1,2	2,1 to 3,05	18,8 (fracture) 5,7 (formations)	4	1
	K - m/day		---	---	---	---	---	---	0,3	0,1
	Safe abstraction rate (L/s)		0,2 (8 hrs/day)	1,5 (12 hrs/day)	0,34 (8 hrs/day)	0,06 (6 hrs/day)	0,21 (8 hrs/day)	2,2 (8 hrs/day)	---	---

2.2.3 Aquifers present

Two main aquifers are typically found in the Karoo sediments of the Ermelo Coal Field. These are a shallow weathered aquifer and a deeper fractured rock aquifer. These are discussed in more detail below.

Please note that perched water in the soil horizon does not form part of the geohydrological study. It is noted that this water often contributes to wetland functioning in the region.

2.2.3.1 Weathered aquifer

The shallow weathered aquifer forms within the limit of weathering (LOW). Information on the LOW available from exploration boreholes, National Groundwater Database (NGDB) boreholes and the newly drilled monitoring boreholes is summarised in Table 5.

Table 5 Summary of information on the limit of weathering in the project area

Source	Minimum depth (m)	Maximum depth (m)	Average depth (m)
NGDB boreholes	0,3	15,8	6,4
Exploration boreholes	1,3	14,9	5,7
Monitoring boreholes	3	50	15,5

It is shown that the average depth of the LOW varies between 5,7 and 15,5 from the three available sources. For the purpose of conceptualisation, it will be assumed that the average LOW is down to a depth of 9m. This depth will be used to estimate the extent of the upper weathered aquifer during the geohydrological impact assessment presented in this report.

Clay material was found in boreholes drilled around the larger of the two pans on site. This suggests that the pans are formed on clay lenses that do not facilitate vertical infiltration of surface water. The clay lenses are most probably associated with highly weathered dolerite sills that were identified during the exploration drilling phase of the project.

The permeability of weathered aquifer is variable, but groundwater occurrence is most often associated with the transition between weathered and fresh rock. In this area, the dolerite sill could form a barrier between the upper weathered and deeper fractured rock aquifers. At present, the permeability of the dolerite is not known, but based on experience in similar aquifer conditions, it is thought that the permeability of fresh and unfractured dolerite is low compared to the host rock and that it will therefore act as an aquitard or even an aquiclude, forming a barrier to the vertical flow of groundwater from the weathered to fractured rock aquifers.

In low-lying areas, the groundwater table is shallow. Springs develop in the weathered aquifer where groundwater seeps to surface along areas of lower permeability for example against a dolerite intrusion or a palaeographic high or where the topography cuts into the water table. Six springs were identified during the hydrocensus (see Appendix 1).

The average depth to groundwater in the shallow boreholes drilled during the investigation is 4,37m, varying between 1,04 and 6,4m below surface.

This aquifer is not considered significant in terms of water supply due to its limited thickness. Information obtained from monitoring boreholes suggests that no water strikes occur in this aquifer. The exception is borehole Site8b, which yielded a blow yield of 5000 L/hr. but it does play an important role in terms of recharge to the underlying fractured rock aquifer and to the baseflow of streams and pans, especially in the dry season.

Permeabilities could be calculated from two of the shallow monitoring boreholes drilled. The results indicate that the permeability of the weathered material varies between 0,1 and 0,3m/d.

The rate of recharge to this aquifer is typically assumed to be around 3% of the mean annual precipitation (MAP) (Hodgeson and Kranz, 1998).

2.2.3.2 Fractured rock aquifer

Underneath the shallow weathered aquifer, groundwater is associated with fractures, faults, bedding planes and contact zones with intrusions. The rock matrices are tight and do not transmit significant volumes of groundwater, as indicated from the results of the aquifer tests. Groundwater flow in the fractured rock aquifer therefore takes place along the identified preferential flow paths. These include the two major north NE-SW striking lineaments and the dolerite intrusions.

The two large lineaments delineated on the regional geological map (Figure 3) were identified as aquifers and will therefore preferentially transmit groundwater. Monitoring boreholes 5-110, 6-220 and PM3 target these lineaments. Some of the private boreholes also target these lineaments, including KR11, KR19 and possibly KR7, KR8 and KR12.

The permeability of these aquifers is highly variable as it is dependent on the nature and extent of the secondary features mentioned. Results from the aquifer tests on these boreholes suggest that although the fractures carry groundwater, they are quickly dewatered when pumped due to the fact that inflows from the rock matrix are slow and cannot therefore sustain high volumes of groundwater abstraction. Transmissivities calculated from the aquifer tests for the lineaments vary between 19 and 26 m^2/d. This is higher compared to transmissivities calculated for the unfractured rocks, where transmissivities vary between 0,3 – 7 m^2/d. The wide range in transmissivities calculated from the available data (Table 4) is typical of the heterogeneous nature of fractured rock aquifers.

The aquifer testing data obtained during this study further indicates that vertical groundwater flow between the weathered and fractured rock aquifers are generally low, except along the strike of the NE-SW lineaments. Where present, zones of increased permeability allow groundwater flow through otherwise tight rock matrices . Measurements in borehole pairs that were drilled into the lineaments confirm that groundwater levels in the shallow boreholes react when the deeper boreholes are pumped.

Depth to groundwater in the deeper boreholes varies between 0,9 and 22,38m, based on data from the private and monitoring boreholes. Groundwater levels in the monitoring boreholes vary between 0,9 and 9,7m below surface, which is similar to that measured in the shallow boreholes. How well the seals were installed into the annulus of the deeper boreholes affects groundwater level measurements. For the purpose of this study, it will be assumed that the seals are intact and that groundwater level measurements in the deep monitoring boreholes indicate conditions in the fractured rock aquifer.

Based on the information obtained, the average depth to groundwater in the deeper boreholes based on all the data points is 9,4m, which is just below the average limit of weathering. The average depth to groundwater in the monitoring boreholes is 4,7m, which falls within the limit of weathering. Based on this information, the fractured rock aquifer seems to be confined to semi-confined, as groundwater levels rest above the depth of groundwater strikes in these. The dolerite sill could play a role in creating confined conditions in the fractured rock aquifer, where it is present.

2.2.4 Groundwater flow patterns

Groundwater flow contours were generated with the information obtained from the monitoring boreholes for both the shallow weathered and the deeper fractured rock aquifers in order to establish groundwater flow patterns at the site. The information used to generate the contours is presented in Table 2 and 3 and the flow contours for the two aquifers are shown in Figures 4 and 5. The extent over which the contours are generated depends on the available dataset. More data points are available for the fractured rock aquifer, compared to the weathered aquifer.

The groundwater flow gradient in the shallow weathered aquifer is towards pans. This suggests that groundwater from the shallow weathered aquifer discharges to the pans, especially during the wet season. The springs to the west of the Kranspan farm boundary are higher compared to that of the monitoring boreholes, as shown. The groundwater flow gradient in weathered aquifer is approximately 1:53 (0,019).

Groundwater flow patterns in the fractured rock aquifer are dominated by a depression around private boreholes KR3 and KR4 and monitoring borehole PM1. This is most probably indicative of groundwater flow towards the large pan, as no groundwater abstraction takes place from boreholes KR3 and KR4.

The average groundwater flow gradient in the fractured rock aquifer is 1:83 (0,012), which is flatter compared to the weathered aquifer.

2.2.5 Groundwater quality

Groundwater Abstract collected Seven (7) groundwater samples during the 2019 hydrocensus. The boreholes sampled are indicated in Appendix 1. The water samples were submitted to Waterlab, a South African National Accreditation System (SANAS) accredited laboratory, for analysis. Samples were collected from boreholes across the project area to ensure a good indication of ambient groundwater qualities.

Samples were taken using single valve, decontaminated bailers or from pump discharge lines in the case of boreholes, which were equipped, and in use. Sterilized 1 litre sample bottles were used and filled to the top. Samples were stored in a cooler box during the site surveys.

The water samples were analysed for basic inorganic parameters and the results were compared against the SANS 241:2015 Drinking Water Standards. It is recommended that all identified boreholes, used for abstraction for domestic and agricultural purposes be sampled again before the construction phase of mining, if the application is successful in order to update the baseline assessment and build a water quality database for the area. The database will help to identify water quality and level trends in the area and will serve as reference to identify and quantify potential impacts on private boreholes.

Groundwater samples were also collected from the 8 monitoring boreholes during the 2019 aquifer testing programme. The results are discussed below.

The results of the analyses are presented in Table 6 and the certificates of analyses in Appendix 5. The information presented in Table 6 contains the main elements present in the water. A full analysis, including trace elements, is presented in Appendix 5. It is noted that the results indicate that the concentrations of most of the trace elements are below laboratory detection limits.

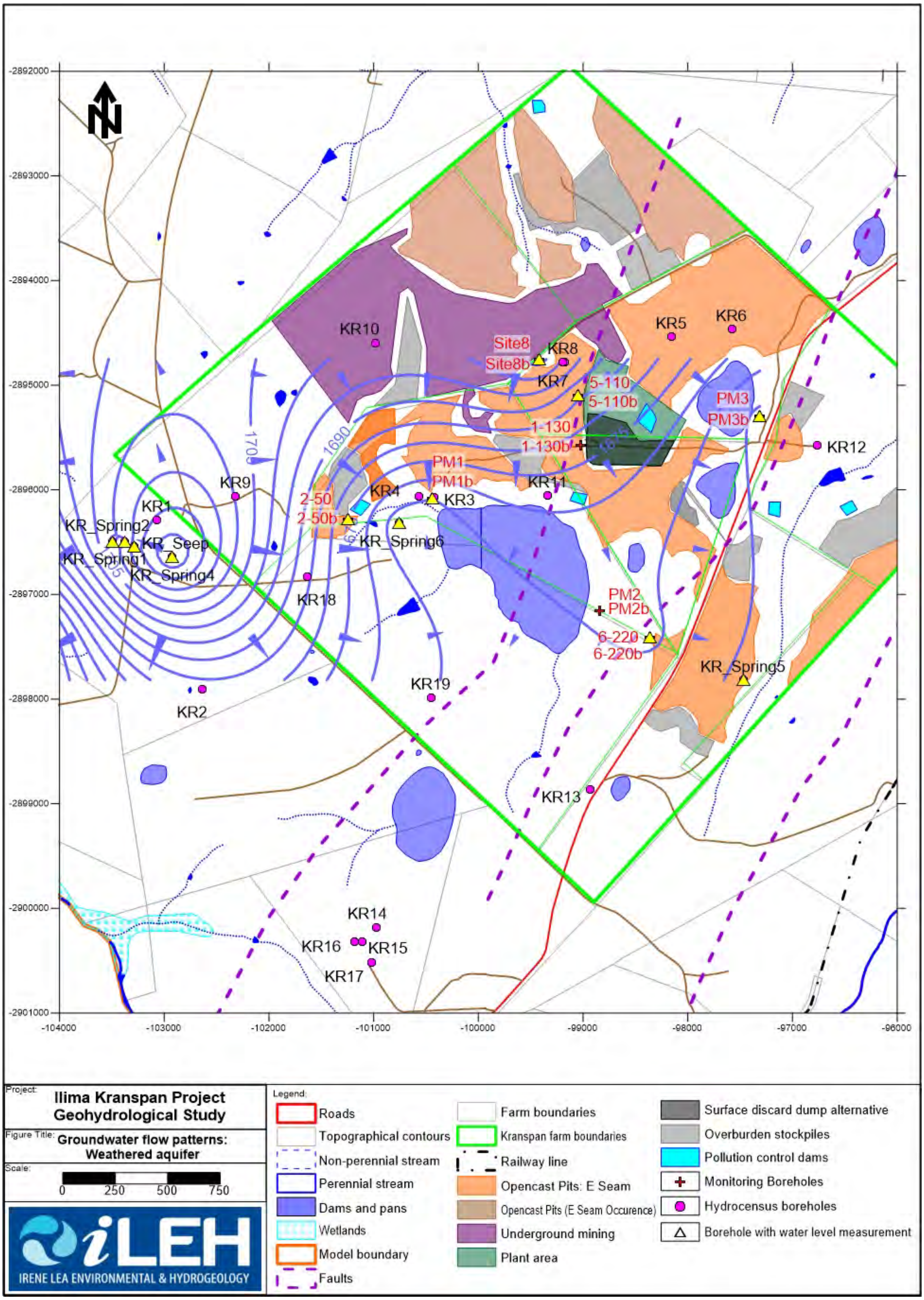

Figure 4 Groundwater level contours in the shallow weathered aquifer

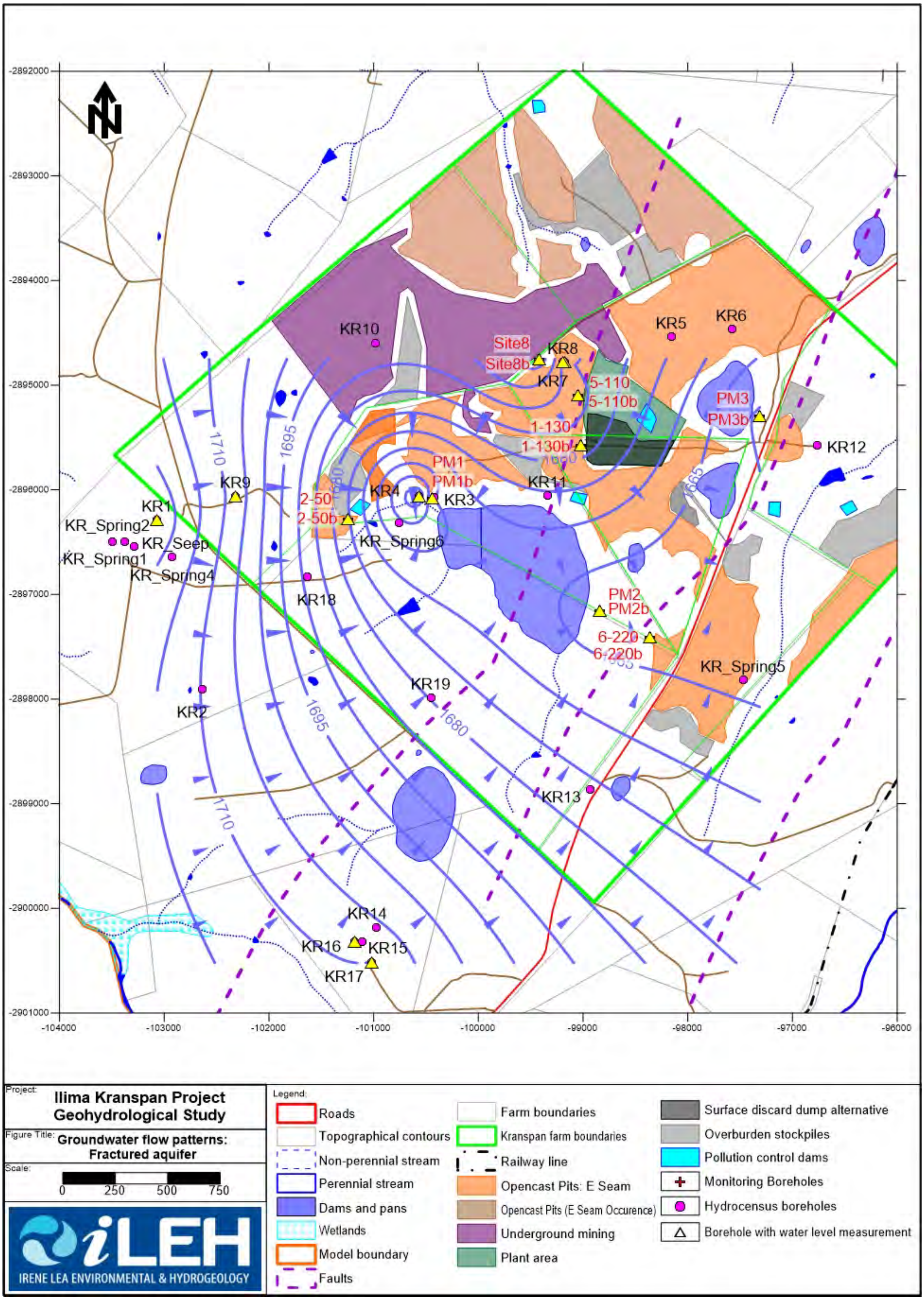

Figure 5 Groundwater level contours in the fractured rock aquifer

Table 6 Groundwater Quality – Hydrocensus January 2019

Parameter	SANS241 Drinking Water Standard		DWS Drinking Standards	Sample Numbers						
Unit: mg/l unless otherwise stated	**Aesthetic Limit**	**Health Limit**		**KR3**	**KR11**	**KR12**	**KR14**	**KR18**	**KR19**	**KR Spring 3**
pH – Value at 25°C	≥5 - ≤9.7			7.9	8.0	7.7	8.8	8.6	7.7	5.7
Electrical Conductivity in mS/m at 25°C	Aesthetic ≤170			31.0	48.5	41.9	25.2	26.3	31.2	4.8
Total Dissolved Solids at 180°C	Aesthetic ≤1200			216	375	365	255	177	285	21
Total Alkalinity as $CaCO_3$	NS	NS	NS	116	156	128	100	136	80	<5
P-Alkalinity as $CaCO_3$	NS	NS	NS	<5	<5	<5	10	10	<5	<5
Bicarbonate as HCO_3	NS	NS	NS	141	190	156	99	142	98	5
Total Hardness as $CaCO_3$	60–120 mg/l, moderately hard	120–180 mg/l, hard	more than 180 mg/l, very hard	47	139	27	42	71	94	7
Chloride as Cl	Aesthetic ≤300			16	58	35	14	3	2	7
Sulphate as SO_4	Aesthetic ≤250	Acute health ≤500		22	8	20	14	5	69	3
Fluoride as F		Chronic health ≤1.5		0.6	0.2	0.6	0.2	0.2	0.7	<0.2
Nitrate as N		Acute health ≤11		0.5	0.1	2.7	0.3	0.7	0.2	0.2
Nitrite as N		Acute health ≤0.9		<0.05	<0.05	<0.05	0.2	<0.05	<0.05	<0.05
Total Nitrogen as N	NS	NS	NS	0.8	0.9	3.2	1.6	1.4	1.4	0.5
Ortho Phosphate as P	NS	NS	NS	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
Kjeldahl Nitrogen	NS	NS	NS	<0.5	0.8	0.6	1.1	0.7	1.1	<0.5
Free & Saline Ammonia as N	Aesthetic ≤1.5			0.2	0.5	0.6	1.1	0.2	0.2	0.2
Calcium as Ca			No health. Scaling intensifies from 32mg/L	11	29	6	10	18	20	1
Potassium as K			No aesthetic or health effects below 50mg/L	3,1	4,1	5,2	3,2	4,2	7,6	1,9
Magnesium as Mg	Aesthetic ≤0.1	Chronic health ≤0.4		5	18	3	5	8	13	1
Sodium as Na	Aesthetic ≤200			46	38	73	32	27	20	4
Total Iron as Fe	Aesthetic ≤0.3	Chronic health ≤2		3,27	0,210	0,033	0,161	0,177	0,350	0,257
Total Manganese as Mn	Aesthetic ≤0.3	Chronic health ≤2		<0,025	0,084	<0.025	<0.025	<0.025	0.16	<0.025
Aluminium as Al	≤0.3			0,183	<0.100	<0.100	0,150	<0.100	<0.100	1,44

Table 7 Groundwater Quality – Monitoring Boreholes

Parameter	SANS241 Drinking Water Standard		DWS Drinking Standards	Sample Numbers							
Unit: mg/l unless otherwise stated	**Aesthetic Limit**	**Health Limit**		**2-50**	**1-130**	**Site8**	**5-110**	**6-220**	**PM1**	**PM2**	**PM3**
pH – Value at 25°C	≥5 - ≤9.7			9.2	8.9	7.2	7.6	7.6	5.7	8.8	6.6
Electrical Conductivity in mS/m at 25°C	Aesthetic ≤170			53.4	25.0	28.4	29.3	26.3	25.0	74.9	32.5
Total Dissolved Solids at 180°C	Aesthetic ≤1200			425	215	200	180	120	113	453	300
Total Alkalinity as $CaCO_3$	NS	NS	NS	284	120	120	160	128	12	304	136
P-Alkalinity as $CaCO_3$	NS	NS	NS	52	15	<5	<5	<5	<5	48	<5
Bicarbonate as HCO_3	NS	NS	NS	219	109	146	195	156	15	253	166
Total Hardness as $CaCO_3$	60–120 mg/l, moderately hard	120–180 mg/l, hard	more than 180 mg/l, very hard	<5	75	95	105	20	53	27	55
Chloride as Cl	Aesthetic ≤300			9	5	8	5	12	44	68	22
Sulphate as SO_4	Aesthetic ≤250	Acute health ≤500		<2	9	19	3	<2	28	6	6
Fluoride as F		Chronic health ≤1.5		0.9	1.0	0.2	0.2	1.0	<0.2	1.7	0.4
Nitrate as N		Acute health ≤11		0.1	0.1	<0.1	<0.1	<0.1	2.5	<0.1	<0.1
Nitrite as N		Acute health ≤0.9		<0.05	<0.05	0.4	<0.05	<0.05	<0.05	0.6	<0.05
Total Nitrogen as N	NS	NS	NS	1.0	0.6	<0.5	<0.5	<0.5	2.5	0.6	<0.5
Ortho Phosphate as P	NS	NS	NS	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Kjeldahl Nitrogen	NS	NS	NS	0.8	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Free & Saline Ammonia as N	Aesthetic ≤1.5			0.7	0.6	<0.1	<0.1	0.1	<0.1	<0.1	<0.1
Calcium as Ca			No health. Scaling intensifies from 32mg/L	1	15	22	28	5	9	6	12
Potassium as K			No aesthetic or health effects below 50mg/L	1.2	8.0	6,6	3,3	3,6	3,7	17,7	7,4
Magnesium as Mg			Diarrhoea and scaling issues from 70mg/L	<1	10	13	14	3	9	4	9
Sodium as Na	Aesthetic ≤200			127	17	13	13	45	18	144	40
Total Iron as Fe	Aesthetic ≤0.3	Chronic health ≤2		0,058	5,89	7,47	0,077	0,197	2,77	1,34	1,44
Manganese as Mn	Aesthetic ≤0.3	Chronic health ≤2	Diarrhoea and scaling issues from 70mg/L	<0,025	0,186	0,096	0,079	0,030	0,067	0,065	0,110
Aluminium as Al	≤0.3			0,115	0,895	0,171	<0.100	<0.100	0,124	0,350	<0.100

2.2.5.1 Interpretation of groundwater quality information

The results of the chemical analyses presented in Tables 6 and 7 show that the groundwater quality in the hydrocensus and monitoring boreholes generally comply with the SANS241:2015 Drinking Water Standards. The exceptions are hardness, iron, aluminium and fluoride. These are discussed in more detail below. Reference is made to DWAF (1996) in the interpretation of the result :

- **Acute Health effects**: Exceedances may pose an intermediate unacceptable health risk.
- **Aesthetic effects**: Exceedances may taint the water with respect to taste, odour or colour, but does not pose an unacceptable health risk.
- **Hardness**: the groundwater is naturally hard. This is caused by high concentrations of calcium and magnesium salts. Temporary hardness is due to the presence of bicarbonates and can be removed by boiling the water. Permanent hardness is attributed to other salts (sulphates and chloride salts), which cannot be removed by boiling. Excessive hardness can result in scaling in plumbing and household heating appliances and pose a nuisance to personal hygiene (the so-called "soap destroying" nature of water).
- **Iron**: elevated iron concentrations were recorded in one private borehole (KR3) and three monitoring boreholes (boreholes 1-130, Site8 and PM1). The elevated iron concentrations are considered natural and is probably associated with the rock formations present. It is unlikely that the surrounding mining activities could impact on groundwater quality at the Kranspan project. At concentrations exceeding 2 mg/l, a pronounced aesthetic effect (taste) and staining in plumbing is expected. Health effects are expected in young children and sensitive individuals. These are associated with hemochromatosis and tissue damage. Elevated iron concentrations in water also promote the proliferation of iron-oxidising bacteria, which manifests as slimy coatings in plumbing.
- **Aluminium**: The main effect of aluminium at the concentrations observed is relating to the discolouration in the presence of manganese. Concentrations below 0,5 mg/l are not expected to result in adverse health effects. Prolonged exposure to concentrations exceeding 0,5 mg/l may result in neurotoxic effects.
- **Fluoride**: One monitoring borehole (PM2) yielded elevated fluoride concentrations. If ingested, it is absorbed and retained in the skeleton and teeth. At the concentration recorded in the borehole, a small risk of dental mottling exists, but no skeletal fluorosis is expected. It is noted that fluorosis is less severe when the water is hard, since the occurrence of calcium limits fluoride toxicity.

The information presented in Tables 6 and 7 will form the groundwater quality baseline for the project. Future monitoring results must be compared to these concentrations to establish the impact of coal mining on groundwater quality.

2.2.5.2 Piper Diagram

A Piper Diagram uses the relationship between selected chemical parameters to classify water samples according to the dominant cation and anions composition, as well as allowing for the grouping of water according to hydrogeological facies. The Piper Diagram uses concentrations calculated in meq/L to represent a percentage of the total cations or anions. The cations and anions of each sample are plotted on the respective triangular plot and the points are then projected onto the central diamond graph. The Piper Diagram prepared with the Kranspan data is presented in Figure 6. Depending on where the sample point falls on the diamond graph, basic assumptions can be attributed to the sample, and for this reason the diagram is divided into quarters. Plotting the results of the chemical analysis on the diagram gives an understanding and comparing the types of groundwater present.

The left quarter in a Piper Diagram represents freshly recharged water, dominated by calcium-magnesium-bicarbonate signature. The right quarter is associated with stagnant or slow-moving groundwater and is dominated by sodium and chloride. The bottom quarter is typical of dynamic groundwater flow and is dominated by sodium and bicarbonates; and the top quarter typically indicates contamination and is dominated by sulphate.

The diagram indicates that groundwater in boreholes KR11, KR14, KR18, KR19, Site8, 5-110, 1-130b and PM3 fall in the freshly recharge groundwater. Groundwater in boreholes KR12, PM2, 6-220 and 2-50 fall in the dynamic category and KR Spring 3 and PM1 contains stagnant groundwater.

2.2.5.3 Stiff Diagrams

Stiff diagrams are graphical presentation of the general chemistry of water. A polygonal shape is created from four parallel horizontal axes extending on either side of a vertical axis. Cations are plotted on the left of the vertical axis and anions are plotted on the right. The diagrams can be relatively distinctive for showing water composition differences or similarities. One feature is the tendency of a pattern to maintain its characteristic shape as the sample becomes diluted. It may be possible to trace the same types of groundwater contamination from a source by studying the patterns.

Stiff diagrams for the water samples analysed are presented in Figure 7.

The results indicate that the dominant anion in all of the samples, except the KR Spring 3 and PM1, is bicarbonate. This also accounts for the hardness in the groundwater. KR Spring 3 and PM1 is chloride dominant, suggesting stagnant flow conditions.

The dominant cations are sodium and potassium, with the exception of boreholes 5-110 and Site8, which are calcium dominant.

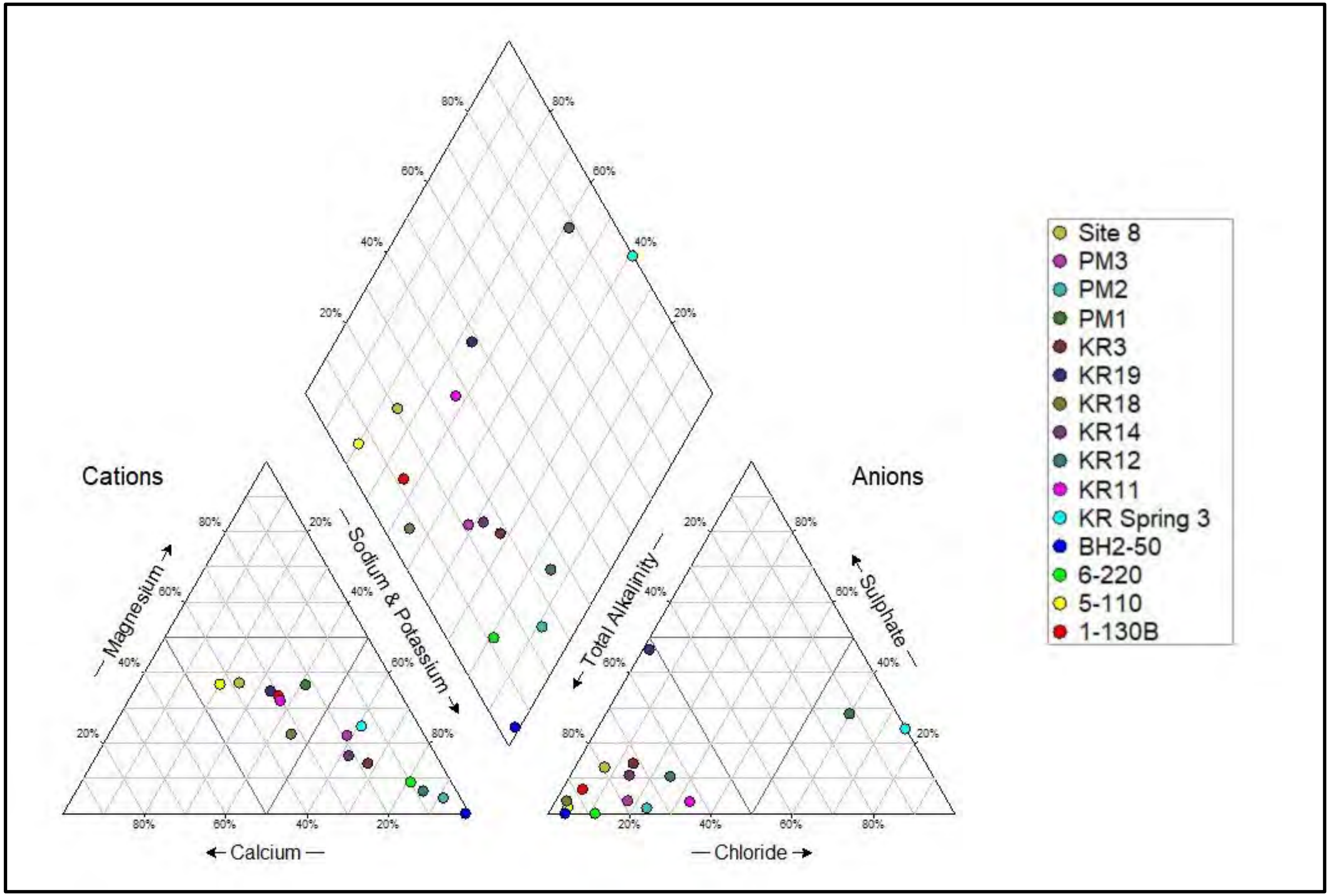

Figure 6 Piper Diagram

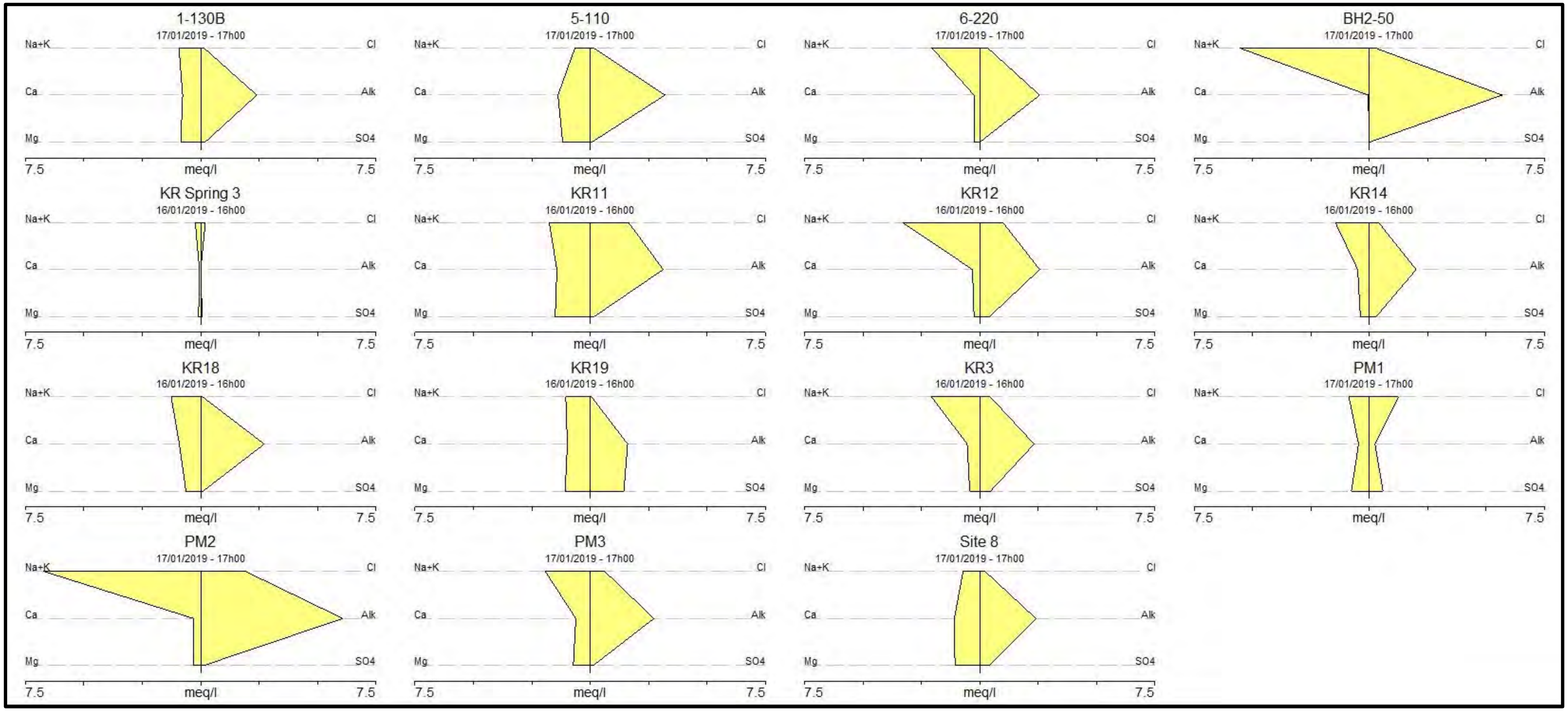

Figure 7 Stiff diagrams

2.3 Summary of conceptual model

The schematic cross section through the project area presented in Figure 8 demonstrates the conceptual model developed from the information discussed above. The location of the cross section is indicated on Figures 1 and 3. The cross section was generated from the exploration borehole data, the digital terrain model (DTM) generated for the area, the geological map presented in Figure 3 and the aquifer information obtained from monitoring and hydrocensus boreholes. This information is summarised in Table 8 as reference.

The cross section indicates the extent of the weathered and fractured rock aquifers as well as the position of the E Seam to be mined using opencast (OC) and underground (UG) mining methods. The NE-SW striking lineaments indicated on the regional geological map is indicated. In the absence of specific information, it is assumed that these structures are vertical and extend to the base of the Ecca Formation. The basement of the geological succession pertinent to the groundwater impact assessment is assumed to be situated beneath the coal seam and comprises Dwyka Tillites.

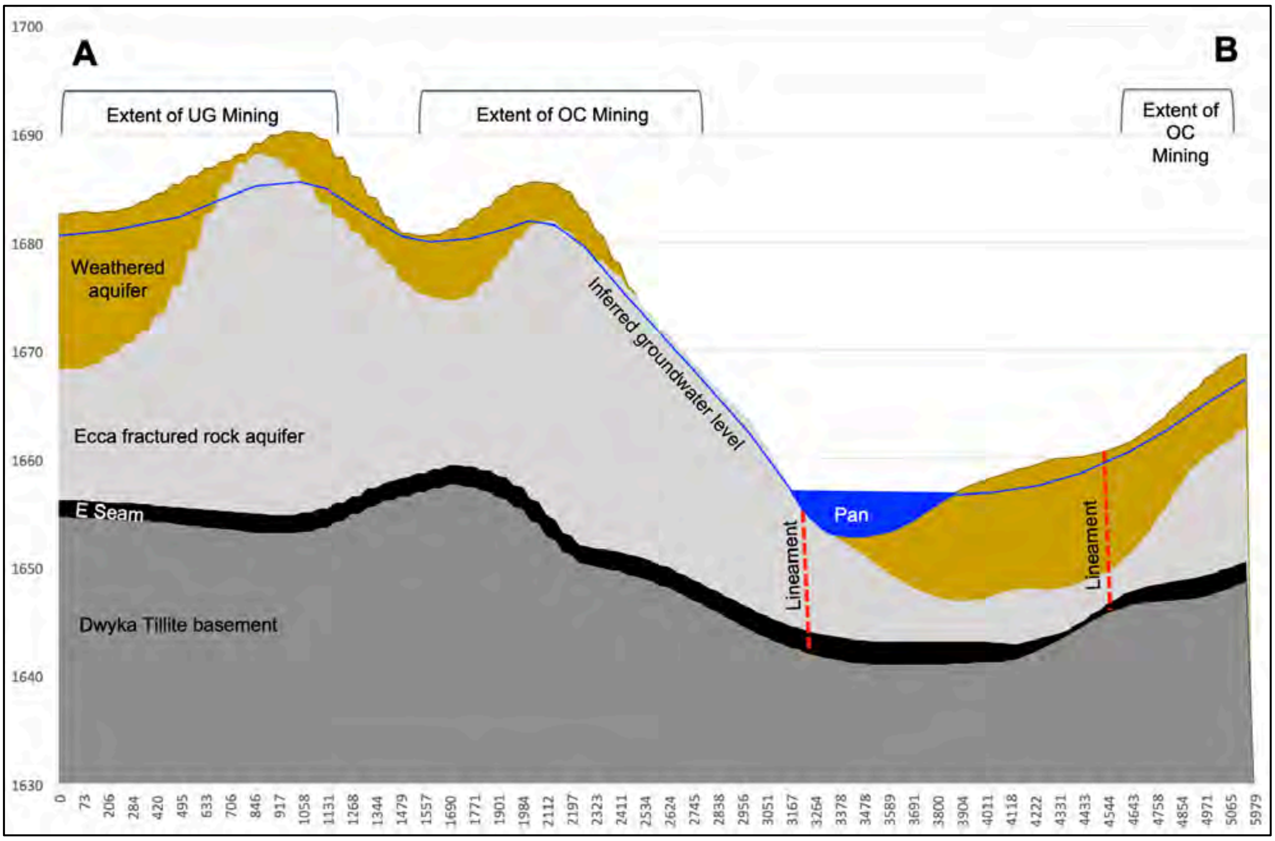

Figure 8 Schematic cross section through the project area

In order to simulate the impact of the proposed mining and auxiliary activities more accurately, especially in terms of the vertical movement of potential contamination from the site, the model was constructed with several layers, as detailed in Table 8.

MODFLOW, the modelling software used during simulations, is based on the assumption that aquifers are continuous porous media. For this reason, average aquifer parameters are assigned during simulations. The heterogeneous nature of a fractured rock aquifer is therefore approximated by a homogenous porous flow field. This is the nature of all groundwater modelling software and not just of MODFLOW. The known lineaments and intrusions are included as discrete zones in the model.

Table 9 Conceptual model configuration

Layer	Description	Thickness (m)	K (m/d): Avg (min; max)	Assumed		
				Sy (-)	S (-)	Porosity (%)
1	Weathered aquifer	9	0,2 (0,1 – 0,3)	0,1		10
2	Fractured aquifer	20	0,08 (0,01 – 0,15)		1,00E-04	1
3		20	0,08 (0,01 – 0,15)		1,00E-04	1
4	E Seam	2	0,08 (0,01 – 0,15)		1,00E-04	1
	Dolerite sill: discrete zone	Varies	0,58 (0,48 – 0,67)		1,00E-03	5
	NE-SW lineaments: discrete zones	Varies	0,58 (0,48 – 0,67)		1,00E-03	5

3 SOURCE TERM

In order to identify and quantify the potential sources to groundwater contamination at the Kranspan project, a desktop study was completed on the available dataset. A geochemistry study will be completed as part of the mining right application. The laboratory results of leach tests completed on various rock samples taken at the operations as part of the geochemistry study was made available for inclusion in the geohydrological impact assessment. A detailed discussion of these results will be provided in the geochemistry report. Evaluation of the geochemical information confirms that sulphate (SO_4) is the indicator element for the project. Elevated sulphate concentrations are characteristic of the impact of coal mining on water quality. Increased sulphate concentrations result from the oxidation of pyrite and other sulphide minerals in the coal, overburden and discard material. This reaction takes place when sulphide-rich rocks are disturbed and exposed to oxygen and water during the mining process.

The information presented in Table 9 reflects sulphate concentrations from static leach tests using three different extraction conditions. It is shown that for all the rock samples taken at the project, sulphate concentrations remain below 250 mg/l. These concentrations are expected to increase with time, especially if acid mine drainage takes in the long-term. The specific concentrations can be determined from kinetic leach tests that are currently underway, as well as from geochemical modelling of the mining environment. The latter falls outside the scope of this investigation. Assumed sulphate concentrations for the operational, medium and long-term that will be used during simulations are presented in Table 10. These are based on the author's experience in similar environments.

Table 9 Results of leach tests completed on rock samples

Sample No	Distilled Water Leachable concentration (mg/l)	Acid Leachable concentration (mg/l)	Peroxide leachable concentration (mg/l)
Ant 3 (2)	249	210	118
Ant 110 (1) E Seam	52	64	210
And 100 (4) E Seam	12	7	146
Ant 105 (1) B Seam	25	30	187
Ant 185 (1) E Seam	39	34	87
Ant 105 (3) CU	21	22	144

Table 10 Assumed source term

Sulphate concentrations	Short-term operational conditions	Medium-term post-closure conditions (<25 years after closure)	Long-term post-closure conditions (25 – 100 years after closure
Opencast mining area	50 - 250	500 – 3000	3000 - 1000
Underground mining: 5 Seam	50 - 250	500 – 3000	3000 - 1000
Discard material	50 - 250	500 – 3000	3000 - 1000

4 POTENTIAL PATHWAYS AND RECEPTORS

Based on the available dataset, the following aquifer pathways are identified for the project:

- Vertical flow through the unsaturated soil horizon from surface source of contamination like the overburden stockpiles, the coal crushing plants, discard dumps and possibly the PCDs to the underlying weathered and fractured rock aquifers. It is noted that the PCDs will be HDPE lined and as such should not impact on groundwater quality unless they overflow or if the liners leak. The rate at which the vertical flow can take place is governed by the permeability of the soils.
- Vertical and horizontal flow through the weathered aquifer from surface sources of contamination as well as mining areas that intersect this aquifer. It is noted that the contact between fresh and weathered rock is considered a preferential flow path to groundwater.
- The dolerite sill that has intruded into the shallow Ecca Formation sediments in the western part of the mining area is expected to act as a barrier to vertical flow over the extent that it has been mapped. The rate at which potential contamination could migrate through the dolerite sill is not clearly understood and assumptions have been made during simulations, which must be tested and updated as necessary.
- Once the possible contamination reaches the fractured rock aquifer, the preferential flow paths include fractures, faults, joints and bedding planes in the rock formations. Groundwater will also flow through the rock matrix, but at much lower rates compared to the preferential pathways (NE-SW trending lineaments).

The following receptors were identified:

- Existing private groundwater users.
- The pans present within the mining area.
- Rivers and streams down gradient of each mining area. Groundwater is expected to contribute to river and stream baseflow, specifically during the wet season when groundwater levels are expected to rise above the base of the streams as a result of the recharge of rainwater.

5 KEY ASSUMPTIONS AND LITERATURE-BASED DATA INPUTS

The numerical modelling is based on the following assumptions:

- Aquifer parameters were inferred from the fieldwork programme completed as part of this study. Aquifer parameters used to construct the numerical model are presented in Table 4, as discussed above. Parameters that were assumed include aquifer storage coefficients, porosities and the rate of recharge. It is further assumed that the vertical permeability is 1/10th that of the horizontal permeability.
- The source characterisation used for the project was inferred from the existing dataset. The values that will be assigned during simulations are presented in Table 10.
- Only advective transport of contaminants was simulated. Assumptions made regarding advection, are discussed below. While it is acknowledged that attenuation will take place in the soils, there is currently insufficient information available to quantify the extent to which this takes place. As such, simulations are based on the precautionary principle and take the worst-case scenario into consideration.
- The extent of the numerical model is based on natural groundwater barriers, as discussed below. These include water divides as well as rivers and streams.
- The extent and timing of mining activities were obtained from information made available as part of the study. Details of this are discussed below.

6 NUMERICAL GROUNDWATER MODELLING

6.1 Modelling objectives

The objectives of the numerical modelling undertaken as part of the project are to:

- Define the radius of influence that will be created by mine dewatering and identify which existing private groundwater users would be affected by mine dewatering.
- Estimate the volume of groundwater that would seep into the opencast and underground workings during mining.
- Estimate the impact of mine dewatering on rivers, streams and wetlands.
- Determine the period of time it would take for groundwater levels to recover after mining ceases.
- Assess whether or not decant from the underground workings is likely.
- Define the extent of possible contamination originating from the proposed mining areas and mine infrastructure on the shallow weathered and deeper fractured rock aquifers during and post mining.
- Estimate the impact of groundwater contamination associated with the mining areas on private groundwater users, rivers, streams and wetlands.

6.2 Delineation of the modelling area

The project location within the chosen model boundary is indicated on Figure 1. The following aspects were considered during the delineation of the model boundary:

- The extent and location of quaternary catchment boundaries.
- Natural groundwater flow boundaries, for example streams, rivers, water divides and geological contact zones.
- The extent of the project area.

The model boundary will comprise a no-flow boundary along its northern and southern sections. General head boundaries are used along the eastern and western sections in order to allow for flexibility in groundwater level elevations at model boundaries. Positions where the Vaalwaterspruit and the Boesmanspruit exit the model area are simulated with constant head boundaries.

The model boundary covers an area of 270 km^2. The NE-SW trending lineaments indicated on the 1:250 000 geological map for the project area are included as discrete zones.

Aquifer characteristics compiled from all sources for the monitoring boreholes on site, as discussed above, are included in the model.

6.3 Model construction

The numerical modelling was undertaken according to accepted industry principles and standards, including the South African Department of Water and Sanitation's Best Practice Guideline for Impact Prediction (DWS BPG G4, 2008). The design and construction of the numerical model is based on the conceptual model discussed above.

The numerical model for the project was constructed using MODFLOW and MT3DS. MODFLOW is a modular three-dimensional groundwater flow model and MT3DS a modular three dimensional solute transport models published by the United States Geological Survey. MODFLOW and

MT3DS use 3D finite difference discretization and flow codes to solve the governing equations. MODFLOW and MT3DS are a widely used simulation codes, which is well documented. MODFLOW is used to simulate groundwater flow rate and direction. MT3DS is superimposed on the MODFLOW simulation results and is used to predict the rate and direction of contaminant movement in the aquifers.

The NW-SE trending lineaments indicated on the 1:250 000 geological map for the project area are included as discrete zones in the model domain. The dolerite sill present along the western boundary of the project area was also included as a discrete zone.

The model boundary comprises a no-flow boundary along its northern and eastern sections. The perennial rivers and streams that co-incide with model boundaries were simulated as general head boundaries. Water divides and catchment divides were simulated as no-flow boundaries. The positions where perennial streams exit the model domain were simulated as constant head boundaries. Perennial streams that fall inside the model domain were simulated with the MODFLOW River Package. Non-perennial rivers and streams inside the model boundary were simulated with MODFLOW's Drain Package. The drains will remove groundwater from the model if the groundwater level rises above the specified drain elevation.

The model area was refined into block cells of 25 x 25m around the mining areas (Figure 9). The finer grid allowed more detailed simulations around the areas of interest. Towards the model boundaries and away from the area of interest, the model grid size increases to 200m.

The model grid comprises cubic cells, used to represent the aquifers present. The layer configuration used during simulations is summarised in Table 11.

In the vertical direction, four layers were included in the model. The position and thickness of each layer was inferred from the exploration and monitoring borehole data made available to the study. The upper layer presents the weathered aquifer. The second to fourth layers represent the Ecca aquifer. The dolerite sill is included as a discrete zone in Layer 2 of the model.

The upper layer was simulated as an unconfined aquifer. The remainder of the layers were simulated as varying between confined and unconfined conditions with the transmissivity for each layer calculated from the hydraulic conductivities prescribed and the varying groundwater levels. All units used during simulations were presented in metres (length) and days (time).

6.4 Model input files and integration

6.4.1 Groundwater flow simulations

The conceptual model discussed above was used to construct the numerical model for the project area. The modelling input parameters used are based on the information currently available for the project area, as discussed earlier in this report. The initial parameters were gradually adjusted during calibration to obtain an acceptable fit between simulated and measured heads, as discussed below.

The initial head conditions, used during model calibration, were interpolated from the digital terrain model (DTM) for the model domain. It was assumed that the average depth to groundwater in the upper weathered aquifer is 4,4m, as calculated from the groundwater monitoring dataset. The average depth to groundwater in the underlying fractured rock aquifer is 9,7m.

The DTM was also used to ensure that the elevations of the river and General Head and Constant Head Boundary conditions reflect the ground conditions as closely as possible.

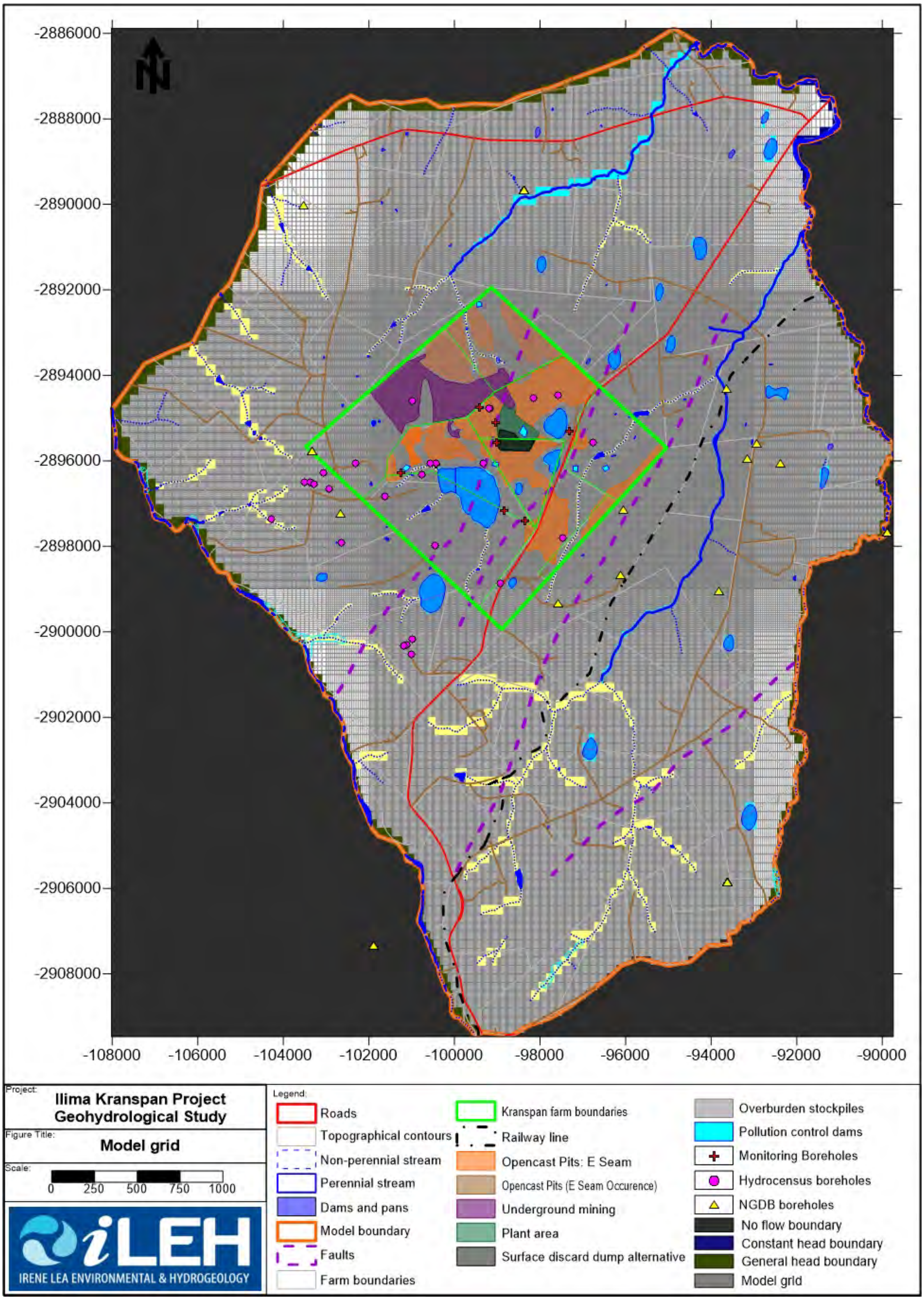

Figure 9 Model grid layout

6.4.2 Contaminant transport simulations

The MT3DS contaminant transport model used for the project is based on the calibrated flow model. During simulations contamination was simulated only under advective and dispersive conditions. Darcy's Law governs advective flow. Under advective flow, the distance that the simulated plumes may move under uniform flow conditions is calculated from the flow velocity and the specified simulation times.

It was assumed that flow would predominantly take place in the horizontal flow direction and that transverse dispersivity is 10 times lower. Molecular diffusion, which is mainly the result of transverse dispersivity, was simulated with a coefficient value of 8,64E-5 m^2/d and that the longitudinal dispersivity is between 50 and 100m.

It is acknowledged that other factors play a role in the movement of contamination in the aquifers, other than advection and dispersion. This may include chemical reaction with or adsorption to clay and soil material, ion exchange or precipitation of salts from solution. These chemical reactions were not included during simulations undertaken for the project. It is acknowledged that these chemical processes would in most instances further retard plumes thus reducing the concentrations of contaminants. There is currently insufficient information available to consider these factors during simulations. As such, advective and dispersive contaminant transport simulations provide a worst-case outcome scenario, as it assumes that the plume will move at the same rate as groundwater flow.

The impact of the proposed Kranspan project on groundwater quality was simulated using SO_4 as indicator element. The conceptual source term used to commence contaminant transport simulations is presented in Table 10.

During simulations, it was assumed that the pollution control dams (PCDs) will be lined with HDPE and are designed to meet the requirements of GN704. As such, these dams are not expected to leak or spill during the operational phase and should therefore not pose a threat to groundwater contamination. If leaks and spills occur, it would be impossible to predict when, where and how these would take place, excluding realistic simulations with the model. Upon closure, the PCDs will be removed and fully rehabilitated, leaving no long-term risk to groundwater contamination.

6.5 Groundwater flow model calibration results

Calibration of a numerical model refers to the demonstration that the model is capable of reproducing field-measured data, which are the calibration values. Calibration is achieved when a set of parameters, boundary conditions, source terms and stresses are found that produce simulated heads and concentrations that match field measured data within the calibration criteria set for the project. This is an important step in the modelling project, which ensures that model results are reliable.

The calibration criteria set for the project are presented in Table 12.

Table 12 Flow model calibration criteria

Requirement	Acceptability criteria	Compliance
Model convergence	Maximum change in head of 0,001m	Complied with (see discussion below)
Water balance	Difference between inflow and outflow <1%	Complied with (see discussion below)
Calibration error	80% of targets with <5m error between simulated and measured head	Complied with (see discussion below)

The model convergence of 0,001m was achieved during calibration. The water balance error obtained at the end of calibration was 0%, as presented in Table 14.

Table 14 Model water balance output

Flow term	Inflow (m^3/d)	Outflow (m^3/d)	Balance (m^3/d)
Storage	1,139E+02	1,373E+04	-1,259E+04
Constrant head	7,152E+00	1,911E+01	-1,196E+01
Drains	0.000E+00	2,526E+02	-2,526E+02
Recharge	1,532E+04	0.000E+00	1,532E+04
River leakance	1,143E+01	6,615E+02	-6,501E+02
General Head Boundaries	1,505E+04	1,686E+04	-1,812E+03
Total flow	3,152E+04	3,152E+04	0,000E-03
Discrepancy (%)	0%		

Model calibration results are discussed below.

It is shown that the calibration residual (the difference between measured and simulated head) is less than 5m for 85% of the steady state calibration data points. The term "head" refers to the groundwater levels. During transient calibration, 81% of the data points complied with the calibration residual criteria.

The root mean square error (RMSE) of the calibration results was calculated in order to determine the goodness of fit of the calibration results. This calculation provides an indication of the standard deviation of the calibration errors. As the calibration error measures how far the simulated values are from the regression line, the root mean square error provides an indication of how spread out the calibration errors are. The RMSE of the steady state calibration results is 3,27m; and 4,57m for the transient calibration set, which are both within the calibration criteria set.

6.5.1 Steady state calibration

The steady state calibration was completed with the available groundwater level monitoring set and the results are presented in Table 13 and in Figure 10.

Table 13 Steady state calibration results

Monitoring position	Simulated head (mamsl)	Measured head (mamsl)	Residual (m)
KR1	1719,30	1723,56	-4,26
KR4	1653,67	1649,88	3,79
KR7	1688,37	1685,49	2,88
KR8	1688,54	1690,23	-1,69
KR9	1704,43	1707,94	-3,52
KR16	1697,56	1708,04	-10,48
KR17	1705,06	1710,04	-4,98
1-130	1678,92	1682,46	-3,54
2-50	1669,29	1675,78	-6,49
5-110	1684,64	1687,01	-2,37
6-220	1660,79	1663,70	-2,91
PM1	1663,54	1665,10	-1,56
PM2	1661,54	1662,09	-0,55
PM3	1657,14	1659,02	-1,88
KR-SPR1	1706,17	1711,00	-4,83
KR-SPR2	1700,45	1708,00	-7,55
KR-SPR3	1647,78	1648,00	-0,22
KR-SPR4	1729,88	1730,00	-0,12
KR-SPR5	1659,32	1659,00	0,32
KR-SPR6	1663,74	1662,00	1,74
KR-SEEP	1711,48	1718,00	-6,52
2-50B	1671,29	1675,48	-4,19
5-110B	1682,73	1685,56	-2,83

Monitoring position	Simulated head (mamsl)	Measured head (mamsl)	Residual (m)
6-220B	1661,79	1665,87	-4,08
SITE8B	1702,90	1707,46	-4,57
PM1B	1663,54	1664,96	-1,42
PM3B	1657,14	1658,46	-1,32

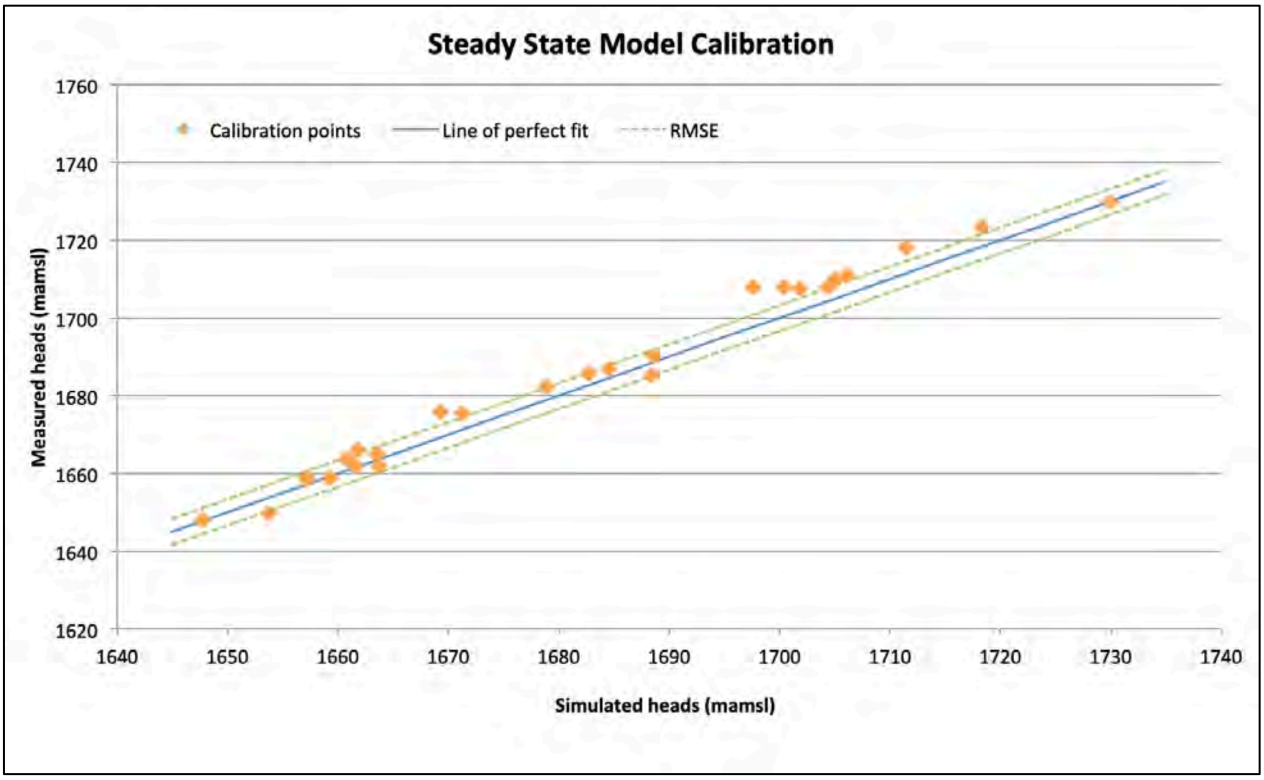

Figure 10 Steady state calibration error distribution

A scatter diagram of the calibration results is presented in Figure 10. A perfect calibration will yield results that fall on a straight line through the origin at zero with a slope of one. The RMSE of the calibration results is also indicated on the graph. It is shown that most of the calibration results (85%) plot close to or within the RMSE bandwidth on the graph.

6.5.2 Transient calibration

Transient calibration was completed with the current monitoring information and the results are presented in Table 14 and Figure 11.

As mentioned above, 81% of the data points were within the 5m calibration residual criteria, as demonstrated on the graph in Figure 14.

The RMSE for the transient calibration process is 4,57m, which is within the calibration criteria set.

Table 14 Transient calibration results

Monitoring position	Simulated head (mamsl)	Measured head (mamsl)	Residual (m)
KR1	1719,10	1723,56	-4,46
KR4	1658,31	1649,88	8,43
KR7	1689,31	1685,49	3,82
KR8	1689,49	1690,23	-0,74
KR9	1705,15	1707,94	-2,79
KR16	1704,14	1708,04	-3,90
1-130	1679,57	1682,46	-2,89
2-50	1669,49	1675,78	-6,29
5-110	1684,83	1687,01	-2,18
6-220	1665,48	1663,70	1,78
PM1	1665,20	1665,10	0,10
PM2	1666,51	1662,09	4,42
PM3	1660,79	1659,02	1,77
KR-SPR1	1702,88	1711,00	-8,12
KR-SPR2	1707,10	1708,00	-0,90
KR-SPR3	1652,16	1648,00	4,16
KR-SPR4	1725,37	1730,00	-4,63
KR-SPR5	1663,39	1659,00	4,39
KR-SPR6	1666,60	1662,00	4,60
KR-SEEP	1708,12	1718,00	-9,88
2-50B	1673,76	1675,48	-1,72
5-110B	1686,25	1685,56	0,69
6-220B	1665,46	1665,87	-0,41
SITE8B	1698,45	1707,46	-9,01
PM1B	1668,43	1664,96	3,47
PM3B	1662,06	1658,46	3,60
KR17	1711,66	1710,04	1,62

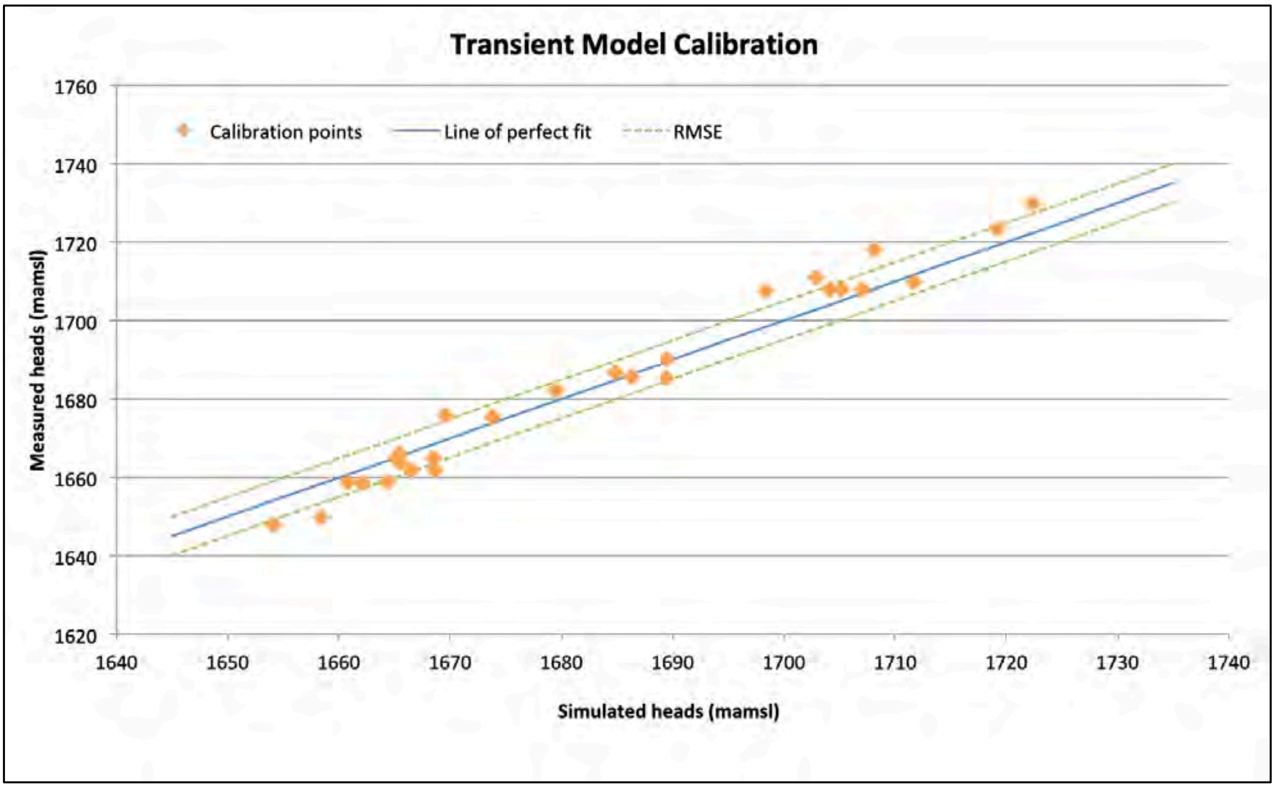

Figure 11 Transient calibration error distribution

6.5.3 Measures to improve calibration results

Factors that influence the calibration process and results include the following:

- Errors in the coordinates and elevations recorded for the hydrocensus boreholes. These boreholes were captured with a hand-held GPS, which is not always accurate.
- Errors in groundwater level measurements.
- The effect of groundwater abstraction by private groundwater users on the measured groundwater level measurements.
- The absence of borehole logs and depths which to characterise the aquifer conditions that groundwater levels in hydrocensus boreholes represent. The purpose of calibration, it was assumed that all hydrocensus and monitoring boreholes target the fractured rock aquifer. The springs recorded were used to calibrate the weathered aquifer.
- The use of average values to approximate heterogeneous aquifer conditions also adds to the calibration error.

6.5.4 Calibrated aquifer parameters

The calibrated aquifer parameters, based on the outcome of model calibration, are presented in Table 15. The calibrated rate of recharge is 3% of MAP.

Table 15 Calibrated aquifer parameters

Layer	Description	Thickness (m)	K (m/d): Avg (min; max)	Specific yield (-)	Specific storage (-)
1	Weathered aquifer	9	2E-3	0,06	
2	Fractured aquifer	20	8E-4		3,2E-6
3		20	8E-4		3,2E-6
4	E Seam	2	8E-4		3,2E-6
	Dolerite sill: discrete zone	Varies	5E-3		6,7E-5
	NE-SW lineaments: discrete zones	Varies	3		2,98E-5

6.6 Model sensitivity

A sensitivity analysis was completed on the model. The purpose of the sensitivity analysis is to quantify the uncertainty in the calibrated model caused by uncertainty in the estimates of aquifer parameters, stresses and boundary conditions. The level of heterogeneity of the aquifer material can never be accurately measured with field data. The uncertainty of the impact of heterogeneity on simulations is therefore assessed as part of the sensitivity analysis. Test simulations were therefore undertaken to determine the sensitivity of the modelling results to variations in key parameter values.

The results of the sensitivity analysis are presented in Figure 12. The larger the head changes during the analysis, the more sensitive the model is to that parameter.

The results indicate that the model is most sensitive to changes in the rate of recharge to the aquifers as well as the specific yield of the upper weathered aquifer. There is currently no site-specific information available to characterise these parameters and the calibration results are based on estimates based on the author's experience. A better understanding of these parameters can be obtained through analysis of hydrographs (groundwater level fluctuations with time) that will be available once a groundwater monitoring programme is in place at the proposed mine.

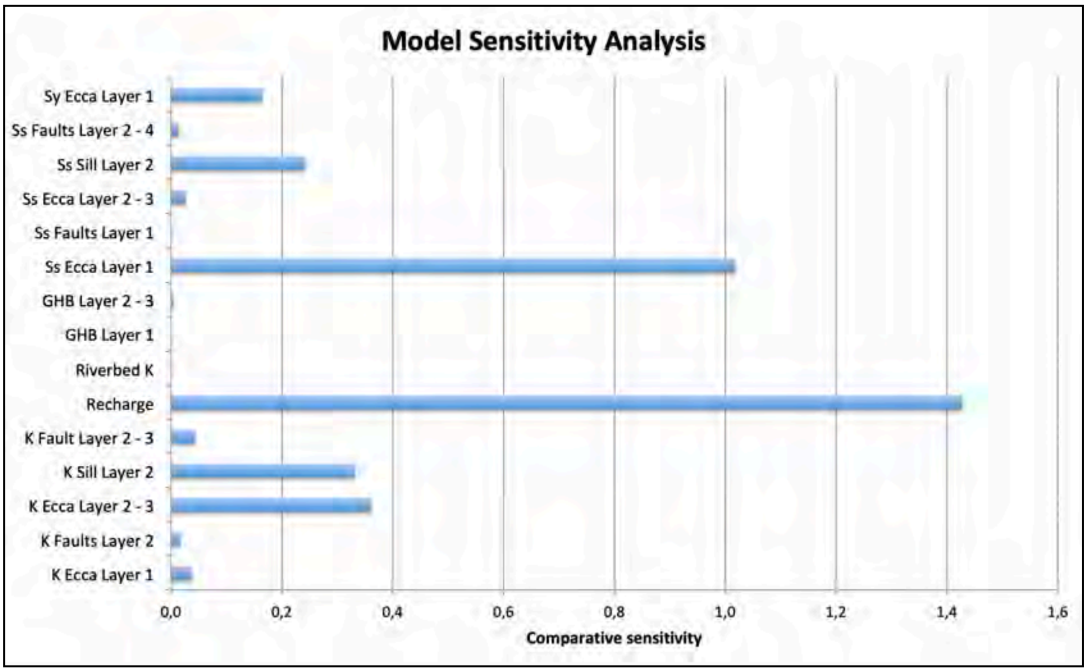

Figure 12 Sensitivity analysis

6.7 Assessment uncertainties

The accuracy of the modelling project depends on the quality of the input data, the available information, time available to complete the calibration process and to test the outcome of scenario modelling. Even with an unchanging environment, impacts are difficult to predict with absolute certainty. Predictions were calculated with the calibrated flow model, which is a simplified version of reality. The model represents a tool that can be used to assess the impact of the proposed mining areas on the aquifers and to identify data gaps. The calibration error is discussed above and is thought to be acceptable. The model should be updated and verified with site-specific monitoring information, when it becomes available. Calibration against hydrographs will be of specific value in improving the current understanding of aquifer parameters. Uncertainties are approached conservatively, based on the precautionary principle, in order to ensure that the predictions and impact assessment in this report addresses the maximum potential impact of the proposed development. The uncertainties in the model include:

- **Uncertainties regarding aquifer conditions within the project area**: This understanding can be improved through the implementation of a groundwater level and quality monitoring programme at the mine.
- **Uncertainties regarding borehole depth, construction and geology intersected**: This information is not available for the hydrocensus boreholes. For this reason, it was assumed that all hydrocensus boreholes target the fractured rock aquifer.
- **Uncertainties regarding the borehole elevations**: The elevations used for the hydrocensus boreholes during simulations were inferred from hand-held GPS measurements and inaccuracies may occur. It is however thought that the error in elevation will not exceed the calibration error of 5m.
- **Mathematical modelling uncertainties**: It is not possible with the available information to quantify the heterogeneity present in the aquifers simulated. For this reason, there are inherent uncertainties in the model. The level of confidence in the model can be improved with the incorporation of additional monitoring data.

The uncertainties listed above can be reduced or eliminated through implementing an on-going groundwater monitoring programme at the mine. This information can be used to improve aquifer parameter estimation and model calibration.

7 GEOHYDROLOGICAL IMPACT ASSESSMENT

7.1 Mine plan used

The mine plan used during the simulations is presented in Figure 13. The figure is based on information made available to the study and indicates the extent and timing of both opencast and underground mining. For the sake of convenience, the pits were numbered in the sequence in which they will be mined. Mining will commence from Pit 1 situated close to the Plant area. Opencast mining will be undertaken over a 14-year period. Mining will be completed at Pits 10 and 11. Underground mining will be completed over a period of 12 years, as indicated in the Mining Work Programme submitted for the project (Ilima, 2018).

The E Seam floor contours are overlain on the figure. It is shown that the depth to coal increases towards the northwest. In this area, underground mining is proposed. The coal seam is shallower in the southern and eastern mining areas. The dip of the coal seam is indicated as vectors on Figure 13. It is shown that the dip of the coal seam is variable over the mining area.

7.1.1 Wetlands

The wetlands are often associated with areas of shallow groundwater table conditions, as well as with the pans and streams present. As such, the impact of mining on the shallow weathered aquifer is of importance to the sustainability of wetlands during and after mining. A lowering in groundwater levels would have a negative impact on wetlands. The impact of mine dewatering is therefore of importance when evaluating the impact on wetlands.

The wetlands were delineated as part of the Scoping Phase of the project. The extent of these, including the mandatory buffer zone around each, is indicated on all figures in this report.

It is thought that any permanent lowering of the groundwater table will reduce the groundwater that feeds many of the wetlands in the area, on which the wetland fauna and flora is dependent for survival. This could result in a loss of riparian vegetation and wildlife habitat. The depth of groundwater fluctuation that would negatively affect wetland sustainability will depend on the root depth of the plants. For the simulations discussed below, it is assumed that wetlands that fall in zones of impact where the groundwater level is lowered by more than 1 m, would be negatively affected during mining. This assumption needs to be confirmed and re-assessed, if necessary. It is however a conservative approach, as a 1 m drawdown in groundwater level would be closely associated with the edge of the zone of influence delineated by the 0 m drawdown contour.

In addition to the impact of fluctuations in groundwater levels, contaminated groundwater that infiltrates from the mining areas will also have adverse impacts on wetland flora and fauna. Any changes in the geochemical character of the soil and/or water are expected to have a negative impact on biological communities in the wetlands. This is especially true if the pH of water drops because of acid mine drainage or if the salt and metal concentrations increase to toxic levels in the groundwater discharging to the wetlands.

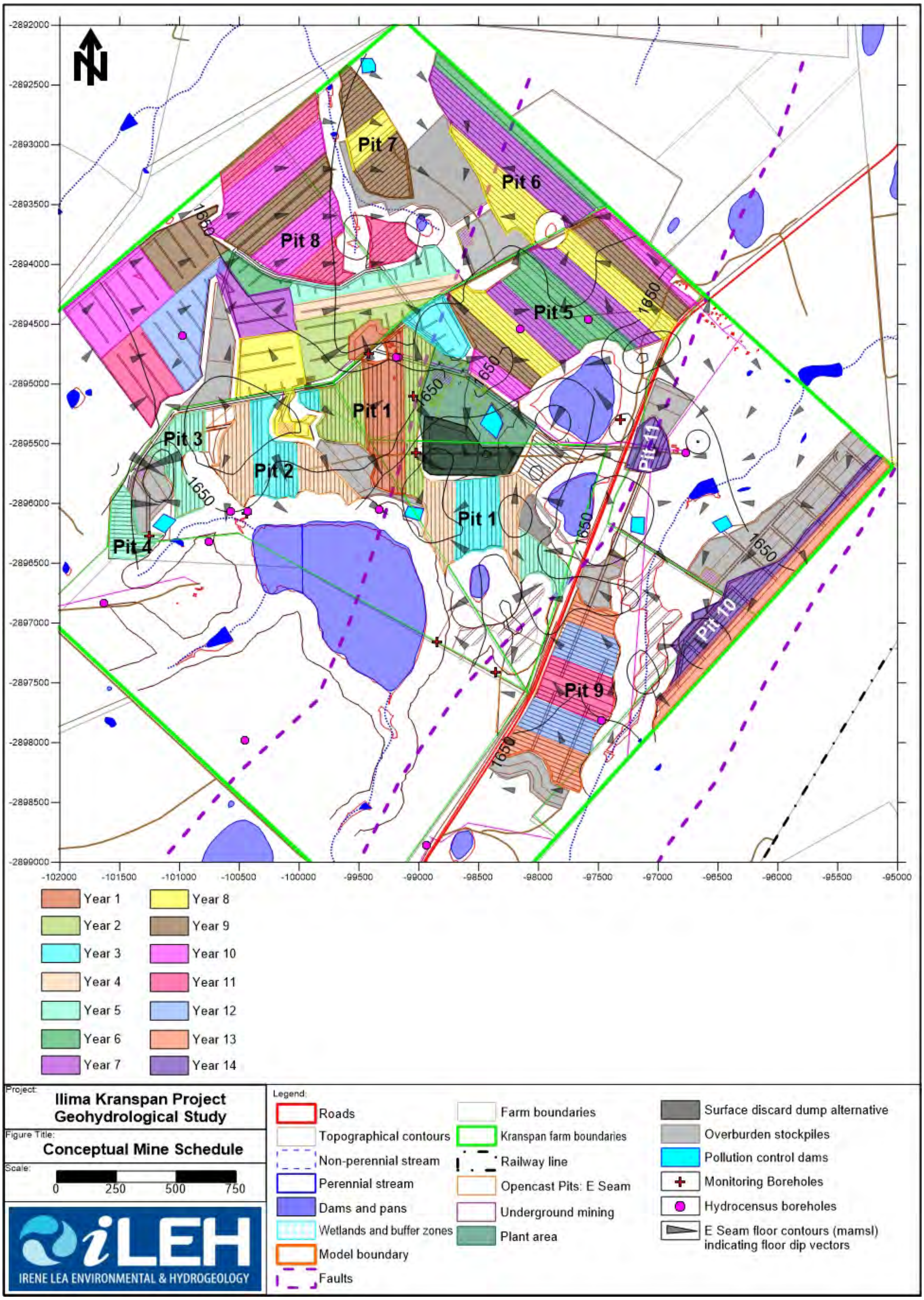

Figure 13 Mining schedule used during the assessment

7.1.2 Risk of acidification of the mine water

A geochemical assessment is currently underway. To date, the results of static tests completed on samples taken from the Kranspan project, are available (Van Hille, 2019). Kinetic testing is still underway and the results of these were not available at the time of compilation of this report.

Two rock sampling sets were analysed as part of the static tests completed. These include discard samples generated during a small-scale washing experiment, using reject coal samples. A number of drill core samples were also taken for analysis. There are representative of waste rock/overburden stockpile material. The results of whole rock analyses on the samples taken indicate that zinc and to a lesser extent manganese are indicator trace elements and are present in significant concentration in six of the samples analysed.

In addition, the tests completed indicate that the samples have relatively low concentrations of calcium and magnesium, suggesting limited acid neutralising capacity. The results of acid base accounting analysis completed by Van Hille (2019) indicate that five of the six coal discard samples must be considered acid generating. It is noted that the remainder of the samples had a low neutralising capacity.

The results of the leach tests indicate that the drill core samples were essentially inert under deionised water leach conditions. Under acid leach conditions, elevated barium, manganese and lead were recorded. Net Acid Generation leach tests yielded elevated concentrations of chromium, manganese, lead and nickel, but not exceeding the LCT1 threshold values.

The study concludes that the discard material tested has a high probability of becoming acid generating if stored in a surface impoundment for a significant amount of time. There is however a level of uncertainty regarding the magnitude of the acid generating potential in the outcome of the tests. Greater clarity is expected once the kinetic testing is completed.

It is further concluded that the waste rock (drill core) samples poses a lower environmental risk with only one out of twenty samples taken demonstrating significant acid generating potential.

Based on the discussion above, the modified sulphate concentrations presented in Table 10, will be applied during simulations.

The trace elements that leached from the discard and rock samples will be used to design an appropriate groundwater monitoring programme for the operations.

7.1.3 Discard management

Two possible discard management measures are considered for the project. The preferred option entails backfilling the discard material into mined-out pits. The alternative option is to construct a discard facility on surface. The position of the alternative is indicated on Figure 13.

According to the Scoping Report (ABS Africa, 2018), the following details are applicable to discard management:

- The preferred alternative is to dispose of discard from the wash plant in-pit as part of the on-going rehabilitation of the opencast mining areas.
- The possible surface engineered discard stockpile alternative will cover an area of 26,94 ha. If this alternative is implemented, the discard stockpile will be designed in compliance with the Regulations governing the Planning and Management of Residue Stockpiles and Residue Deposits, 2015.
- For the purpose of the impact assessment presented in this report, two scenarios were tested

for the surface discard stockpile, namely an unlined and a lined facility.

- The rate at which leachate can infiltrate from the discard stockpile in the unlined scenario, will depend on the permeability of the soils underlying the facility. In the absence of site-specific measurements, the permeability of the weathered aquifer will be assigned to test this scenario.
- If the facility is to be lined, the type of liner will depend on the characteristics of the discard material and an assessment against the National Environmental Management: Waste Act (Act 59 of 2008) (NEM:WA),the Waste Classification and Management Regulations, as amended (R635) and the Regulations governing the Planning and Management of Residue Stockpiles and Residue Deposits, 2015. This assessment falls outside the scope of the geohydrological study. A discussion of the results of static geochemical tests completed by Van Hille (2019) suggests that the samples analysed did exceed the TCT0 and LCT0 threshold values for a number of elements, but in these cases the values measured were significantly below the relevant TCT1 and LCT1 values. Under these conditions, it is likely that a surface discard stockpile may require at least a Class C liner (modified compacted clay liner), or a liner as prescribed by the professional engineer appointed to complete the designs for the facility. It is acknowledged that the liner requirements will depend on the outcome of a risk assessment and recommendations made by a competent person, as indicated in the the Regulations governing the Planning and Management of Residue Stockpiles and Residue Deposits, 2015 For the purpose of the geohydrological impact assessment, a Class C liner will be evaluated.

In order to obtain a first approximation of the impact of a lined and unlined surface discard stockpile, literature-based leachate volumes were used. These are based on the work undertaken by Rowe (2012), as presented in Table 17. In order to complete the simulations, it was assumed that a Class C liner will be considered and that the construction controls are less than perfect in order to assess the worst case scenario. Under these conditions, the rate of recharge from the discard stockpile will be around 0.96% of the mean annual precipitation (MAP), which is less than the natural rate of recharge to the aquifers of 3% of MAP.

Table 17 Class C liner leakage volumes (after Rowe, 2012)

Liner installation conditions	**Leakage volume**		**% of MAP**
	m^3/s	**m^3/d**	
Tight control	1,48E-06	0,13	0,02
Less control	5,95E-05	5,14	0,96

7.1.4 Rehabilitation measures included during simulations

It was assumed that all surface infrastructure would be removed and rehabilitated upon mine closure, including PCDs and the plant area. The surface will be rehabilitated and made free-draining. Under these conditions, the rate of recharge would revert back to natural rates.

The overburden dumps will be continually backfilled into mined out pits during the operational phase. During simulations, it was assumed that rehabilitation would reduce the rate of recharge of rainwater to the facilities from 20% of MAP to 5% of MAP. This will in turn reduce the volume of contaminated leachate that could infiltrate from the overburden stockpiles to the underlying aquifers in future. At closure, it was assumed that all overburden stockpiles will be backfilled into mined-out pits and that the remnant surface areas would be rehabilitated, shaped and free draining. The rate of recharge to unrehabilitated and rehabilitated opencast mining areas were taken from Grobbelaar et al (2004), as summarised in Table 16.

Table 16 Recharge rates used during simulations (after Grobbelaar et al, 2004)

Mining area	Literature-based recharge rate (% of MAP)	Value used
Unrehabilitated spoils	30 – 80%	50%
Levelled spoils	15 – 30%	20%
Rehabilitated spoils	5 – 10%	5%

During long-term simulations, it was assumed that the adit will be backfilled, shaped and made free-draining. Under these conditions, the rate of recharge to the underground workings would revert to natural rates. It is further assumed that no subsidence will take place above the underground workings. This will be achieved through sound planning and the implementation of the necessary safety factors to ensure stability. As no subsidence of ground is expected above the underground workings, the rate of recharge to areas disturbed by underground mining was assumed to be 3% of MAP.

In the opencast mining areas, it is assumed that backfilling and shaping of the pits will reduce the rate of recharge, but not to natural rates. It is unlikely that rehabilitation of the disturbed areas would result in pre-mining recharge conditions.

7.2 Impact on groundwater availability

The impact on groundwater availability was assessed with the aid of the calibrated groundwater flow model prepared for the project.

As discussed earlier in this report, the model assumes average permeabilities for the rock formations that will be intersected during mining. The aquifers are however heterogeneous and variable groundwater seepage rates can therefore be expected. For example, if a water-bearing feature is intersected, the rate of groundwater seepage will increase. On average however, the aquifers present in the area are not considered strong, as suggested by the outcome of the hydrocensus and the results of the monitoring borehole drilling and testing programme.

The NE-SW trending lineaments indicated on the regional geological map and discussed earlier in the report, are however expected to act as preferential flow paths to groundwater. The intersection of these structures during mining could therefore result in increased groundwater inflow into the mining areas. Two of these lineaments transect the mining area. The northern-most lineament crosses through the largest pan, Pit 1 and Pit 6. It may also affect the eastern extremities of the proposed underground workings and the northwestern section of Pit 5. The southern-most lineament only cuts through Pit 11.

The rate of groundwater seepage is influenced by the depth and method of mining. Mining that takes place at shallow depths that intersects the shallow weathered aquifer may experience increased groundwater seepage rates, as these formations are expected to have higher permeabilities. Increased groundwater seepage rates are anticipated along the zone of transition from weathered to fresh rock.

Underground mining in the fractured rock aquifer is expected to experience groundwater seepage at lower rates, as the average permeability with depth is expected to decrease as the rock formations become tighter. Higher seepage rates will however be encountered if a water-bearing structure is intersected. In summary, the rate of groundwater seepage is influenced by the following factors:

- The extent of mining: groundwater seepage rates will increase for larger mining areas.
- Depth of mining: groundwater seepage rates to shallower mining areas are expected to be higher compared to deeper mining areas where the water-bearing fractures are expected to be tighter.
- The intersection of water-bearing features: the two main lineaments are expected to increase the groundwater seepage volumes if and when intersected during mining.
- Cumulative impact of mine dewatering: the rate of groundwater seepage may be high when new ground is broken, but may reduce as the aquifers around the mining areas are dewatered. Groundwater levels will also start to recover in areas where pits are backfilled and rehabilitated, thus affecting groundwater flow gradients and seepage rates.

- The cumulative impact of mining at the adjacent Msobo and Northern Coal mines. Although these mines are located inside the modelled area, no specific mining layout and schedules were available to include mining at these collieries during simulations.

7.2.1 Rate of groundwater seepage during the construction phase

During construction of the box cut and the adit to the underground workings from Pit 1, groundwater seepage to the mining areas will occur as the regional groundwater table will be intersected.

The volume of groundwater seepage to the first opencast strip and the construction of the adit of the underground workings are expected to be approximately 125 m^3/d in total. As the aquifers are heterogeneous, the volume may be lower (around 100 m^3/d) or higher (up to 400m^3/d), depending on whether water-bearing fractures are intersected. For the purpose of pollution control dam design, it is recommended that the dam size cater for around 100 m^3/d of groundwater over and above direct rainfall and runoff, as not all the groundwater will be dewatered to surface. The seepage is expected to be most prominent during the wet season, which means that over a year, approximately 18 000m^3 of groundwater may have to be contained during the construction phase to ensure safe and dry mining conditions.

7.2.2 Rate of groundwater seepage during the operational phase

The results of simulations to calculate the rate of groundwater seepage during the operational phase of mining are presented in Table 18 and Figure 14. The seepage rates presented are cumulative (total) volumes as mining progresses.

The volumes presented indicate the expected average groundwater seepage rates and a progressive increase in the indicated percentage points to evaluate uncertainty in the permeability of the rocks that may be intercepted during mining. It is unlikely that permeabilities 200% above average conditions would prevail over extensive sections of the mining areas. The possibility however exists that these volumes may be encountered in discrete zones over short periods of time until the fractures are dewatered.

It is also possible that the rate of groundwater seepage may be lower than the expected average conditions. Calculations were made to cater for this eventuality, as shown in Table 18.

Table 18 Estimated groundwater seepage rates (Unit: m^3/d)

Mining Schedule	Expected average	25% below average	25% above average	50% above average	100% above average	200% above average
Year 1	125	103	148	184	252	408
Year 2	114	97	134	158	212	318
Year 3	145	120	172	205	282	480
Year 4	186	148	221	265	367	624
Year 5	177	146	211	254	365	624
Year 6	154	130	181	215	293	483
Year 7	254	206	305	366	510	869
Year 8	277	223	332	398	554	931
Year 9	325	257	391	470	656	1099
Year 10	341	278	407	487	667	1028
Year 11	289	239	344	412	569	922
Year 12	278	216	343	407	552	840
Year 13	290	235	342	403	537	698
Year 14	278	225	337	393	522	578

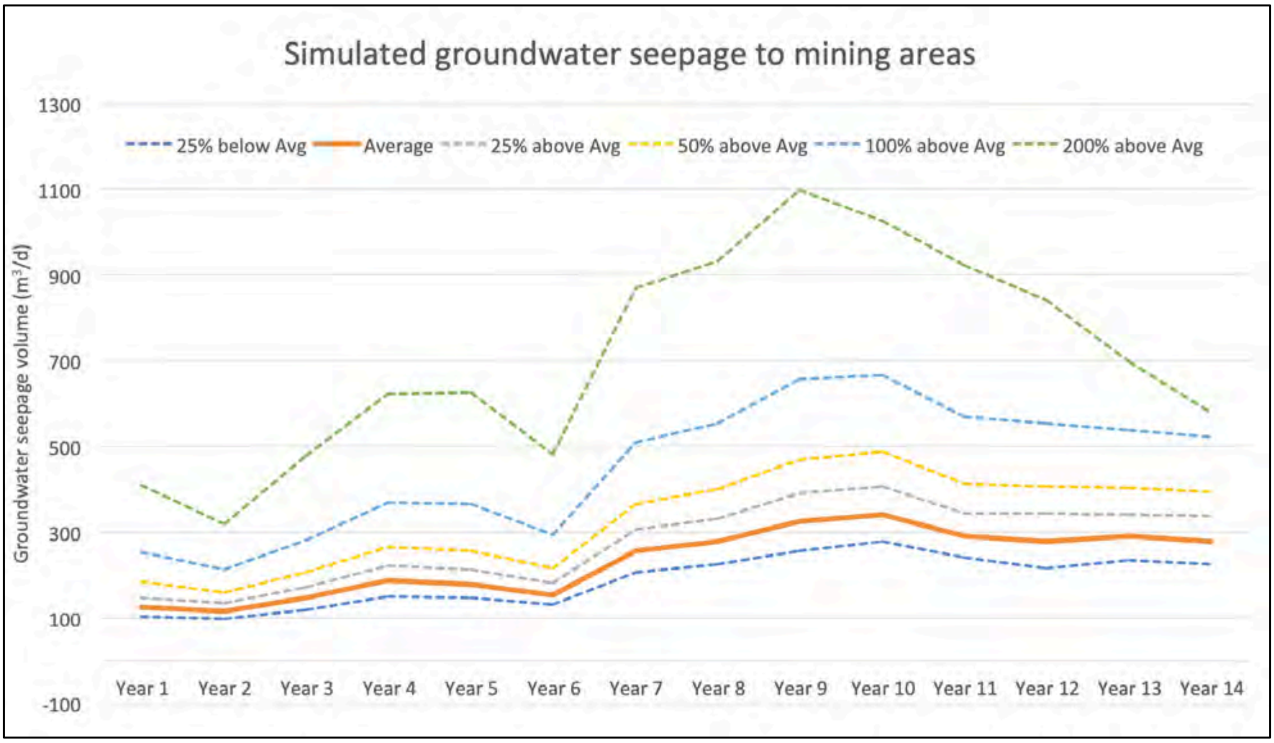

Figure 14 Simulated groundwater seepage to mining areas

The expected average volume of seepage that must be contained and managed during mining may vary between 100 and 340 m^3/d over the course of the operational phase. The volume of groundwater is expected to gradually increase during the operational phase and reach a maximum during Year 10. From Year 11, the volume is expected to decrease as underground mining reaches completion. At the end of life of mining, the total volume of groundwater that may seep to the mining areas is expected to be around 280 m^3/d on average. This volume may be as low as 225 m^3/d and as high as 578 m^3/d, depending on aquifer conditions. As the aquifers around the mining areas will be dewatered as mining progresses and mined out pits will be concurrently backfilled, it is unlikely that the higher groundwater seepage rates will be experienced during mining.

The groundwater may be contained in dedicated sumps in the pits and the underground workings, but it is expected that a portion of this water will have to be dewatered to surface from the mining areas to ensure safe mining conditions.

For the purpose of PCD design during the operational phase, it is recommended that provision is made for a total of 280 m^3/d of extraneous groundwater. This is equivalent to a total volume of 50 400 m^3/a at the end of the life of mine. The current surface layout plans cater for six PCDs across the operations. On average, each dam must therefore allow for the containment of around 8 400 m^3/a of groundwater seepage over and above direct rainfall and surface runoff.

7.2.3 Impact of mining on private groundwater users

The active removal of groundwater seepage from the mining areas will result in a lowering in groundwater levels in the surrounding aquifers. This will create a cone of depression around the mining area and will reverse groundwater flow towards areas where mine dewatering is taking place.

The cone of depression delineates the zone of influence that the proposed mining activities will have on groundwater availability, especially in private boreholes.

Due to the fact that concurrent rehabilitation will take place during opencast mining, the extent to which the aquifers may be dewatered will depend on where, how deep and how long the mining will take place. For this reason, the cone of depression changes on an annual basis as mining and rehabilitation progresses. In order to assess the maximum extent of the impact of mining on groundwater availability, the simulated drawdown cones for all fourteen years of mining were overlain and are presented in Figures 15 and 16 for the weathered and fractured rocks respectively.

It is shown that the most significant lowering in groundwater levels is associated with the northern sections of the mine, where the coal seams are deeper. In this area, groundwater levels may be lowered by up to 40m in the fractured rock aquifer. The weathered aquifer is expected to dry up in this area. In the southeastern section, the impact is expected to be less pronounced, as the depth of mining is shallower.

7.2.3.1 Impact on the shallow weathered aquifer, wetlands and springs

The extent over which groundwater levels could be lowered by 1m and more in the weathered aquifer is indicated in purple on Figure 15. This is considered the maximum zone of impact on groundwater levels in the weathered aquifer.

Wetlands that may be affected by the lowering of groundwater levels in the weathered aquifer, or by the total dewatering of the aquifer, are indicated on the figure. It is anticipated that the wetlands will not function optimally in these areas and may be permanently lost due to a decrease in groundwater availability as a result of mine dewatering. The most significant impact is expected in the central portions of the mining area around the largest pan. Preferential drawdown is also expected along the strike of the northern most lineament, which connects the mining areas with the largest pan.

It is further likely that spring KR_Spring 5 will be destroyed during mining at Pits 9 and 10. Mr Koos Jordaan owns this spring. It is currently fenced in and is used to supply water to animals on the farm. The spring was not sampled for chemical analysis as part of the fieldwork completed for the study and the flow rate is not currently known.

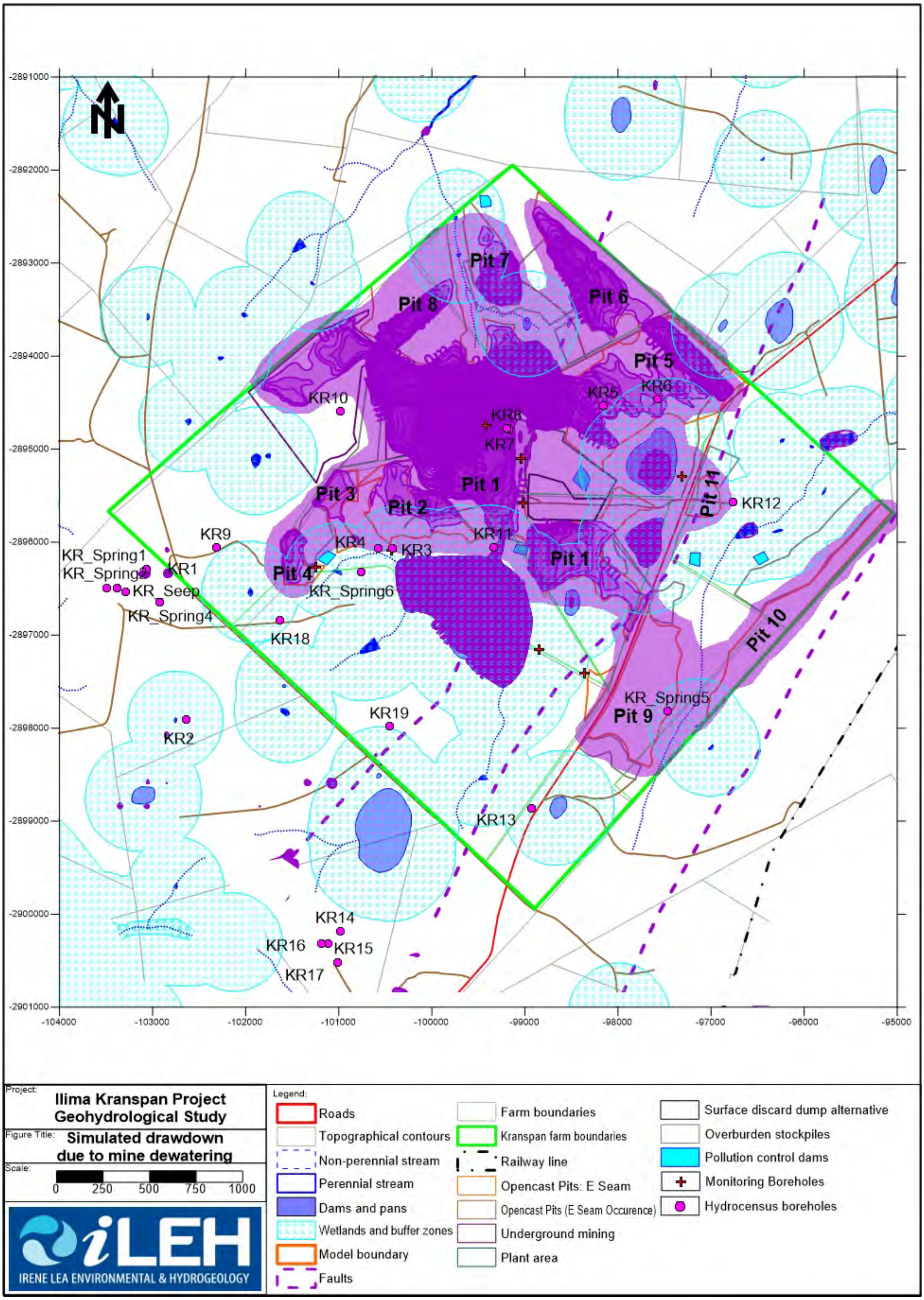

Figure 15 Extent of the dewatering zone of influence in the weathered aquifer

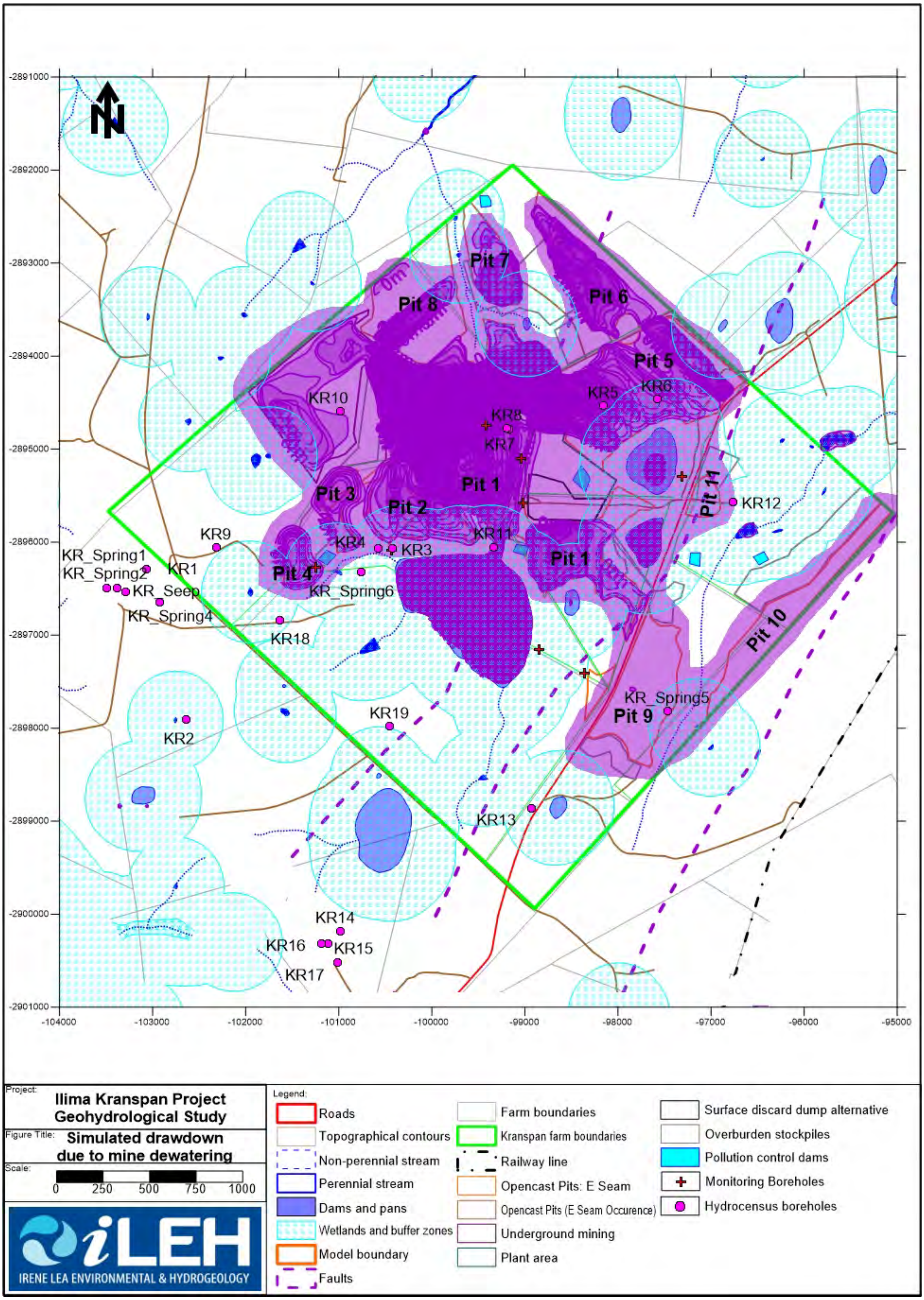

Figure 16 Extent of the dewatering zone of influence in the fractured rock aquifer

7.2.3.2 Impact on the fractured rock aquifer and private boreholes

The extent of the maximum anticipated cone of depression in the fractured rock aquifer is presented in Figure 16. As with the weathered aquifer, the most significant impact is expected in the central and northern parts of mining where the coal seam is deeper. Underground mining activities is also expected to have a more significant impact on groundwater levels due to the fact that it will be continually dewatered during the operational phase. In this area, groundwater levels may be lowered by up to 30m immediately above the underground workings. The extent to which this may impact on private boreholes will depend on the depth and construction of the borehole, details which are not currently available for the private boreholes.

The boreholes and springs that will be destroyed during opencast mining are listed in Table 19. Even though these boreholes will be destroyed, the assessment will address the impact of mining on each of these for comparative reasons.

Table 19 Private boreholes and springs that will be destroyed during opencast mining

BH ID	Owner	Current use
KR5	Jaco Papenfus	Open hole not in use
KR6	Jaco Papenfus	Open hole not in use
KR7	Jaco Papenfus	Submersible pump (not operational): supply to house and animals
KR8	Jaco Papenfus	Windpump not in use
KR_Spring5	Koos Jordaan	Fenced in: supply to animals

The extent of the cones of depression around the opencast pits are less pronounced due to their comparatively short lives and the effect of concurrent rehabilitation. The cones of depression are steep around the mining areas and do not extend significantly beyond 200m from the mining areas. This is due to the low average permeability of the matrix of the fractured rock aquifer.

As mentioned above, preferential drawdown is expected along the northern most lineament, which may result in a connection between the mining areas and the largest of the pans. Simulations suggest that a drawdown of up to 2m may occur along the lineament in the vicinity of the pan.

The impact of mine dewatering on the private boreholes are summarised in Table 20. It is shown that groundwater levels may be lowered by between 1 and 25m in the private boreholes. The timing of each impact is also indicated in the table. This is linked to the mine schedule that will be implemented.

The most significant impact on private boreholes is expected for boreholes KR7 and KR8 that belong to Mr Jaco Papenfus. Mining is expected to lower groundwater levels by up to 25m in these boreholes and the impact will most probably prevail over the life of the operations due to the proximity of the underground workings. Groundwater from borehole KR7 is not currently in use as the pump installed is not operational. The owner indicated during the hydrocensus that the borehole was previously used to supply the farm house and animals. There is a high risk that this borehole will dry up and will no longer be available for use by Mr Papenfus. As such, this impact is considered significant and should be managed with care, as detailed later in the report. Borehole KR8 is not in use.

Boreholes KR5 and 6 may experience a drawdown of 10m during Years 6 – 11 of mining. These two boreholes are not currently in use.

Lesser impacts are anticipated in boreholes KR3, KR4, KR10, KR11 and KR 12 and groundwater levels may be lowered by between 2 and 5m during mining. It is likely that this will not have a significant negative impact on the use of these boreholes. It is however prudent that the boreholes are effectively monitored to identify significant negative impacts timeously and to implement responsible groundwater management plans. These are discussed later in this report.

In summary, the impact on groundwater availability in private boreholes within the anticipated zone of influence in the fractured rock aquifer could have a significant negative impact. This is mainly due to the fact that farmers in the area are dependent on groundwater for water supply. Current farming activities and domestic use could temporarily cease over the life of the operations as a result of mine dewatering. Of most concern is the anticipated significant negative impact and possible loss of borehole KR7 belonging to Mr Jaco Papenfus.

The current rate of groundwater abstraction from the private boreholes in the zone of influence of mine dewatering is not currently known. It is important that this is established before mining commences in order to ensure that management of this impact is implemented in a responsible manner.

Table 20 Impact of mine dewatering on private boreholes

Affected BH	Owner Current Use	Current abstraction volume (l/hr)	Anticipated lowering in groundwater level (m)	Timing of impact (year of mining)
KR3	Rudi Prinsloo Windpump: supply to animals	Not available	<2	Year 3 – 5
KR4	Rudi Prinsloo Open borehole: not in use	Not available	<2	Year 3 – 5
KR5	Jaco Papenfus Open borehole: not in use	Not available	<10	Year 6 – 11
KR6	Jaco Papenfus Open borehole: not in use	Not available	<10	Year 6 - 11
KR7	Jaco Papenfus Submersible pump (not operational): supply to house and animals	Not available	<25	Year 1 - 14
KR8	Jaco Papenfus Windpump: not in use	Not available	<25	Year 1 - 14
KR10	Gysbert Klein Windpump: supply to animals	Not available	<5	Year 10 - 14
KR11	Rudi Prinsloo Windpump: supply to house and animals	Not available	<5	Year 1 – 5
KR12	Koos Jordaan Submersible pump: supply to house and animals	Not available	<2	Year 14

7.2.4 Cumulative impact on groundwater availability

As mentioned previously, two existing coal mines are located to the north and northwest of the proposed Kranspan project, namely Msobo and Northern Coal. At the time of compilation of this report, not information was available on the extent, depth and scheduling of mining in these areas. It was therefore not possible to include an assessment of the cumulative impact of mining on groundwater availability.

The extent of the cone of depression for the Kranspan project does not exceed the Mineral Rights Area significantly, as discussed above. For this reason, it is not likely that mining at the Kranspan project would significantly impact on groundwater levels to the north and northwest.

7.2.5 Impact of mining on groundwater quality during the operational phase

The impact of mining on groundwater quality during the operational phase was assessed at the hand of sulphate concentrations, based on the results of leach tests, as presented in Table 9. In order to do so, the maximum sulphate concentrations obtained from the leach tests were assigned to the mining areas and waste rock dumps. Based on the available information, sulphate concentrations of up to 250 mg/l are expected in the mining areas. This is equivalent to the SANS241:2015 drinking water standard for sulphate based on aesthetic considerations.

The backfilling of discard to the pits or the construction of a surface discard stockpile was not included in this assessment. Discard management was simulated separately and is discussed later in the report.

The simulated sulphate plumes at the end of the operational phase are presented in Figures 17 and 18. Under the prevailing conditions, sulphate concentrations are expected to increase to above 150 mg/l in all the mining areas, as shown. The extent of the zone of impact on groundwater quality is delineated in the two figures presented. Ambient sulphate concentrations are variable, but on average below 50 mg/l. An increase above 50 mg/l is therefore considered as the result of impact of mining.

Sulphate concentrations at the end of the operational phase in groundwater in the private boreholes within the delineated zone of influence is summarised in Table 21. The most significant impact at the end of life of mine is expected to occur in the vicinity of boreholes KR7 and 8, where sulphate concentrations may increase to above 100 mg/l. It is however noted that at these concentrations, the groundwater will still be usable and should not pose any health or aesthetic risks from a sulphate concentration perspective. Sulphate concentrations in the other boreholes in the zone of influence are not expected to exceed 100 mg/l.

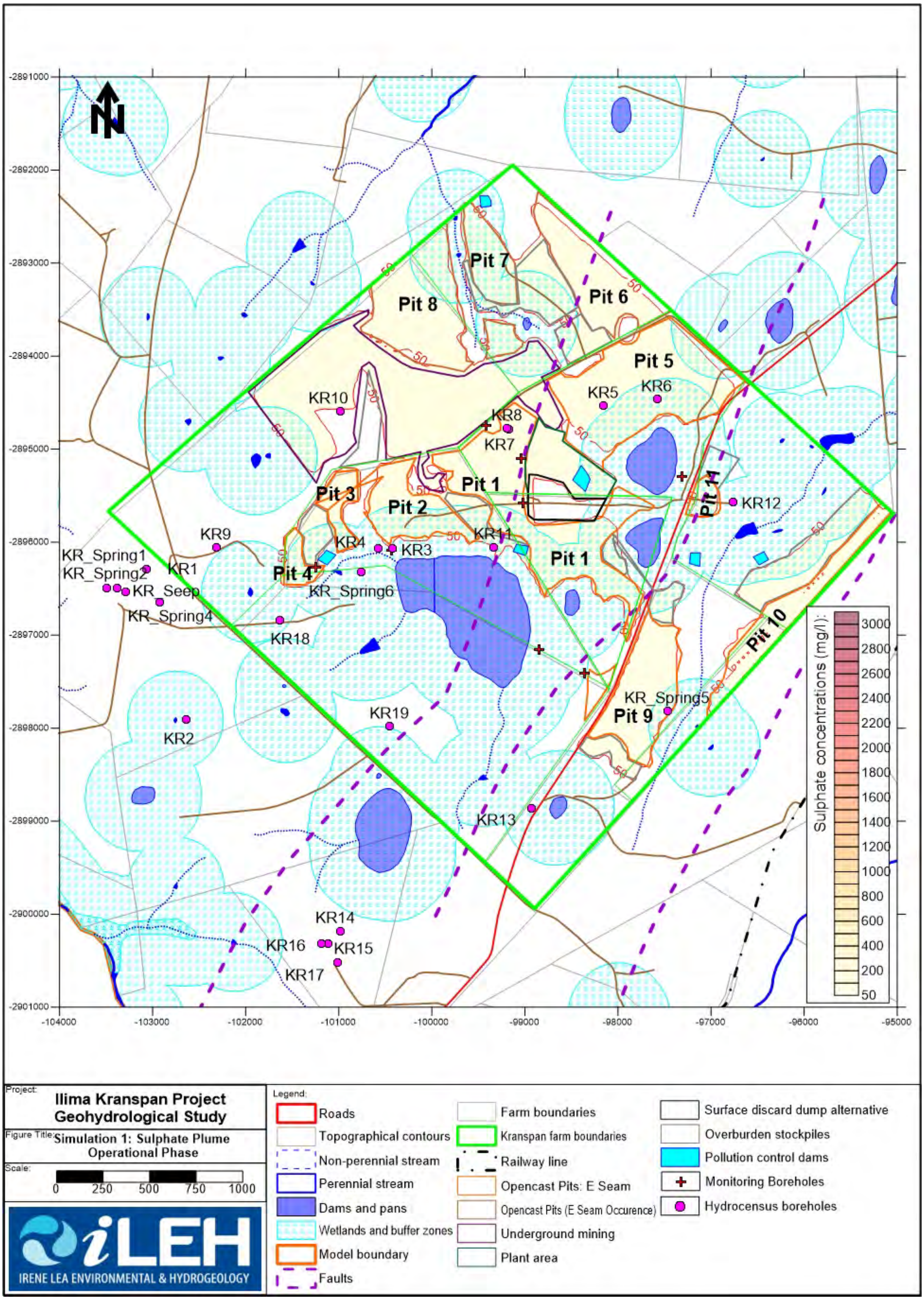

Figure 17 Simulated SO_4 plume at the end of the operational phase: weathered aquifer

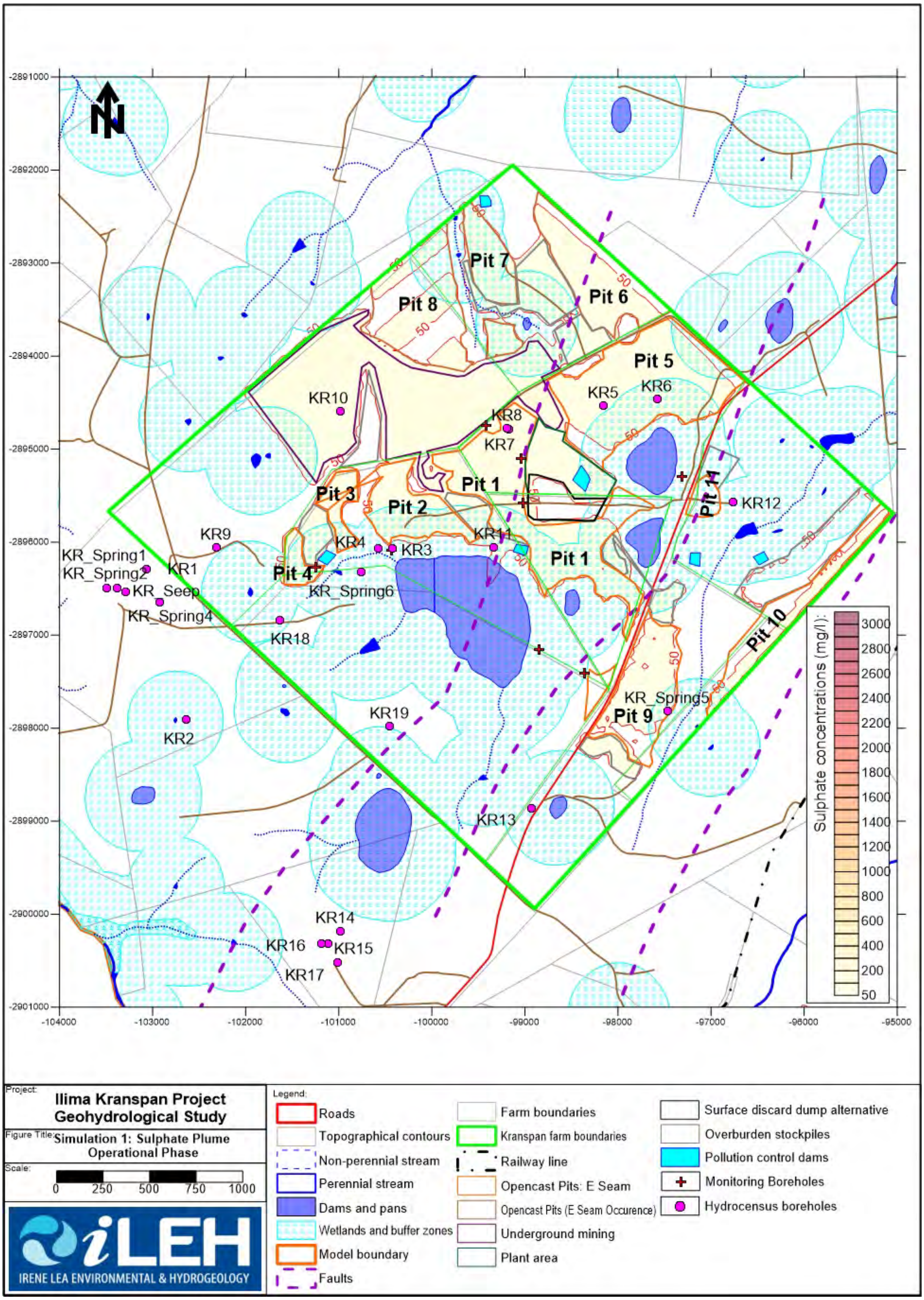

Figure 18 Simulated SO_4 plume at the end of the operational phase: fractured aquifer

Table 21 Impact on groundwater quality in private boreholes at the end of mining operations

BH ID	Owner Current groundwater use	Predicted SO_4 concentration (mg/l)
KR5	Jaco Papenfus Open borehole: not in use	<60
KR6	Jaco Papenfus Open borehole: not in use	<60
KR7	Jaco Papenfus Submersible pump (not operational): supply to house and animals	>100
KR8	Jaco Papenfus Windpump: not in use	>100
KR10	Gysbert Klein Windpump: supply to animals	<100
KR11	Rudi Prinsloo Windpump: supply to house and animals	<60
KR_Spring 5	Koos Jordaan Supply to farm animals	<80

7.3 Long-term impacts on groundwater

7.3.1 Rate of groundwater level recovery once mining is completed

Once mining and dewatering of the underground workings and pits ceases, groundwater levels will start to recover. The rate at which the groundwater levels will recover depends on the permeability of the aquifers, the depth and the extent of mining as well as the rate of recharge of rainwater.

Another factor that may play a role in the rate of groundwater level recovery is whether subsidence of ground above the underground workings will take place in future. This will increase the rate of recharge to the underground workings, thus affecting the rate of flooding. It is however assumed that no subsidence will take place and for this reason, average recharge rates were used over the underground workings during this assessment.

It is estimated that regionally groundwater levels will take approximately 30 – 50 years to recover, as demonstrated in Figure 19. During this time, groundwater flow will be reversed towards the mining areas, thus restricting the movement of contaminated groundwater from away from the mining areas.

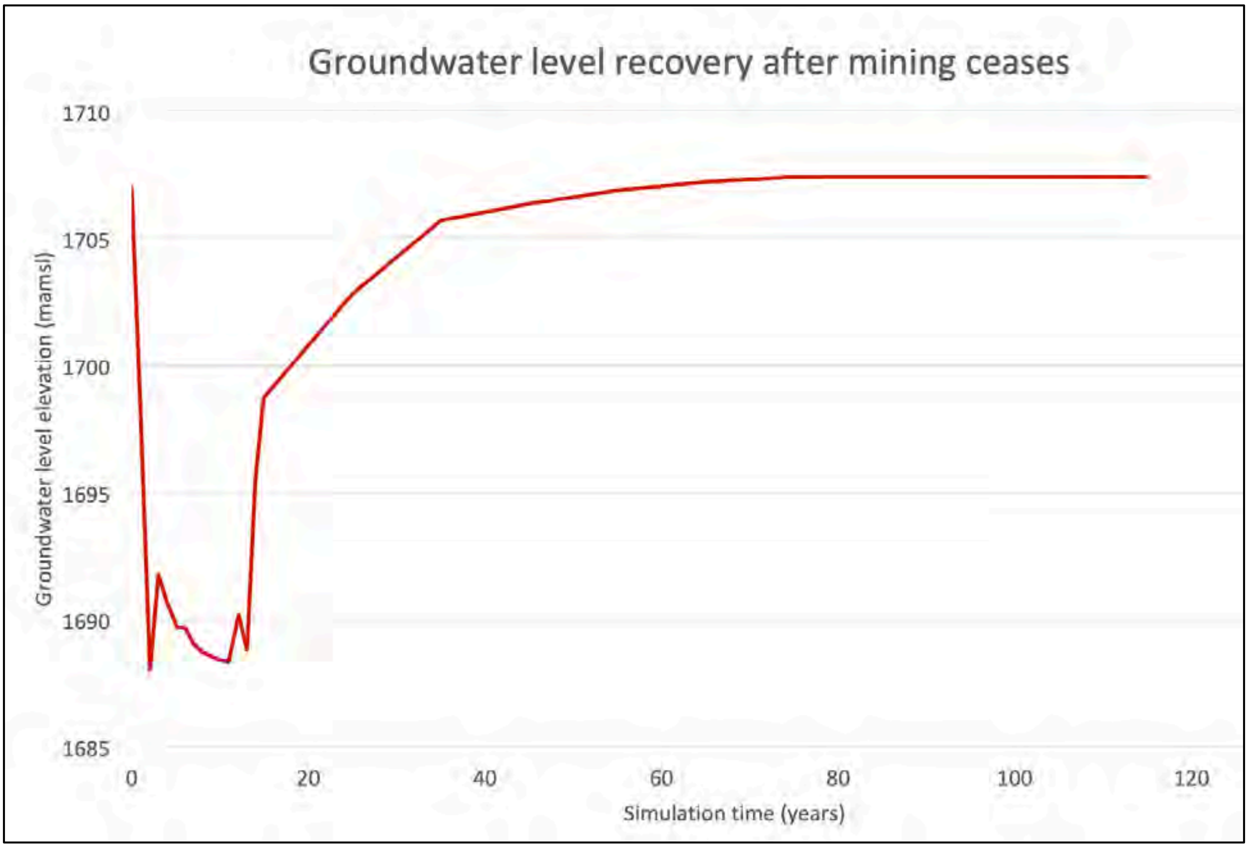

Figure 19 Anticipated regional rate of groundwater level recovery

7.3.2 The risk of decant

Decant from mining areas refers to the daylighting of mine void or underground water on surface, most often in the long-term. At mine closure, active mine dewatering ceases and groundwater levels start to recover, as discussed above. The likelihood of whether decant will take place, depends on the volume of water that enters the mining areas post closure. Inflow to the mining areas post closure will take place from two main sources, namely the recharge of rainwater and natural groundwater through flow. If this combined volume is higher than natural rates, it is likely that a mining area would decant. If the inflow volume is less than or equal to natural rates, it is unlikely that decant would take place.

The rate of groundwater inflow to the mining areas will be determined by the flow gradients, the permeability of the rock formations intersected and the area over which groundwater seepage will take place. Initially the inflow to the underground workings will be fast, post closure, due to steep flow gradients towards the mining area. As the mines start to flood, the gradients will become shallower as groundwater levels rise, which will reduce the volume of groundwater inflow to near natural conditions.

Comparatively, the volume that groundwater inflow contributes post closure is lower than the volume of water added through recharged of rainwater. The rate of recharge to the mining areas is therefore the main driving force behind decant.

With the available dataset and mine plan, it is concluded that the risk of decant from the underground workings is very low. If no subsidence takes place, the rate of recharge to the underground workings will remain close to natural rates. Under these conditions, underground water levels are not expected to rise above natural trends, thus eliminating the risk of decant.

Decant is however possible from the pits as the rate of recharge to the backfilled pits are expected to be higher compared to natural conditions. If this is the case at closure, a total of 20 potential decant points were identified as part of this assessment. These are indicated on Figure 20 and detailed in Table 22. The timing of decant varies according to the rate at which groundwater and rainfall recharge may flood the pits and may occur between 6 and 39 years after mining ceases, depending on the prevailing conditions.

The volume of decant will be mainly driven by the rate of recharge to the backfilled pits. These volumes may vary between 1 160 and 21 900 m^3/a, depending on the size of the pit and the success of the rehabilitation process.

The quality of the decant cannot be assessed with certainty with the static geochemical tests completed to date on the project. It is understood that kinetic testing is currently underway. The results of these tests will provide more insight into the long-term water qualities expected at the operations. The static test results indicate that there is an acid generating potential for some of the material that will be handled on site, specifically the coal and discard material. For this reason, the quality of decant is not expected to be suitable for discharge. The decant is expected to be acidic (pH<5), with elevated salt and trace metal concentrations.

Table 22 Possible decant locations

Decant No	Pit	X Coordinate	Y Coordinate	Decant elevation (mamsl)	Time to possible decant (yrs)	Possible decant volume (m^3/a)
1	Pit 1	-98799	-2896533	1659	26	21873
2		-99224	-2895885	1672		
3		-97912	-2896949	1656		
4	Pit 2	-99579	-2895965	1665	16	7849
5		-100466	-2895956	1665		
6	Pit 3	-100963	-2896080	1666	14	2848
7	Pit 4	-101166	-2896267	1671	17	2257
8	Pit 5	-97885	-2894874	1661	19	23431
9		-97273	-2894688	1664		
10		-97850	-2893845	1667		
11	Pit 6	-97770	-2893668	1666	19	11732
12		-98861	-2892258	1668		
13	Pit 7	-99623	-2892453	1653	32	5118
14	Pit 8	-99881	-2892622	1652	39	15014
15	Pit 9	-97672	-2896808	1654	13	11908
16		-97362	-2896949	1653		
17	Pit 10	-96812	-2897180	1656	10	8078
18	Pit 11	-97282	-2895708	1655	6	1724
19	Pit 12	-99410	-2893606	1671	32	1635
20	Pit 13	-98045	-2897375	1663	13	1159

The most likely decant point at each pit is associated with the lowest topographical elevation. Five of the pits may have more than one decant point, due to small variations in the surface elevations of the pits and the error margin of the DTM used to assess the decant points. In all likelihood, decant will commence at the lowest topographical elevation at each of theses pits. Depending on the head that may build up inside the pits, decant may also occur from the other decant points identified.

Decant points 2 and 3 are linked to the fault zones that intersect the mining areas. If groundwater is under pressure in the faults (as the current fieldwork dataset suggests), decant may take place along the fault zone, even though the surface elevation of these positions are higher compared to the other decant points identified.

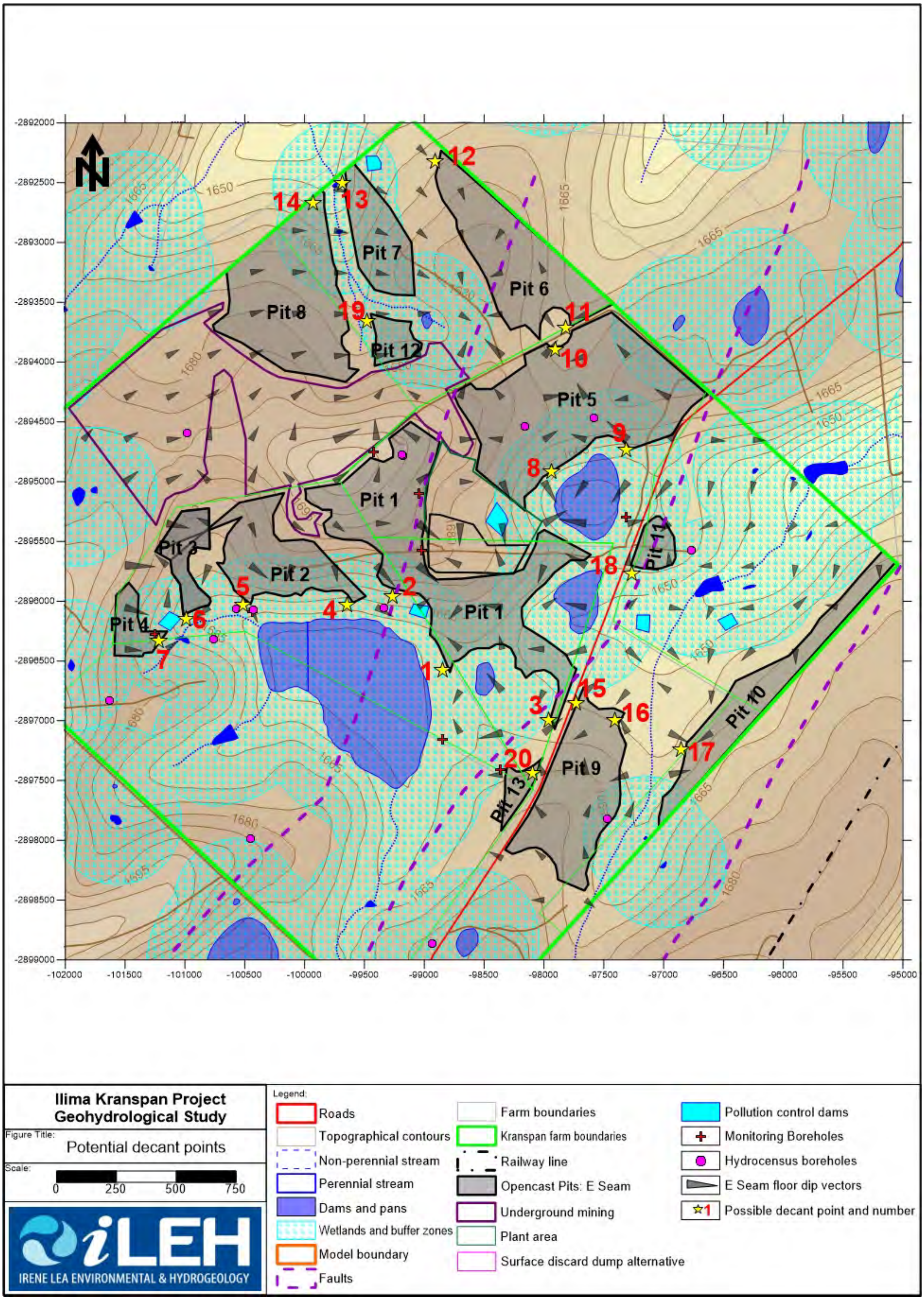

Figure 20 Possible decant locations

The most significant impact of decant will be on wetland functioning. As the decant points are all associated with low-lying areas, they are typically associated with wetlands. This is demonstrated in Figure 20, which shows that most of the decant points are within the delineated wetlands or their buffer zones.

The impact of decant quality on the wetlands is considered most significant. If the decant is not contained, the acidic pH conditions and high salt and trace metal concentrations are expected to kill the wetland fauna and flora. These impacts would most probably be irreversible in the long-term.

In addition to impacting negatively on wetlands, the unmanaged decant will also flow across land to the pans and non-perennial streams that drain the project area. As with the wetlands, the decant will negatively affect water quality in these surface water bodies and will most probably result in irreversible acidification and unacceptable salt loads.

Due to the fact that decant quality cannot be assessed with certainty with the existing dataset, a quantitative impact assessment cannot be undertaken.

It is possible that decant from Pits 6, 7 and 8 could impact on mining activities to the north of the Kranspan project, if it is not contained and managed.

7.3.3 Long-term impact on groundwater quality

The model was used to simulate the long-term impact of mining on groundwater quality. This was achieved at the hand of four scenarios, namely:

- Scenario 1: the long-term impact if all rehabilitation measures are implemented and deterioration in groundwater quality does not take place during the operational phase of mining. Post closure, sulphate concentrations were assumed to increase as a result of acidification, which is likely based on the results of static geochemical tests. The increase in sulphate concentration post closure is based on the author's experience in similar environments in the absence of the results of kinetic geochemical testing. The values used during simulations are presented in Table 10.
- Scenario 2: tests the impact of placing discard material into the mine-out pits. Although it is acknowledged that this will not take place in all of the pits as the volume of discard generated will be less than the void space available in all the pits, the model was used to see the impact of backfilling all the pits with discard. This will allow identification of pits that may be more suitable for backfill with discard. In order to complete this scenario, it was assumed that the discard material would acidify during the operational phase as well as post-closure resulting in an increase in sulphate concentrations. In the absence of more specific data, it was assumed that sulphate concentrations of up to 3000 mg/l would leach from the discard material. This assumption must be tested and re-evaluated once the results of the kinetic testing are available.
- Scenario 3: evaluates the impact of placing discard in a stockpile on surface within the plant area. The scenario assumes that the discard stockpile will not be lined and the rate of seepage would be governed by the permeability of the weathered aquifer.
- Scenario 4: test the effect of lining the discard stockpile with a Class C liner according to the discussion presented in Section 7.1.3.

The model was run for a period of 100 years after mining stops and the results presented and discussed below are provided for the impact on the shallow weathered as well as the deeper fractured rock aquifers.

7.3.3.1 Results of Scenario 1: Long-term impact if all rehabilitation measures are implemented

This scenario tests the long-term impact of mining on sulphate concentrations if all rehabilitation measures proposed are implemented. This scenario excludes placing discard into the pits or on a surface discard stockpile.

The simulated sulphate plumes 100 years after mining stops are presented in Figures 21 and 22 for the weathered and fractured rock aquifers under the assumptions made for Scenario 1. The sulphate concentrations were fluctuated according to the information presented in Table 10 during the simulation, as discussed above.

The simulations indicate that potential contamination is not expected to move significant distances from the Kranspan mining areas during this period. On average, the plumes do not move more than 300m from the mining areas during this period. This is due to two main factors, namely the low permeability of the aquifer matrices through which the contamination must flow and the effect of groundwater level recovery post mine closure. As discussed earlier, the groundwater levels may take between 30 – 50 years to recover after mine dewatering stops at the end of the life of mine.

The contamination moves mainly in a southwesterly direction towards the largest of the pans, but also moves towards the three smaller pans to the northeast. The model indicates that preferential flow of contamination will take place along the northern most lineament towards the largest of the pans. The plume can move up to 1km along the lineament towards the pan during the 100 year simulation period. Very limited movement of the plume takes place in a northerly and northeasterly direction along the lineaments. The main direction of flow is in a southerly to southeasterly direction, as indicated.

Sulphate concentrations within the mining area are expected to increase in the long-term. Within the backfilled pits, concentrations exceeding 1000 mg/l may be expected under the assumed conditions. Along the northern most lineament fault zone, sulphate concentrations may increase to above 400 mg/l where it intersects the largest pan. Sulphate concentrations along the edges of the pan not associated with the fault are not expected to exceed 150 mg/l for the scenario. The southeastern lineament transects Pit 11. Down gradient of this fault, sulphate concentrations may exceed 600 mg/l in the long-term, moving preferentially in a southerly direction.

The impact of the underground workings on groundwater quality will be confined to the fractured rock aquifer with little to no impact on the weathered aquifer in this area. In the immediate vicinity of the underground workings, sulphate concentrations in the fractured rock aquifer may increase to around 800 mg/l.

The impact of the conditions simulated during Scenario 1 for the wetlands, springs, streams and private boreholes are presented in Table 23. It is acknowledged that some of the wetlands, boreholes and springs will be destroyed during mining. The sulphate concentrations are however provided as reference and for comparison with other scenarios.

The impact of elevated sulphate concentrations on wetland functioning falls outside the scope of this study. It is however noted that under acid pH conditions with elevated salts and trace metal concentrations, the impact on wetlands is considered significant.

Groundwater with sulphate concentrations exceeding 250 mg/l is expected to have negative aesthetic impacts (taste, colouration and odour). Groundwater with sulphate concentrations exceeding 600 mg/l are expected to have adverse health impacts and will become unfit for use. These include boreholes KR5, KR6, KR7, KR8 and possibly KR11. Groundwater from KR_Spring5 will also not be fit for use.

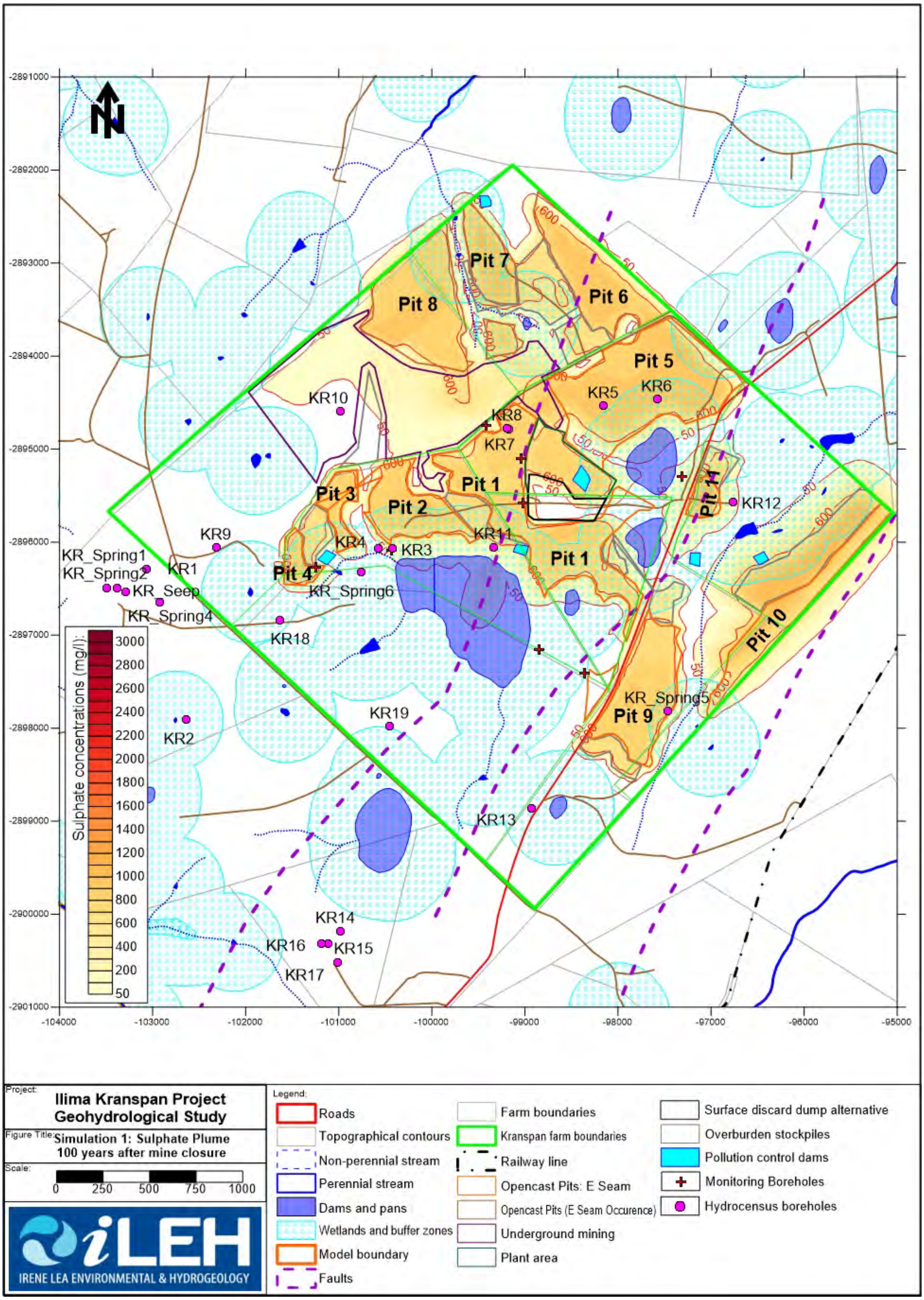

Figure 21: Scenario 1: Impact on the weathered aquifer 100 years after mining ceases

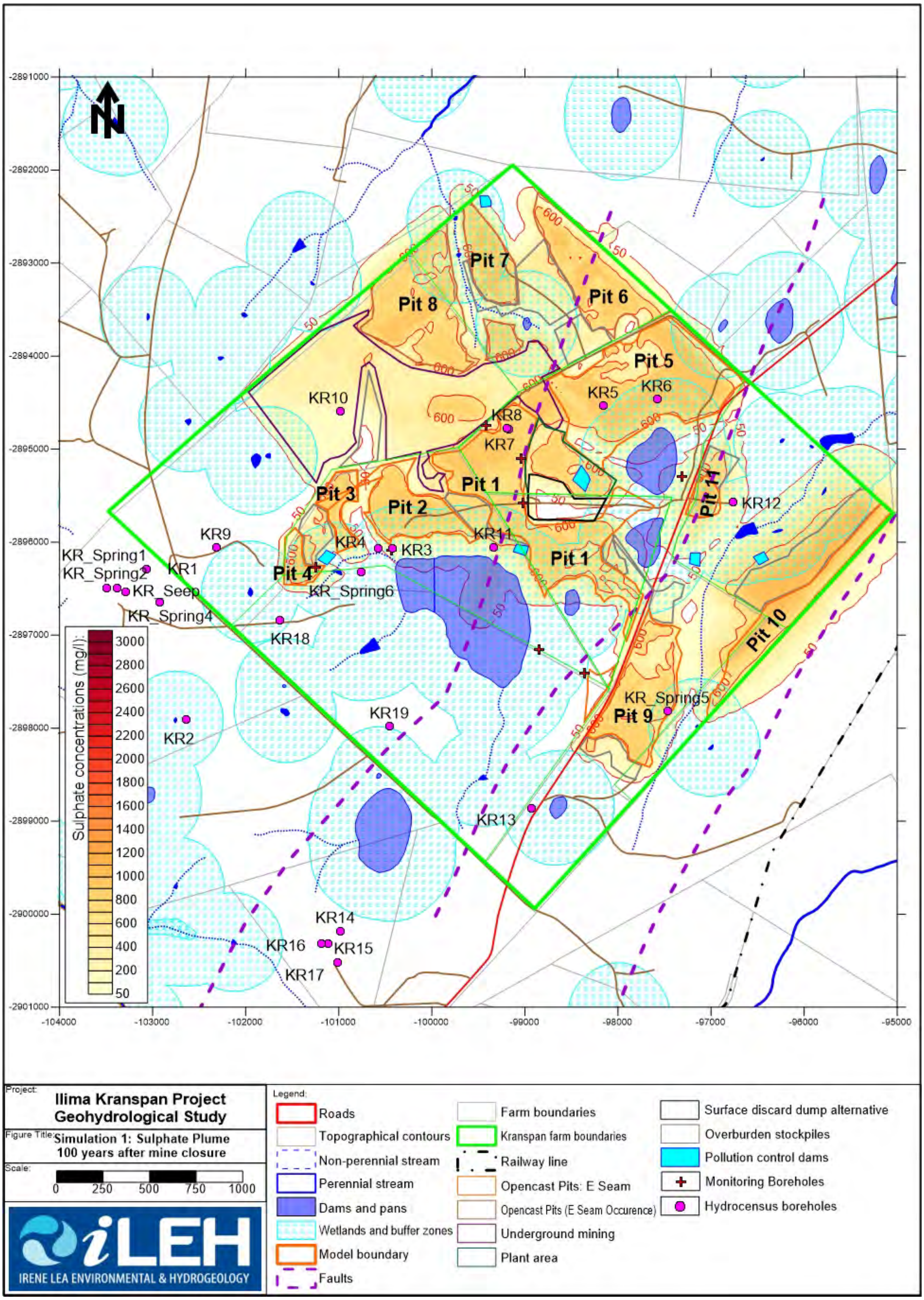

Figure 22 Scenario 1: Impact on the fractured rock aquifer 100 years after mining ceases

Table 23 Anticipated long-term sulphate concentrations at various receptors for Scenario 1

Pans and streams		Wetlands		Private boreholes and springs	
Description	SO_4 (mg/l)	Description	SO_4 (mg/l)	Description	SO_4 (mg/l)
Largest pan	150 - 400	Largest pan	400 - 900	KR_Spring5	700
Smallest pan	200	Pits 7 & 8	200 - 600	KR3	400
Smallest NE pan	100	Pit 5	400 - 900	KR4	50
Largest NE pan	100 - 350	Pit 11	200 - 1000	KR5	1000
Non-perennial stream Pit 10	50	Pit 10	100 - 1000	KR6	900
Non-perennial stream Pit 7 & 8	200 - 400	Pit 9	400 - 900	KR7	800
Non-perennial stream Largest Pan	50			KR8	800
				KR10	300
				KR11	500

7.3.3.2 Results of Scenario 2: Long-term impact if discard is backfilled into the pits

Scenario 2 tests the impact if discard material is backfilled into the pits during the operational phase of mining. It is unclear which pits would be earmarked for this activity. In order to complete a comprehensive impact assessment, it was assumed that all pits would be used for discard disposal. The surface discard stockpile is excluded from this scenario. Sulphate concentrations described in Table 10 were applied during the simulations. During the operational phase, it was assumed that sulphate concentrations of 3000mg/l could leach from the discard due to acidification of the material with time. This is based on the description of the source term presented in Section 3 of this report. This assumption must be tested and re-evaluated once the results of the kinetic geochemistry tests are available. The results of the simulations for the weathered and fractured rock aquifers are presented in Figures 23 and 24.

The simulated plumes indicate that if discard is backfilled into the pits, sulphate concentrations are expected to increase in both aquifers. Preferential flow along the northern most lineament will result in the plume moving up to 1,1km from the mining areas for this scenario. The plume may also move up to 500m from the pits during the 100 year simulation period.

Sulphate concentrations within the backfilled pits may increase to above 1300 mg/l in the long-term for this scenario. This is expected to have a significant negative impact on the quality of decant from the pits in the long-term. Along the northern most lineament, sulphate concentrations may increase to above 600 mg/l at the largest pan. Away from the fault, the plume at the largest pan may increase to above 300 mg/l in the long-term. A summary of the long-term impact of this scenario on the receptors identified for the project is presented in Table 24. It is shown that groundwater with sulphate concentrations exceeding 600 mg/l is expected in boreholes KR5, KR6, KR7 and KR11 for this scenario. These boreholes will no longer be fit for use.

Table 24 Anticipated long-term sulphate concentrations at various receptors for Scenario 2

Pans and streams		Wetlands		Private boreholes and springs	
Description	SO_4 (mg/l)	Description	SO_4 (mg/l)	Description	SO_4 (mg/l)
Largest pan	300 - 600	Largest pan	400 - 1200	KR_Spring5	800
Smallest pan	350	Pits 7 & 8	350 - 1000	KR3	450
Smallest NE pan	300	Pit 5	400 - 1200	KR4	50
Largest NE pan	200 - 400	Pit 11	200 - 1000	KR5	1200
Non-perennial stream Pit 10	70	Pit 10	150 - 1100	KR6	1000
Non-perennial stream Pit 7 & 8	300 - 600	Pit 9	450 - 1000	KR7	1200
Non-perennial stream Largest Pan	70			KR8	1200
				KR10	300
				KR11	900

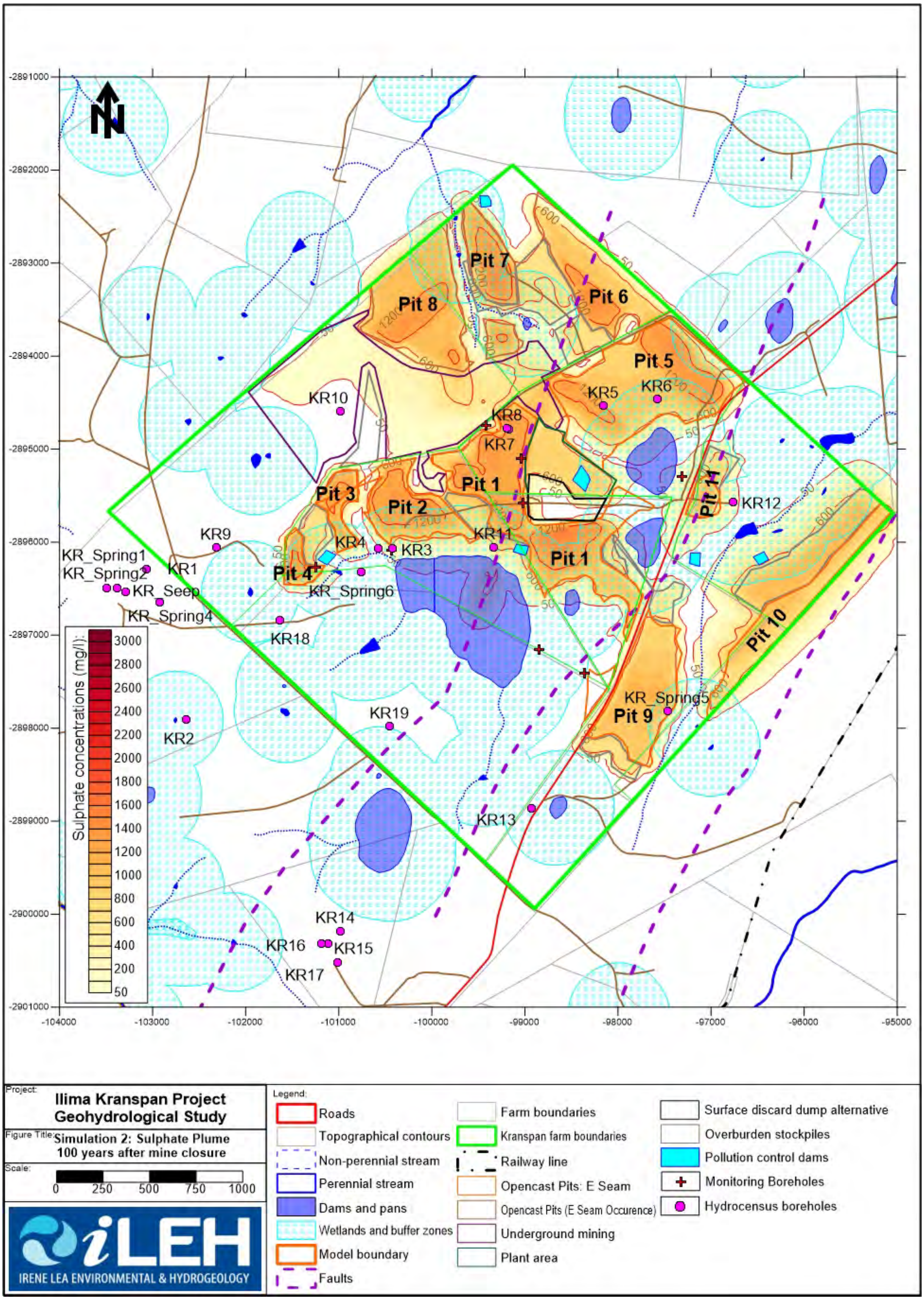

Figure 23 Scenario 2: Impact on the weathered aquifer 100 years after mining ceases

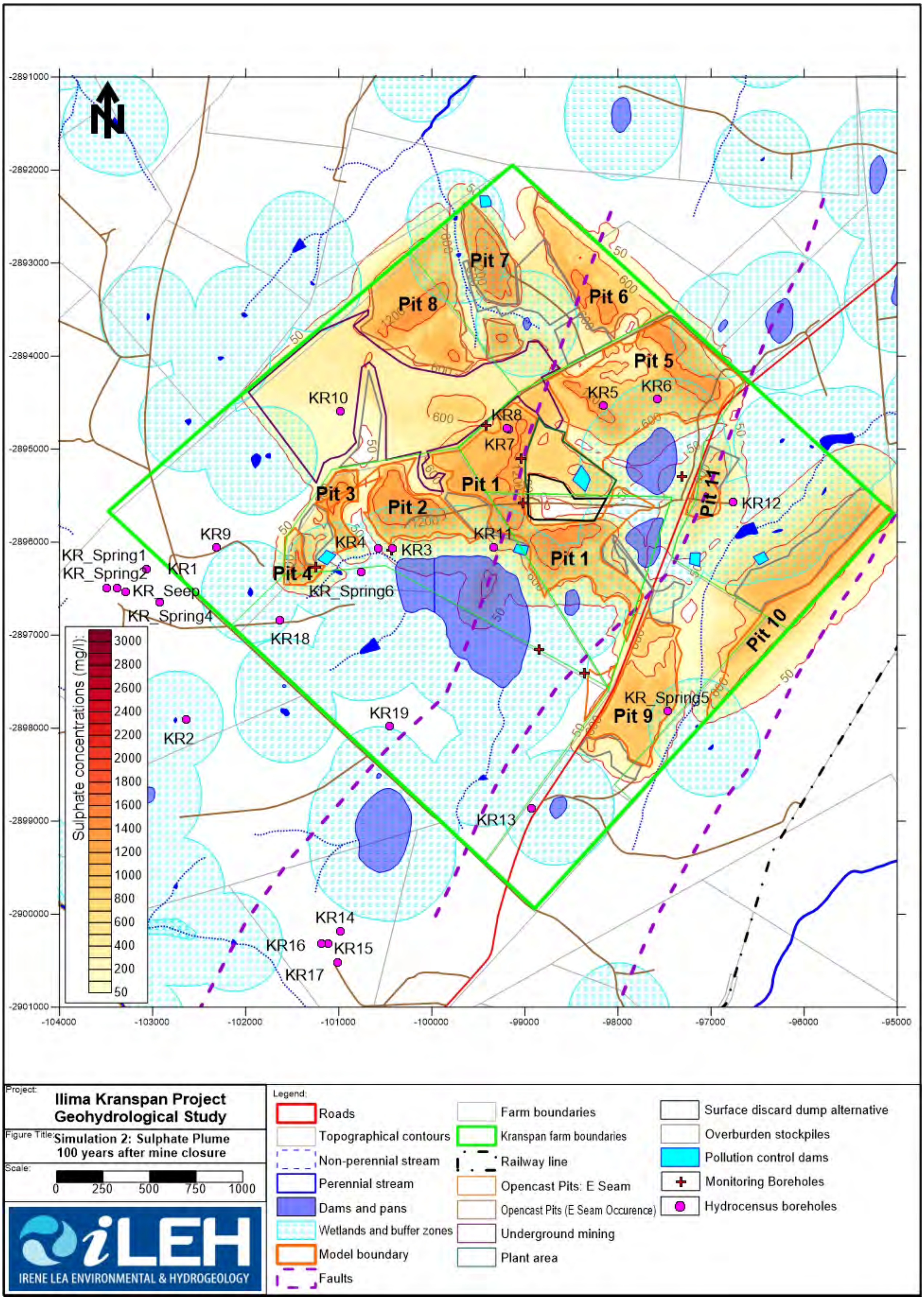

Figure 24 Scenario 2: Impact on the fractured aquifer 100 years after mining ceases

If the preferred discard management measure is to backfill the material to the pits, the following must be taken into consideration:

- The quality of decant from the pits post closure will be negatively affected by this activity. It is not possible to say with certainty what the decant quality will look like with the available dataset, but modelling results suggests that sulphate concentrations may increase by 30% in the long-term inside the pits. The preliminary results of the kinetic testing indicates that the discard material will most likely acidify in the long-term, which will compound the impact on groundwater quality, the wetlands and private boreholes.
- The pits around the largest pan should not be used for discard backfilling due to the anticipated negative long-term impact on the pan and the wetlands in this area. One of the known preferential flow paths to groundwater transects the pan and the mining area and for this reason it is not recommended that additional contamination potential is introduced in this area. The pits that should not be used for discard backfill due to proximity to the largest pan, wetlands and the presence of a preferential groundwater flow path include:
  - Pit 1, Pit 2, Pit 3, Pit 4 and Pit 9
- In addition, Pits 6 and 11 should also not be used for discard backfill due to the fact that the lineaments (preferential groundwater flow paths) transect the pits.
- It is furthermore not recommended that discard is placed in Pits 7, 8 and 10 due to the fact that they are situated immediately adjacent to non-perennial streams that drain the mining area. Should decant take place from these pits in the long-term, the streams will be directly impacted.
- Based on the current understanding of the project site, the only pit that can be considered for discard backfill is Pit 5. The pit is however not ideal, as it is situated adjacent to the second largest pan and two of the decant points identified will drain towards the pan. If discard is however placed in the bottom of the northern most section of this pit, leachate may be contained more successfully than in the other pits. The coal floor contours suggest that the seam dips in a northerly direction and that this would be the deepest point of the pit. It is however noted that interflow between Pits 5 and 6 are possible in this area. It is important to maintain the boundary strip along the farm portion boundary in this area to avoid that from happening.
- It is strongly recommended that this assessment is tested and possibly re-evaluated once the results of the kinetic geochemistry testing are available.

7.3.3.3 Results of Scenarios 3 and 4: Long-term impact if discard is stockpiled on surface

These two scenarios test the impact if a surface discard stockpile is constructed as an alternative to placing discard into the pits. As discussed earlier, two alternatives were evaluated, namely unlined (Scenario 3) and a lined (Scenario 4) discard stockpile. The remainder of the mining area was simulated under the same assumptions as those discussed for Scenario 1.

The results for both simulations are presented in Figures 25 and 26 for the weathered and fractured rock aquifers.

As expected, an unlined facility will result in a significant increase in sulphate concentrations in the immediate vicinity of the discard stockpile in the long-term. Sulphate concentrations may increase to above 2500 mg/l in the weathered aquifer in the immediate vicinity of the discard facility in this case. It is further possible that the plume may reach the lineament to the west of the discard stockpile and that contamination from the discard stockpile may flow preferentially along the fault towards the largest pan in the southwest. Sulphate concentrations in the fault may increase to above 800 mg/l in the long-term as a result. Where the fault intersects the pan, sulphate concentrations of above 400 mg/l may be expected.

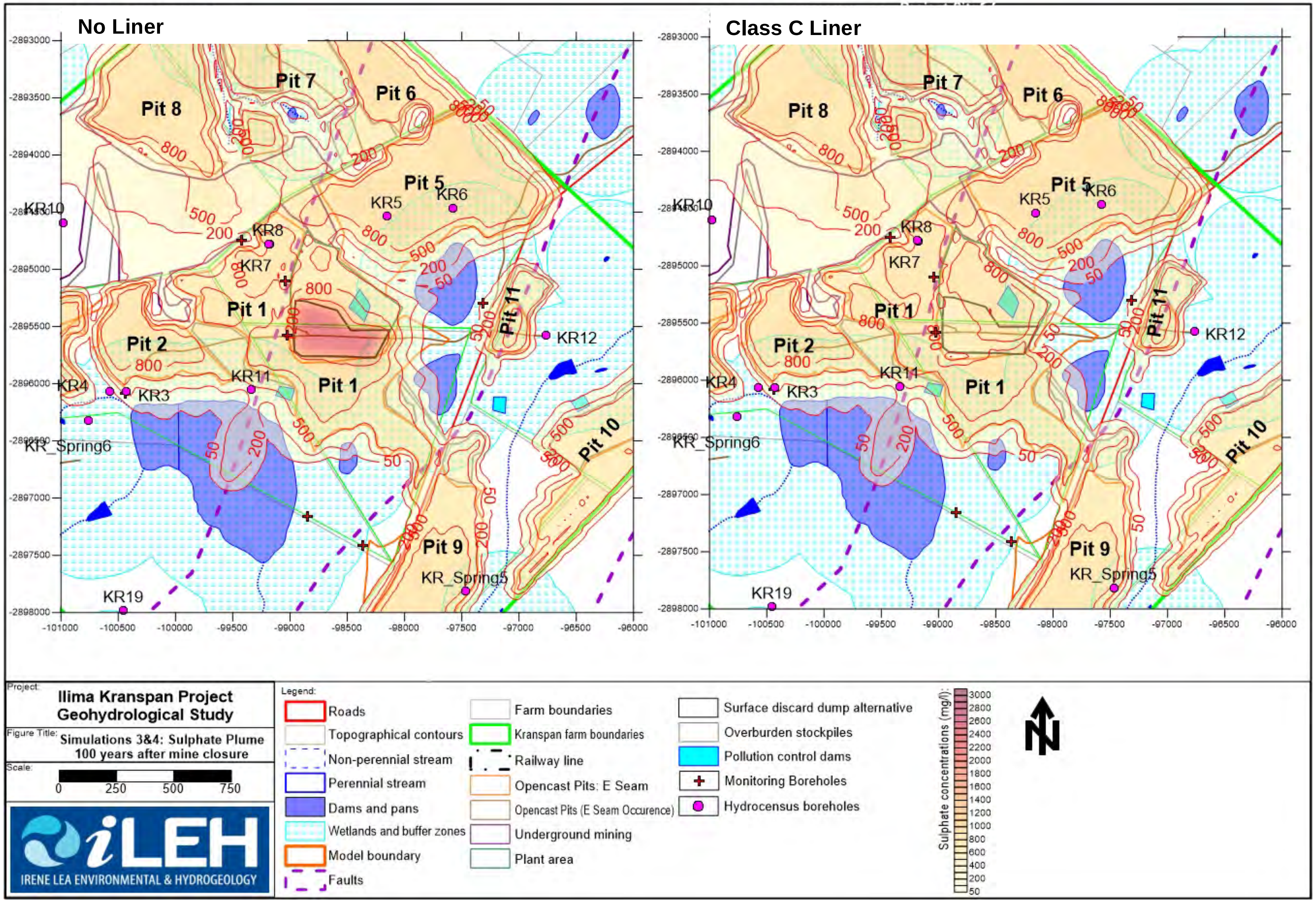

Figure 25 Scenarios 3 and 4: Impact on the weathered aquifer 100 years after mining ceases

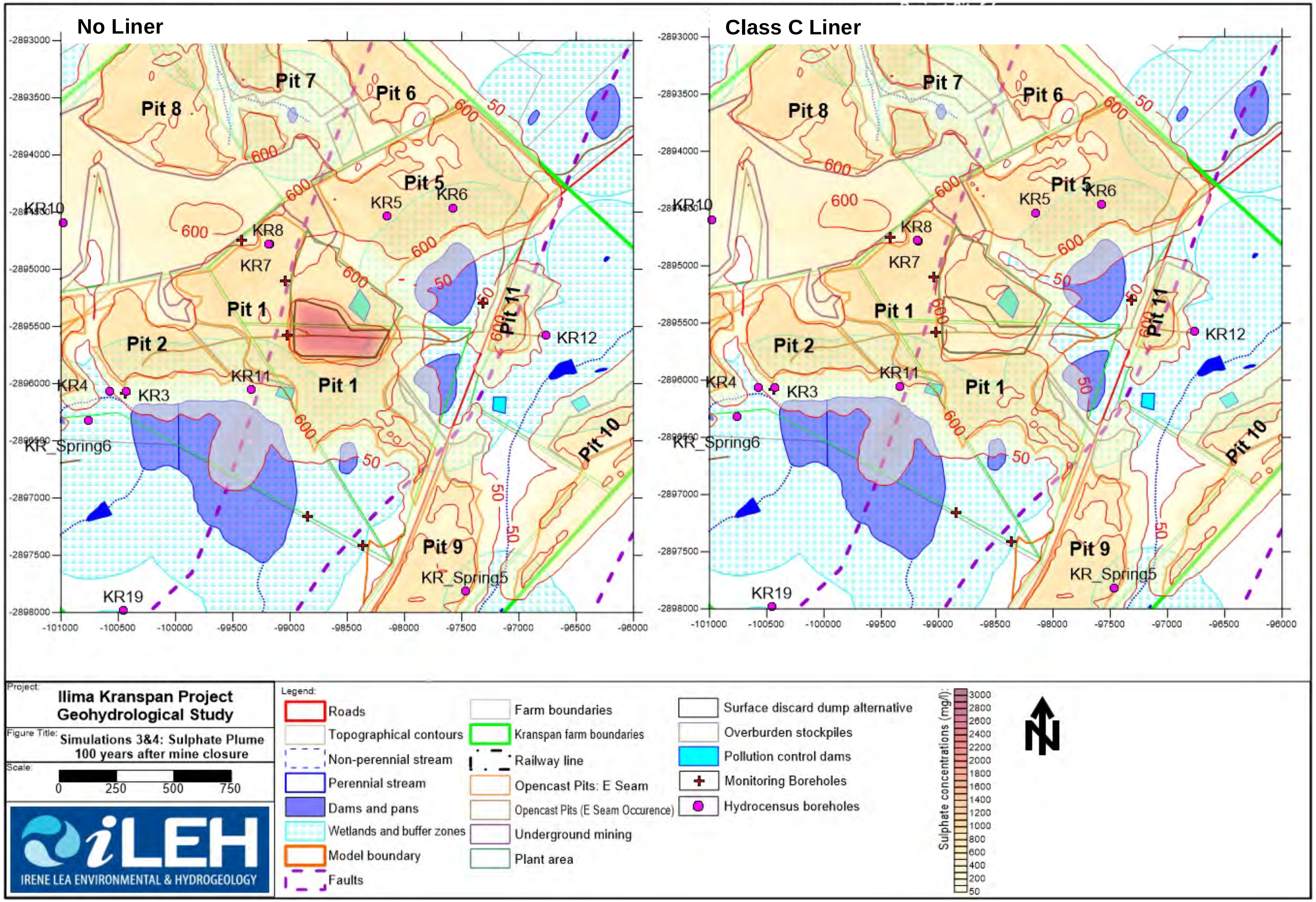

Figure 26 Scenarios 3 and 4: Impact on the fractured aquifer 100 years after mining ceases

The distance that the plumes may migrate from the mining areas are not expected to vary significantly in the unfractured aquifers for the two scenarios. The rate at which the plumes will move are affected by the recovery of groundwater levels post closure and the permeability of the rock formations, both of which will not be impacted on by the placement of the discard dump on surface.

It is expected that leachate from the unlined discard stockpile will be captured in the backfilled Pit 1 and will to a certain extent be contained in the pit until such time that it is flooded. The placement of an unlined discard stockpile up gradient of Pit 1 is therefore expected to have a negative impact on decant quality in the long-term. This impact cannot be quantified with certainty with the existing dataset. Due to the proximity of Pit 1 to the largest pan and the wetlands associated with it, this will result in significant negative impacts in the long-term.

If the discard dump is lined with a Class C liner, the most significant positive impact on sulphate concentrations is expected in the immediate vicinity of the discard dump. For this scenario, sulphate concentrations are expected to remain below 900 mg/l at the stockpile. Groundwater quality will however still be affected by the mining activities in this area and lining of the facility will not mitigate the regional impact of mining on groundwater quality. For this scenario, the discard facility is not expected to have a noticeable impact on pitwater and decant quality associated with Pit 1.

A comparison of anticipated long-term sulphate concentrations for the two scenarios are presented in Tables 25 and 26. It is shown that the most significant impact of an unlined discard facility is that of increased sulphate concentrations in groundwater reaching the wetlands associated with the largest pan.

Table 25 Anticipated long-term sulphate concentrations at various receptors for Scenario 3

Pans and streams		Wetlands		Private boreholes and springs	
Description	**SO_4 (mg/l)**	**Description**	**SO_4 (mg/l)**	**Description**	**SO_4 (mg/l)**
Largest pan	200 - 450	Largest pan	400 - 1100	KR_Spring5	700
Smallest pan	200	Pits 7 & 8	200 - 600	KR3	400
Smallest NE pan	100	Pit 5	400 - 900	KR4	50
Largest NE pan	100 - 350	Pit 11	200 - 1000	KR5	1000
Non-perennial stream Pit 10	50	Pit 10	100 - 1000	KR6	900
Non-perennial stream Pit 7 & 8	200 - 400	Pit 9	400 - 900	KR7	800
Non-perennial stream Largest Pan	50			KR8	800
				KR10	300
				KR11	500

Table 26 Anticipated long-term sulphate concentrations at various receptors for Scenario 4

Pans and streams		Wetlands		Private boreholes and springs	
Description	**SO_4 (mg/l)**	**Description**	**SO_4 (mg/l)**	**Description**	**SO_4 (mg/l)**
Largest pan	150 - 400	Largest pan	400 - 900	KR_Spring5	700
Smallest pan	200	Pits 7 & 8	200 - 600	KR3	400
Smallest NE pan	100	Pit 5	400 - 900	KR4	50
Largest NE pan	100 - 350	Pit 11	200 - 1000	KR5	1000
Non-perennial stream Pit 10	50	Pit 10	100 - 1000	KR6	900
Non-perennial stream Pit 7 & 8	200 - 400	Pit 9	400 - 900	KR7	800
Non-perennial stream Largest Pan	50			KR8	800
				KR10	300
				KR11	500

With regards to the placement of discard on surface, the following is noted:

- The most significant impact of an unlined discard stockpile will be on the weathered aquifer , the pan and the wetlands present down gradient of the facility.
- It is furthermore anticipated that an unlined discard stockpile will have a negative impact on pit water quality and thus long-term decant quality at Pit 1.
- With time after the simulation period of 100 years, the contamination that will leach from an unlined discard dump will however migrate towards the pan. This will result in an increased salt load to the pan.
- A lined facility is not expected to add significantly to sulphate contamination. Groundwater quality in the long-term will however still be impacted on by the surrounding mining activities.
- The discard facility design should take cognisance of the position of the fault zone and if necessary, must be moved to ensure that it does not overly the fault, if this is identified as the preferred alternative for discard management.

7.3.4 Anticipated salt load to the wetlands, pans and streams

The information presented above was used to assess the long-term sulphate salt load on the wetlands, pans and streams present in and down gradient of the mining areas. In order to do so, the sulphate concentrations reported above was multiplied with the average volume of groundwater that would seep into the affected areas over a year. The results are presented in Table 27.

The table presents the average sulphate concentrations within the affected area. It is noted that the concentrations will vary across each area, but for the purpose of the calculation average values were used. The estimated volume of groundwater seepage to each affected area is also presented. These values were used to calculate the average sulphate salt load in tonnes per year.

It is shown that the sulphate load associated with Scenario 2 (backfilling the pits with discard), results in the highest salt load. It is however noted that Scenario 2 represents an over-estimation, as not all the pits would be backfilled with discard, as discussed above. If only Pit 5 is backfilled with discard, only the salt load to the smallest NE Pit may increase from 0,4 to 1,1 tonnes of sulphate per annum.

The calculations further indicate that a Class C liner installed at the surface discard stockpile (Scenario 4), would result in a 9% decrease in the total salt load from the mining area, which is equivalent to 3 tonnes of sulphate per annum.

It is strongly recommended that the information presented in Table 27 is updated and re-assessed, as necessary, once the results of the kinetic geochemistry tests are available.

Table 27 Estimated salt loads

Description	Average SO_4 (mg/l)				Estimated volume (m^3/a)	Salt load (t/a)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4		Scenario 1	Scenario 2	Scenario 3	Scenario 4
Pans and streams									
Largest pan	275	450	325	275	41245	11,3	18,6	13,4	11,3
Smallest pan	200	350	200	200	657	0,1	0,2	0,1	0,1
Smallest NE pan	100	300	100	100	3778	0,4	1,1	0,4	0,4
Largest NE pan	225	300	225	225	3869	0,9	1,2	0,9	0,9
Non-perrenial stream Pit 10	50	70	50	50	5400	0,3	0,4	0,3	0,3
Non-perrenial stream Pit 7 & 8	300	450	300	300	4500	1,4	2,0	1,4	1,4
Non-perennial stream Largest Pan	50	70	50	50	900	0,05	0,06	0,05	0,05
Wetlands									
Largest pan	650	800	750	650	9736	6,3	7,8	7,3	6,3
Pits 7 & 8	400	675	400	400	6912	2,8	4,7	2,8	2,8
Pit 5	650	800	650	650	4702	3,1	3,8	3,1	3,1
Pit 11	600	600	600	600	2822	1,7	1,7	1,7	1,7
Pit 10	550	625	550	550	4748	2,6	3,0	2,6	2,6
Pit 9	650	725	650	650	2030	1,3	1,5	1,3	1,3

8 PROPOSED GROUNDWATER MANAGEMENT MEASURES

8.1 Groundwater objectives and targets

The following objectives and targets are proposed for groundwater management at the operations:

- Implement a management plan aimed at reducing and/or eliminating adverse impacts on the receptors identified. These include existing private groundwater users, wetlands, the pans, rivers and streams.
- Track and record the progress of implementation of all groundwater management measures.
- Implement sufficient monitoring procedures to measure the effectiveness of groundwater management measures in both mine and private boreholes located within the delineated zones of influence.
- Analyse the information obtained from all monitoring programmes against compliance targets to establish trends.
- Should the trends indicate adverse impacts on groundwater levels and/or quality, implement suitable measures within the shortest possible time to remediate and/or eliminate such adverse impacts identified.

8.2 Over-arching groundwater management measures

Ilima should implement a number of broad over-arching groundwater management measures in order to minimise impacts on groundwater during all phases of mining. Most of these form part of good house-keeping measures, as detailed in Table 28.

Table 28 General groundwater management measures

Planning Phase
Ensure that sufficient information is available on all private boreholes inside the zones of influence to quantify existing groundwater use and demand. This information will form the basis for future assessments.
Plan for and provide sufficient budget to implement the groundwater monitoring programme before any mining starts.
Develop sound operating procedures that takes cognisance of impacts associated with groundwater, including spill procedures, dam design, mine residue deposit design, oil and diesel storage area design, on-site environmental incident reporting, etc.
Adjust the mine plan and surface layout to avoid areas with shallow groundwater tables, including wetlands.
Develop sound surface runoff management plans to ensure that all dirty runoff is contained and diverted to the PCDs.
Ensure that PCDs are designed and lined to contain all dirty water generated to prevent overflows and spillages.
Construction Phase
Implement and maintain a groundwater monitoring programme in mine and private boreholes situated in the zones of influence identified for the mining areas.
Implement sound house-keeping measures to prevent and clean spills, address leaks and undertake regular inspections. Ensure that the record-keeping procedure is in place and that instructions given are carried out.
Measure rainfall daily on site.
Operational Phase
Complete regular inspections of PCD, specifically noting incidences of overflow and leakage. If the latter is identified, measures must be taken to rectify non-compliances immediately.
Maintain sound house-keeping measures to prevent spills and leaks.
Maintain the groundwater monitoring programme in mine and private boreholes located
Replace groundwater monitoring boreholes that may be destroyed during mining.
Measure rainfall daily on site
Record all groundwater-related complaints and deal with each complaint within the agreed upon timeframe.
Develop a sound rehabilitation plan to ensure that long-term impacts are minimised
Plan for mine closure by completing a final groundwater impact assessment at least five years before closure.
Decommissioning and Closure Phase
Complete all rehabilitation to a satisfactory level, focussing specifically on the final rehabilitation of the pits, sealing the adits and rehabilitation of the surface discard dump, if implemented and constructed. Effective rehabilitation of these areas must aim to reduce the rate of recharge of rainwater as far as possible. No ponding must be allowed over rehabilitated areas.
Plan for and budget to continue with the groundwater monitoring period for a minimum of two years after mine closure. The continued need for groundwater monitoring will depend on the outcome of the final mine closure groundwater impact assessment.

8.3 Measures to address impacts on groundwater availability

The following specific measures are recommended to minimise and/or eliminate the impacts on groundwater levels and the availability of groundwater to private users:

- The volume and quality of groundwater that is currently abstracted from private boreholes within the delineated zone of influence must be established before mining commences. These boreholes are listed in Table 20. This is a critical step in understanding what impact mining will have on these boreholes and must be use as a basis for managing the loss of any groundwater to private users during mining. In order to achieve this, pumping tests should be completed on the identified boreholes to establish borehole yield. A groundwater sample must be taken from each borehole and submitted for chemical analysis according to the details provided in Table 6.
- An attempt must be made to measure the flow of KR_Spring5 in order to establish baseline conditions. A sample must also be taken from the spring for chemical analysis. These tests must be completed prior to the commencement of mining and must be used as a basis for entering into negotiations with the owner regarding the potential loss of this spring during mining.
- Negotiations must be entered into with the owners of private boreholes that will be destroyed during opencast mining. These boreholes are listed in Table 19.
- A dedicated groundwater monitoring programme must be implemented in all private boreholes within the delineated zone of influence. These boreholes are listed in Table 20. This monitoring programme must include groundwater level and quality measurements. Should monitoring information indicate adverse impacts, Ilima must enter into negotiations with the affected landowners to negotiate alternative water supply options of equivalent quantity and quality.
- Feedback must be provided to owners of boreholes within the affected zones regarding progress made with mining activities, rehabilitation and the outcome of monitoring programmes on a quarterly basis when groundwater monitoring will take place to ensure that they are informed of aspects of mining that may be of significance.
- The volume of water pumped from underground to surface during the operational phase must be recorded. This information must be used to update the impact assessment presented in this report, as necessary.
- If water-bearing structures are intersected during mining that contribute significant volumes of seepage to the pits and underground workings, they must be characterised and quantified. The risk and timing of decant must be re-assessed taking this information into consideration.
- If subsidence over underground workings is identified as a possibility, a geotechnical study must be completed to delineate areas of possible subsidence. This information must be used to re-asses the risk of decant and to quantify the associated impacts. Current simulations assume that no subsidence will take place over the underground workings.
- Surface and underground rehabilitation measures must be designed to minimise the risk of decant . In order to do so, the adit must be sealed upon mine closure and concurrent rehabilitation of the opencast pits must be maintained throughout the life of mining.
- Groundwater levels must be monitored on a monthly basis in the dedicated monitoring boreholes. This information together with daily on-site rainfall measurements must be used to improve the understanding of the rate of recharge as well as of aquifer parameters like storage coefficients and specific yield.
- The numerical model used in this assessment should be updated, verified and re-calibrated on a regular basis as monitoring information becomes available.
- The final model must be prepared at least five years prior to mine closure to ensure that predictions of long-term impacts are undertaken with the highest possible level of confidence.

8.4 Measures to address impacts on groundwater quality

The geochemical static leach tests completed on discard samples prepared from the Kranspan coal indicate that low concentrations of sulphate are expected to leach from the material under the conditions of the test, as discussed in Section 3 and indicated in Table 9. As mentioned, kinetic leach tests and geochemical modelling are currently underway, which will improve the understanding of long-term leachate quality associated with the discard material. Van Hille (2019) however states that the discard material is likely to acidify based on an acid base accounting assessment. If this were to happen, a deterioration in leachate quality is expected. In the absence of this information at the time of compilation of the report, the groundwater impact assessment was based on a worse case scenario, which assumed oxidation of the discard material during the operational phase and post-closure of the operations. This approach is in line with the requirements of the precautionary principle. Ilima is however committed to implementing a number of measures to reduce the risk of groundwater contamination associated with the handling of the discard material on site. For example, for the preferred option of in-pit discard disposal, restrictions are placed on the pit location and depth to which the discard can be backfilled. With the implementation of these management measures, the rate and extent to which the discard could oxidise will be reduced. The resultant discard leachate could therefore be of better quality than what was used in this report. If the leachate associated with the discard is of better quality, the resultant impact on groundwater quality will be reduced. For this reason, it is recommended that the groundwater quality impact assessment is revised once the results of the kinetic tests and geochemical modelling are available.

The following specific measures are recommended to minimise and/or eliminate the impacts on groundwater quality:

- Dedicated monitoring boreholes must be maintained in the two lineaments that transect the mining area. Boreholes 1-130, 1-130b, 5-110 and 5-110b are suitable for this and are situated down gradient of the plant area. Boreholes 6-220 and 6-220b are also situated on one of the lineaments. Based on the available information, it is anticipated that borehole KR11 is also situated on this fault and should therefore be included in the monitoring programme. If any of these boreholes are destroyed during mining, they must be replaced.
- Surface infrastructure, like the plant and the alternative discard stockpile option, must be positioned off the lineaments. Prior to the establishment of these areas, a geophysical survey must be completed to pin-point the faults. The positions of boreholes 1-130 and 5-110 can be used as a guideline in this regard.
- If the preferred discard disposal method is backfilling into mined out pits, only Pit 5 should be considered. It is preferable that discard is placed in the bottom of the northern most part of this pit to contain seepage and limit impacts. The boundary pillar between Pits 5 and 6 must be kept in place to avoid inter-pit flow of leachate associated with the discard. A groundwater monitoring borehole must be drilled down gradient of the area where discard is backfilled to the pit in order to monitoring the impact of this on groundwater quality.
- Prior to the implementation of either a surface discard stockpile of in-pit disposal of the discard, a geochemical study must be completed to evaluate the impact of placement of the discard material. In this study, it was assumed that leachate from the discard would deteriorate according to the description in Section 3 of this report. These assumptions must be confirmed and re-assessed once the results of the kinetic geochemical tests are available. In addition, it is recommended that geochemical modelling is undertaken to establish the potential quality of leachate if the discard is placed at the bottom of the pit and flooded to eliminate contact with oxygen. Conversely, the impact on leachate quality should be assessed if the discard is placed above the coal seam level and remains in contact with oxygen and water. In the latter instance, it is likely that the quality of leachate will deteriorate. Once the outcome of this study is available, the contaminant transport simulations presented in this report must be re-assessed.
- If the surface discard stockpile alternative is implemented, it is recommended that at least a

compacted clay liner be considered in order to reduce long-term adverse impacts on groundwater and decant quality. This facility must be designed according to legal requirements.

- If the option to backfill discard to Pit 5 is implemented, it is important that measures are put in place to monitor and control in-pit water levels. The discard must be placed in the northern section of this pit, where the coal floor contours dip away from the nearby downstream pan and wetlands. The volume of discard that can be placed in this area must be assessed as part of the design phase for this option to determine whether or not it would be sufficient for the life of the operations. Seepage that collects in the portion of Pit 5 that is used for discard disposal should be removed through a penstock or similar measures indicated by the professional engineer appointed to design the facility. A groundwater monitoring borehole should be drilled to the north of this area (between Pits 5 and 6) to monitor the impact of placing discard in this area. This borehole must be drilled prior to the commencement of this activity. The designs for the facility must furthermore take cognisance of the potential decant point that was identified in this area of Pit 5. Potential decant at this position post closure of the facility can be mitigated by creating a PCD or a return water dam in this area to contain seepage and potential decant. It is noted that the pit is not likely to decant if it is kept open for discard disposal during the operational phase of mining. The risk of decant in the long-term can be controlled with the penstock or similar water collection system identified during the design stage of the facility and/or contained in the proposed PCD.
- Once the kinetic geochemical test results are available, the impact assessment presented in this report should be updated and amended, as necessary.
- A monitoring programme must be implemented to establish underground water quality during the life of operations. This information must be used to update the long-term impact of mining on groundwater quality presented in this report.
- Updated contaminant transport simulations must be undertaken once this information is available in order to improve the confidence levels in long-term predictions. These simulations must be completed at least five years prior to mine closure to ensure that effective measures are developed to manage long-term impacts.

8.5 Measures to address impacts associated with decant

The following specific measures are recommended to minimise and/or eliminate the impacts associated with decant:

- If subsidence over underground workings is identified as a possibility, a geotechnical study must be completed to delineate areas of possible subsidence. This information must be used to re-asses the risk of decant and to quantify the associated impacts. Current simulations assume that no subsidence will take place.
- If water-bearing structures are intersected during mining that contribute significant volumes of seepage to the pits and underground workings, they must be characterised and quantified. The risk and timing of decant must be re-assessed taking this information into consideration.
- The quality of decant cannot be assessed without completing kinetic leach tests and geochemical modelling. It is however generally assumed that the quality of decant will be poor and should not be allowed to flow uncontrolled into the environment. Should this be allowed to happen, the poor quality water will have a negative impact on surface water, soil and wetlands.
- Surface and underground rehabilitation measures must be designed to minimise the risk of decant . Opencast mining areas and box cuts must be backfilled, shaped and made free draining to limit the rate of recharge of rainwater to the absolute minimum.
- Measures must be taken during the operational phase of mining to contain all decant anticipated. The PCDs must be sized to take decant volumes into consideration and cutoff trenches and berms must be put in place to divert decant to the PCDs. The planning and possible re-sizing of PCDs must be completed prior to mine closure.

9 GROUNDWATER MONITORING PROGRAMME

9.1 Objectives of the monitoring programme

Groundwater monitoring for the project should be undertaken to meet the following objectives:

- To measure the impacts of mining on groundwater levels and quality.
- To detect short- and long-term water level and quality trends.
- To calculate aquifer parameters, like the rate of recharge and storage coefficients.
- To recognise changes in groundwater characteristics, to enable analysis of their causes and to trigger the appropriate groundwater management response.
- To check the accuracy of predicted impacts.
- To use the information gathered for model calibration and/or verification.
- To develop improved practices and procedures for groundwater protection.

9.2 Monitoring locations

A groundwater monitoring programme must be implemented in all of the dedicated monitoring boreholes drilled as part of this assessment. These boreholes are listed in Tables 2 and 3.

All private boreholes that fall within the affected zones of influence must be included in the routine mine monitoring programme. These boreholes are listed in Tables 20 and 21.

The following additional monitoring boreholes are recommended:

- A shallow and deep monitoring borehole set down gradient of the northern section of Pit 5, should the option of backfilling discard to this pit be opted for. The deep borehole must be sited using geophysical methods and must be drilled to the depth of mining in this part of the pit. The borehole must be screened from top to bottom. The shallow borehole must be drilled to the depth of weathering.
- A dedicated shallow and deep monitoring borehole set must be drilled on the northern most lineament near the position of the private borehole KR11. The construction of these boreholes must adhere to that presented in Tables 2 and 3. The objective of this borehole is to monitor preferential flow of contamination from the mining areas towards the largest pan.
-

9.3 Monitoring requirements

The parameters to be included during monitoring as well as the proposed frequency of monitoring are presented in Table 29.

Table 29 Groundwater monitoring requirements in private and mine monitoring boreholes

Monitoring parameter	Element for analysis	Monitoring frequency
Depth to groundwater level	Groundwater level	Monthly
Water quality	All elements included in Table 7	Quarterly
Spring flow	Actual spring flow rates, where possible. If not, record the visual condition of all springs listed above	Quarterly
Spring water quality	All elements included in Table 7	Quarterly
Rainfall	Rain depth (mm)	Daily on site

All monitoring information must be entered into a spreadsheet for record keeping and analysis. Copies of the certificates of analyses must be kept on file for inspection.

If significant exceedances are recorded during the monitoring programme, the following actions should be taken:

- Log the exceedances in the incident reporting system within 24-hours of it occurring.
- Report the exceedances to the Environmental and General Managers as well as to the regulatory authority.
- Undertake an investigation to identify causes of the exceedances.
- Consult with any landowner or affected party that may be impacted by the exceedances to determine their concerns and to negotiate remedial actions.
- Implement the necessary remedial actions according to the outcome of the investigation and consultation with the affected parties.
- Track the incident until completion.

Regular monitoring reports must be prepared for internal use as well as for submission to the authorities, as required by the operations' water use licenses.

10 REFERENCES

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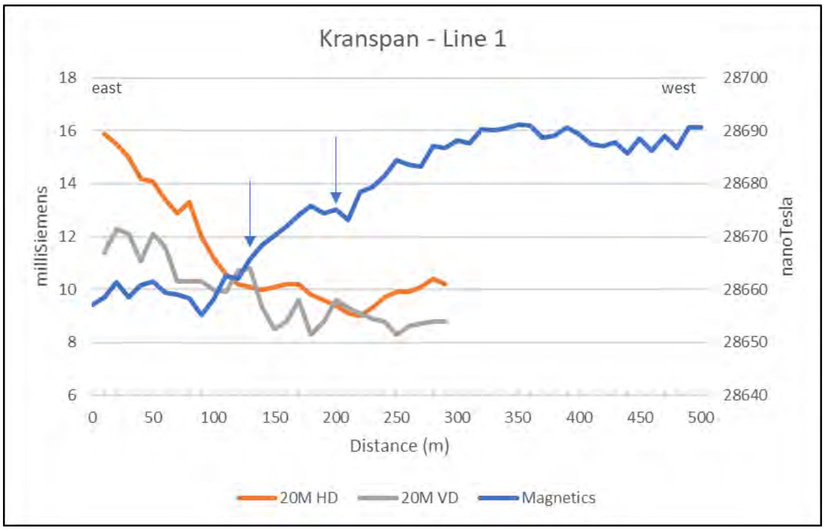
Appendix 1 – Hydrocensus information

Site ID	Farm	Owner	Lat (WGS84)	Long (WSG84)	Elevation (mamsl)	Water depth (mbgl)	Collar height (m)	Water elevation (mamsl)	BH depth (m)	Yield (L/h)	Sampled	Pump type	Use	Note
KR1	Vaalbank Ptn 8	Rudi Prinsloo	26°10'18,8" S	29°58'08,7" E	1743	19,24	0,20	1723,56	--	--	no	windpump	House & animals	Windpump close to house and trig beacon
KR2	Vaalbank Ptn 8	Rudi Prinsloo	26°11'11,6" S	29°58'23,6" E	1725	pumping	--	--	--	--	no	windpump	Animals	Windpump behind school on farm.
KR3	Kranspan Ptn 2	Rudi Prinsloo	26°10'12,4" S	29°59'43,8" E	1664	closed	0,27	--	--	--	yes	windpump	Animals	Rusted windpump on western edge of large pan
KR4	Kranspan Ptn 2	Rudi Prinsloo	26°10'12,2" S	29°59'38,6" E	1662	12,00	0,12	1649,88	--	--	no	open hole	None	Open hole next to cement dam fed by borehole KR3
KR5	Kranspan Ptn 3	Jaco Papenfus	26°09'23,2" S	30°01'06,0" E	1678	blocked near surface	0,18	--	--	--	no	open hole	None	Open hole next to access road to Jaco. Old windpump frame in veld
KR6	Kranspan Ptn 3	Jaco Papenfus	26°09'21,0" S	30°01'26,7" E	1681	blocked at 2m	0,40	--	--	--	no	open hole	None	Dolomite borehole?
KR7	Kranspan Ptn 3	Jaco Papenfus	26°09'30,9" S	30°00'29,2" E	1708	22,38	0,13	1685,49	--	--	no	submerc	House & animals	Pump not operational. Close to old windpump next to house
KR8	Kranspan Ptn 3	Jaco Papenfus	26°09'30,8" S	30°00'28,7" E	1708	17,77	0,00	1690,23	--	--	no	windpump	None	Old windpump next to house
KR9	Kranspan Ptn 4	Gysbert Klein	26°10'11,6" S	29°58'35,7" E	1722	14,00	0,06	1707,94	--	--	no	windpump	Animals	Seems to be out of order - rusted.
KR10	Kranspan Ptn 4	Gysbert Klein	26°09'24,4" S	29°59'24,3" E	1694	closed	0,00	--	--	--	no	windpump	Animals	
KR11	Kranspan Ptn 2	Rudi Prinsloo	26°10'12,2" S	30°00'23,1" E	1662	closed	0,50	--	--	--	yes	windpump	House & animals	Water supply to Jaco Papenfus house. Windpump on northern edge of big pan
KR12	Kranspan Ptn 8	Koos Jordaan	26°09'57,2" S	30°01'55,7" E	1661	blocked at 22m	0,00	--	--	--	yes	submerc	House and animals	Near house and cement dam
KR13	Kranspan Ptn RE	Koos Jordaan	26°11'43,5" S	30°00'36,8" E	1678	blocked at 3m	0,00	--	--	--	no	windpump	None	Used to be for animals. Next to tar road and old house.
KR14	Vaalbank Ptn RE	Koos Jordaan	26°12'25,9" S	29°59'22,8" E	1703	pumping	0,28	--	30	--	yes	solar submerc	House & animals	
KR15	Vaalbank Ptn RE	Koos Jordaan	26°12'30,2" S	29°59'17,9" E	1710	obstructions	0,16	--	30	--	no	submerc	House & animals	Main BH to house
KR16	Vaalbank Ptn RE	Koos Jordaan	26°12'30,3" S	29°59'15,3" E	1712	3,80	0,16	1708,04	30	--	no	open hole	None	Suspect bricks in hole. Obstructed
KR17	Vaalbank Ptn RE	Koos Jordaan	26°12'36,9" S	29°59'21,3" E	1724	13,86	0,10	1710,04	30	--	no	open hole	None	Close to house and workshops
KR18	Kranspan Ptn 6	Kobus Papenfus	26°10'37,0" S	29°59'00,2" E	1682	closed	0,03	--	--	--	yes	windpump	Animals	
KR19	Kranspan Ptn 6	Kobus Papenfus	26°11'14,6" S	29°59'42,3" E	1685	closed	0,10	--	--	--	yes	windpump	Animals	
KR_ Spring1	Vaalbank Ptn 8	Rudi Prinsloo	26°10'25,5" S	29°57'53,2" E	1711	0,00	0,00	1711,00	--	--	no	none	Animals	Spring at house. Not flowing but water in brick ring

Site ID	Farm	Owner	Lat (WGS84)	Long (WSG84)	Elevation (mamsl)	Water depth (mbgl)	Collar height (m)	Water elevation (mamsl)	BH depth (m)	Yield (L/h)	Sam pled	Pump type	Use	Note
KR_ Spring2	Vaalbank Ptn 8	Rudi Prinsloo	26°10'25,5" S	29°57'57,3" E	1708	0,00	0,00	1708,00	--	--	no	none	Animals	Spring at house. Not flowing. Dry
KR_ Spring3	Vaalbank Ptn 8	Rudi Prinsloo	26°10'53,4" S	29°57'24,6" E	1648	0,00	0,00	1648,00	--	1000	yes	none	Animals	Strong flowing spring. Discharges into large cement dam
KR_ Spring4	Vaalbank Ptn 8	Rudi Prinsloo	26°10'30,5" S	29°58'13,7" E	1730	0,00	0,00	1730,00	--	--	no	none	House & animals	Low flow. Wetlands downstream. Near staff houses
KR_ Spring5	Kranspan Ptn 8	Koos Jordaan	26°11'09,9" S	30°01'29,8" E	1659	0,00	0,00	1659,00	--	--	no	none	Animals	Fenced.
KR_ Spring6	Kranspan Ptn 6	Kobus Papenfus	26°10'20,5" S	29°59'31,8" E	1662	0,00	0,00	1662,00	--	--	no	none	Animals	Not flowing
KR_ Seep	Vaalbank Ptn 8	Rudi Prinsloo	26°10'26,9" S	29°58'00,6" E	1718	0,00	0,00	1718,00	--	--	no	none	Animals	Not flowing

Appendix 2 – Results of the Geophysical Survey

Line 1:

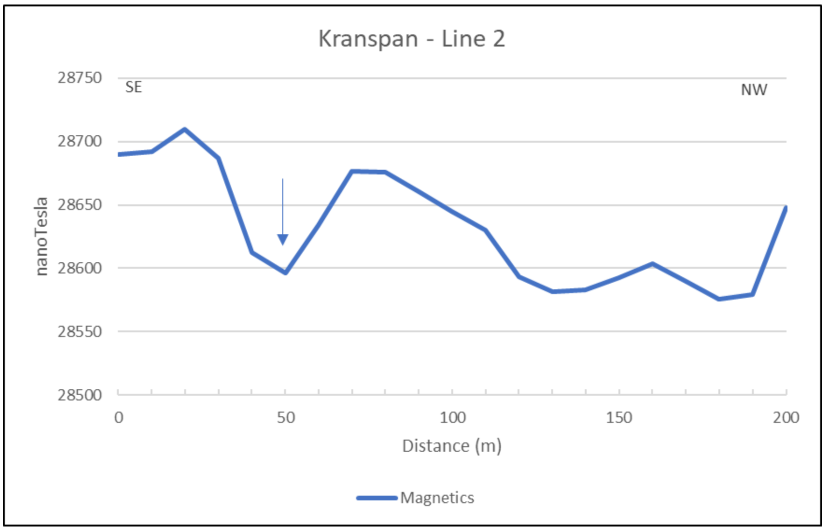


Line 1:	Latitude	Longitude	Notes
Line start coordinates:	S 26.165744°	E 30.010750°	WGS84
Line end coordinates:	S 26.165837°	E 30.006092°	
Line orientation:			East to West
Possible geological feature-1:	S 26.165775°	E 30.009571°	Line 1-130
Possible geological feature-2:	S 26.165791°	E 30.008895°	Line 1-200

Line 1 focused on identifying a north-south trending fault that runs through the big pan on Kranspan. The line was surveyed approximately 600m from the northern edge of the pan along a farm road.

Two geophysical anomalies were identified – at station 130m and at station 200m. Based on the step in the Mag data and also more conductive zone at station 130m it has been assumed that station 130m is potentially the fault. A second possible fractured zone is at station 200m.

Line 2:

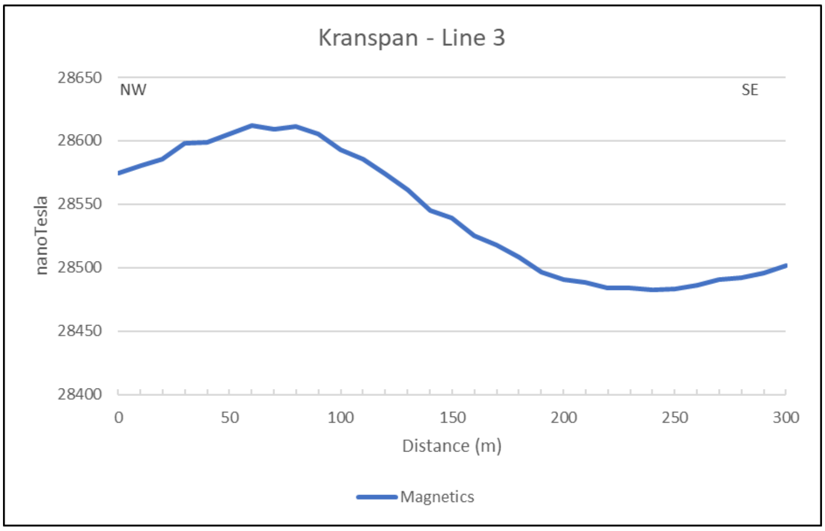


Line 2:	Latitude	Longitude	Notes
Line start coordinates:	S 26.172206°	E 29.987668°	WGS84
Line end coordinates:	S 26.171040°	E 29.986125°	
Line orientation:			Southeast to Northwest
Possible geological feature-1:	S 26.171920°	E 29.987260°	Line 2-50

Line 2 focused on identifying a possible dolerite dyke that that was pointed out by Rudolph Schoeler. It was mentioned that the dyke was identified during the exploration drilling and has a northeast-southwest orientation.

A geophysical anomaly was identified at station 50m. It has been assumed that the negative anomaly represents the dyke position. GWA suspects that this could be the edge of a diabase sill.

Line 3:

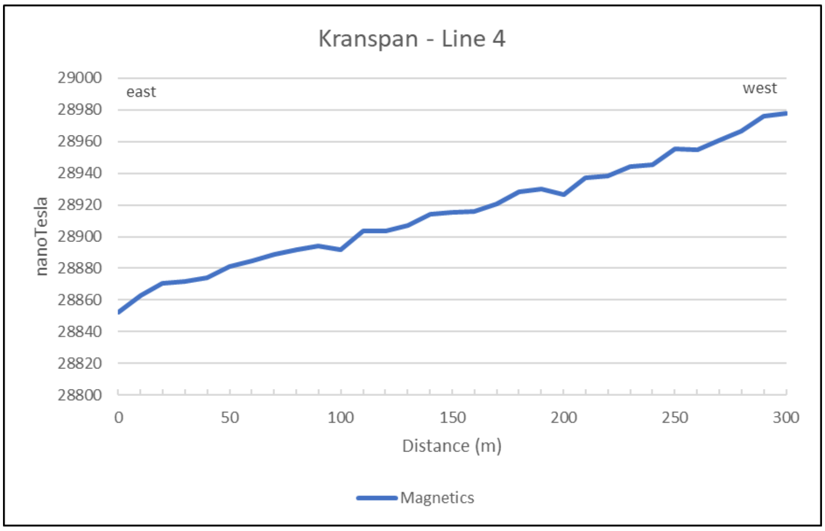


Line 3:	Latitude	Longitude	Notes
Line start coordinates:	S 26.169342°	E 29.992084°	WGS84
Line end coordinates:	S 26.171659°	E 29.993181°	
Line orientation:			Northwest to Southeast
Possible geological feature-1:	No drilling position was marked		

Line 3 focused on identifying a possible dolerite dyke that that was pointed out by Rudolph Schoeler. The line was run to define a possible strike direction for the anomaly identified on Line 2.

A geophysical anomaly was identified along the whole length of the line. It has been assumed that the line does not cross the possible dyke at a 90° angle, but runs along the possible structure at a low angle.

Line 4:

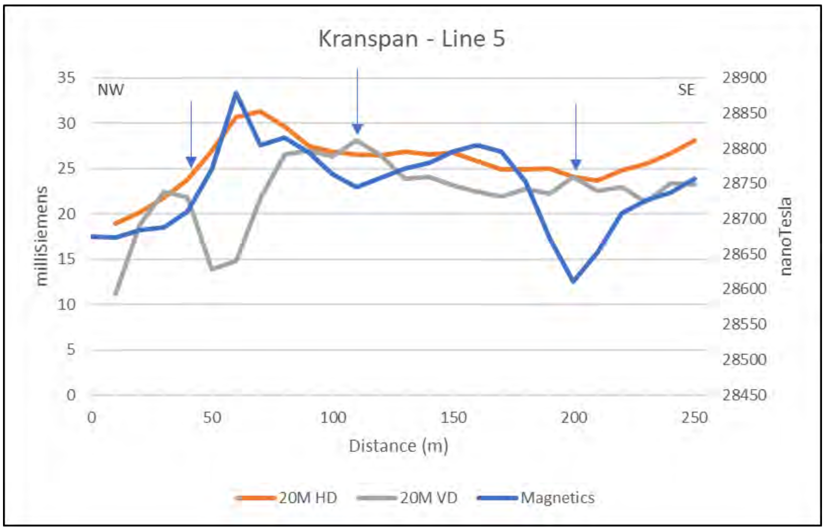


Line 4:	Latitude	Longitude	Notes
Line start coordinates:	S 26.154929°	E 30.032469°	WGS84
Line end coordinates:	S 26.155123°	E 30.029478°	
Line orientation:			East to West
Possible geological feature-1:	No drilling position was marked		

Line 4 focused on identifying the north-south trending fault that runs parallel and close to the main tar road.

No geophysical anomalies were identified and it was concluded that the fault does no cross at the selected position, but possibly further east. The line could not be extended due to the tar road, fences and houses on the opposite side of the road.

Line 5:

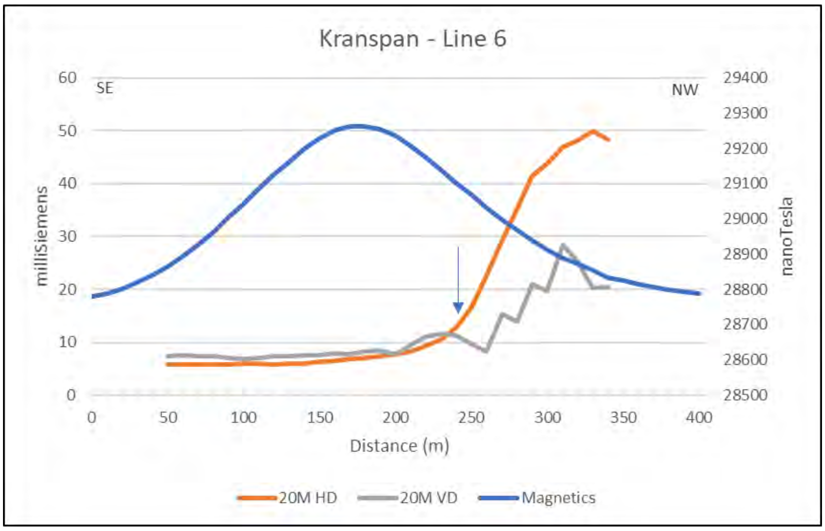


Line 5:	Latitude	Longitude	Notes
Line start coordinates:	S 26.160924°	E 30.008474°	WGS84
Line end coordinates:	S 26.162119°	E 30.101328°	
Line orientation:			Northwest to Southeast
Possible geological feature-1:	S 26.161107°	E 30.008883°	Line 5-40
Possible geological feature-2:	S 26.161470°	E 30.009393°	Line 5-110
Possible geological feature-3:	S 26.161883°	E 30.009967°	Line 5-200

Line 5 focused on identifying the north-south trending fault that runs through the big pan on Kranspan, as well as a possible sill contact.

Three geophysical anomalies were identified – at stations 40m, 110m and 200m. It has been assumed that station 40m is the sill contact; then there is a weathered zone (possible fracture) at 110m, and the fault at station 200m.

Line 6:

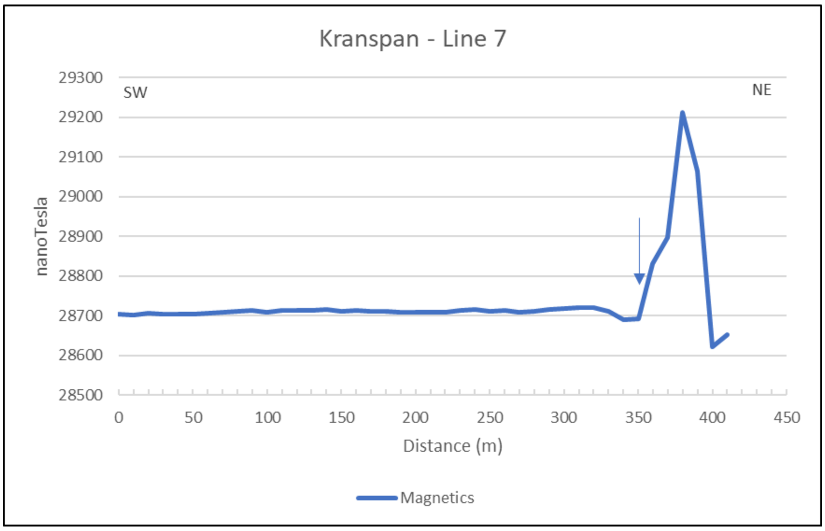


Line 6:	Latitude	Longitude	Notes
Line start coordinates:	S 26.183345°	E 30.017885°	WGS84
Line end coordinates:	S 26.181594°	E 30.014559°	
Line orientation:			Northwest to Southeast
Possible geological feature-1:	S 26.182365°	E 30.016054°	Line 6-220

Line 6 focused on identifying the north-south trending fault that runs parallel and close to the main tar road.

A geophysical anomaly was identified at station 220m. Based on the magnetic data it could be that the geophysical survey was run at an angle across the fault. Based on the step in the EM data and also more conductive zone towards the end of the line it has been assumed that station 220m is potentially the fault. The end of the line is also in a lower lying area with possible clay.

Line 7:

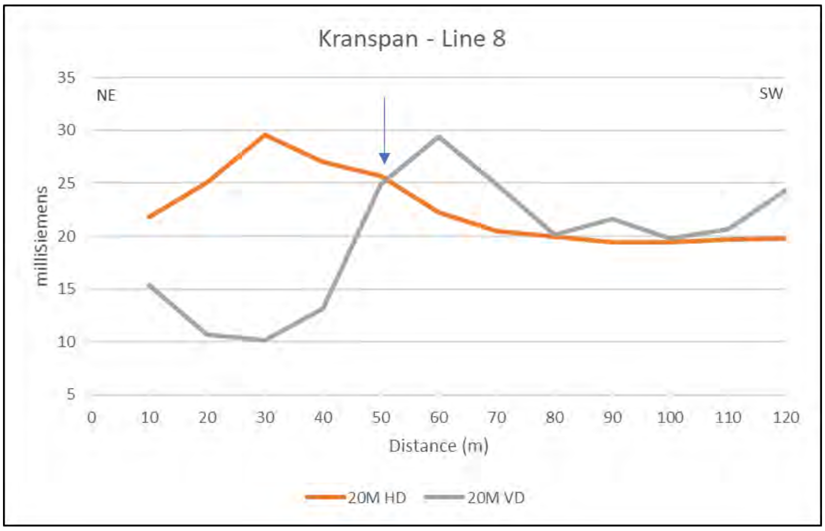


Line 7:	Latitude	Longitude	Notes
Line start coordinates:	S 26.160350°	E 30.002856°	WGS84
Line end coordinates:	S 26.158197°	E 30.006255°	
Line orientation:			Southwest to Northeast
Possible geological feature-1:	S 26.158489°	E 30.005771°	Line 7-350

Line 7 focused on identifying a possible sill as identified by the Client.

A geophysical anomaly was identified at station 350m. Based on the positive Mag anomaly it was assumed that this is the edge of the sill. A fence and buildings stopped the line from extending further north. The drill position was not marked at this point. A second line (Line 8) was run to determine a strike direction.

Line 8:



Line 8:	Latitude	Longitude	Notes
Line start coordinates:	S 26.158172°	E 30.006146°	WGS84
Line end coordinates:	S 26.158723°	E 30.005019°	
Line orientation:			Northeast to Southwest
Possible geological feature-1:	S 26.158387°	E 30.005689°	Line 8-50

Line 8 focused on identifying the orientation of the sill contact identified on Line 7.

A geophysical anomaly was identified at station 50m. Based on the step in the EM data and change in conductivity at station 50m it has been assumed that this is potentially the edge of the sill. The drill position was not marked at this point, but moved 10m away into a grass patch.

Appendix 3 – Monitoring Borehole Drilling Results

Water Monitoring Borehole:	Line 2-50
Drilled by :	WJ Water Drilling
Date Drilled:	10-Dec-18
Logged by:	A Davis
Date Logged:	13-Dec-18
EOH:	50m

From (m)	To (m)	Description
0	5	Laterite and clay
5	25	Brown clay
25	50	Sandstone/shale interbedded. Competent material

Additional Comments:

a bit of of water at 5m and approximately 1000liters per hour on 35m.

Photo of Line 2-50:

Water Monitoring Borehole: Line 1-130
Drilled by : WJ Water Drilling
Date Drilled: 12-Dec-18
Logged by: A Davis
Date Logged: 13-Dec-18
EOH: 50m

From	To	Description
(m)	(m)	
0	3	Brown laterite and weathered sandstone
3	10	competent shale and sandstone layer
10	25	white sandstone - competent
25	40	carbonacoues shale and coal - competent
40	50	Competent sandstone.

Additional Comments:
no major water to report

Photo of Pan Monitoring 2:

Water Monitoring Borehole:	Line 5-110
Drilled by :	WJ Water Drilling
Date Drilled:	13-Dec-18
Logged by:	A Davis
Date Logged:	14-Dec-18
EOH:	50m

From (m)	**To** (m)	**Description**
0	2	brown sand/soil
2	4	weathered sandstone brown
4	7	white siltstone weathered
7	8	sandstone brown competent
8	10	shale
10	12	carbonaceous shale
12	15	sandstone brown slightly weathered
15	20	doleritic zone
20	25	sandtsone and shale
25	35	sandstone possible fracture zone
35	45	carbonaceous shale with some sandstone
45	50	Competent sandstone.

Additional Comments:

1,500 liters per hour is estimated at 15m and on 10,000 liters per hour is estimated at 35m.		

Water Monitoring Borehole: Line 6-220
Drilled by : WJ Water Drilling
Date Drilled: 11-Dec-18
Logged by: A Davis
Date Logged: 13-Dec-18
EOH: 50m

From (m)	To (m)	Description
0	5	weathered sandstone.
5	10	sandstone - appears competent
10	13	carbonaceous shale - competent
13	33	white sandstone - appears competent
33	50	sandstone very wet.

Additional Comments:
At 15m approximately 1000liters per hour and at 45m approximately 2500liters per hour.

Photo of Line 6-220:

Water Monitoring Borehole:	Pan Monitoring 1
Drilled by :	WJ Water Drilling
Date Drilled:	10-Dec-18
Logged by:	A Davis
Date Logged:	13-Dec-18
EOH:	50m

From	**To**	**Description**
(m)	(m)	
0	5	Black clay
5	9	Grey sandstone, shale layer. Appears weathered
9	47	white sandstone layer. Appears weathered
47	50	Dolerite

Additional Comments:

Approximately 2000liters per hour on 30m

Photo of Pan Monitoring 1:

Water Monitoring Borehole:	Pan Monitoring 2
Drilled by :	WJ Water Drilling
Date Drilled:	11-Dec-18
Logged by:	A Davis
Date Logged:	13-Dec-18
EOH:	50m

From (m)	To (m)	Description
0	20	Black clay material
20	50	white sandstone - appears slightly weathered.

Additional Comments:

No major water could be reported, however, very clayey.

Photo of Pan Monitoring 2:

Water Monitoring Borehole: Pan Monitoring 3
Drilled by : WJ Water Drilling
Date Drilled: 13-Dec-18
Logged by: A Davis
Date Logged: 14-Dec-18
EOH: 50m

From (m)	To (m)	Description
0	15	white loose sand
15	20	Carbonaceous shale and sand
20	50	sandstone, very weathered.

Additional Comments:
The flow rate is in excess of 10,000liters per hour.

Photo of Pan Monitoring 3:

Water Monitoring Borehole:	Line 8 Site
Drilled by :	WJ Water Drilling
Date Drilled:	13-Dec-18
Logged by:	A Davis
Date Logged:	14-Dec-18
EOH:	50m

From (m)	To (m)	Description
0	6	brown sand/soil
6	9	highly weathered sandstone
9	15	competent sandstone and shale
15	19	carbonaceous shale
19	20	sandstone
20	22	carbonaceous shale
22	27	sandstone competent
27	32	doleritic zone
32	35	dolerite and coal
35	50	very wet shale and sandstone

Additional Comments:

1000 liters per hour is estimated at approximately 35m on the deep hole.		
Approximately 5000 liters per hour is estimated on 13m on the shallow hole.		

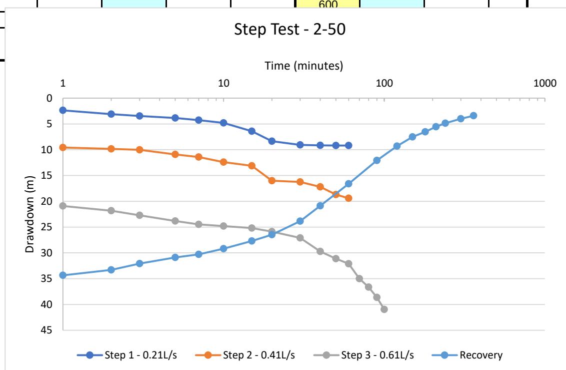
Appendix 4 – Aquifer Testing Results

Borehole Number	2-50	**Lat**	26,1719
BH Diameter	17mm	**Long**	29,98728
Collar Height	0.31m		
BH Depth	48.59m		
Pump Depth	44,18		

STEP DRAWDOWN

Static W/L **4,22**

	step 1			step 2			step 3			step 4				recovery	
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**time**		**WL rec**
1	2,37	**6,59**		9,57	**13,79**		20,91	**25,13**					1	34,35	**38,57**
2	3,11	**7,33**		9,84	**14,06**	**0,32**	21,82	**26,04**					2	33,29	**37,51**
3	3,46	**7,68**		10,03	**14,25**		22,71	**26,93**	**0,66**				3	32,07	**36,29**
5	3,84	**8,06**	**0,21**	10,91	**15,13**	**0,39**	23,83	**28,05**	**0,63**				5	30,89	**35,11**
7	4,25	**8,47**	**0,35**	11,41	**15,63**	**0,41**	24,47	**28,69**	**0,6**				7	30,3	**34,52**
10	4,8	**9,02**		12,4	**16,62**	**0,4**	24,79	**29,01**	**0,64**				10	29,18	**33,4**
15	6,41	**10,63**	**0,32**	13,11	**17,33**	**0,39**	25,19	**29,41**	**0,61**				15	27,7	**31,92**
20	8,35	**12,57**	**0,3**	16,02	**20,24**	**0,44**	25,87	**30,09**	**0,63**				20	26,48	**30,7**
30	9,06	**13,28**	**0,25**	16,24	**20,46**	**0,42**	27,1	**31,32**	**0,62**				30	23,85	**28,07**
40	9,15	**13,37**	**0,21**	17,21	**21,43**	**0,41**	29,71	**33,93**	**0,65**				40	20,88	**25,1**
50	9,17	**13,39**	**0,2**	18,69	**22,91**	**0,42**	31,13	**35,35**	**0,6**				60	16,6	**20,82**
60	9,19	**13,41**	**0,21**	19,41	**23,63**	**0,4**	32,11	**36,33**	**0,64**				90	12,08	**16,3**
70							35,01	**39,23**	**0,64**				120	9,3	**13,52**
80							36,65	**40,87**	**0,59**				150	7,51	**11,73**
90							38,64	**42,86**	**0,61**				180	6,52	**10,74**
100							40,95	**45,17**	**0,59**				210	5,56	**9,78**
110													240	4,86	**9,08**
120													300	4	**8,22**
130													360	3,41	**7,63**
140													420		
150													480		
160													540		
170													600		
180															

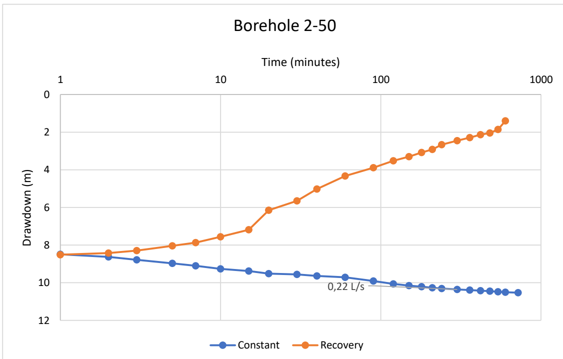


CONSTANT DISCHARGE

WL at start of test **7,63**

Monitoring Borehole
BH No 2-50M
SWL 4,52

				recovery		
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL rec**	**Drawdown**
1	8,49	**16,12**		8,51	**16,14**	**0**
2	8,63	**16,26**		8,42	**16,05**	**0**
3	8,78	**16,41**		8,29	**15,92**	**0**
5	8,97	**16,6**		8,04	**15,67**	**0**
7	9,1	**16,73**	**0,25**	7,87	**15,5**	**0**
10	9,26	**16,89**	**0,23**	7,56	**15,19**	**0**
15	9,38	**17,01**	**0,21**	7,18	**14,81**	**0**
20	9,52	**17,15**	**0,24**	6,15	**13,78**	**0**
30	9,56	**17,19**	**0,2**	5,65	**13,28**	**0**
40	9,64	**17,27**	**0,24**	5,02	**12,65**	**0**
60	9,71	**17,34**	**0,24**	4,33	**11,96**	**0**
90	9,91	**17,54**	**0,22**	3,89	**11,52**	**0**
120	10,06	**17,69**	**0,21**	3,52	**11,15**	**0**
150	10,15	**17,78**	**0,24**	3,3	**10,93**	**0**
180	10,21	**17,84**	**0,25**	3,08	**10,71**	**0**
210	10,27	**17,9**	**0,21**	2,92	**10,55**	**0**
240	10,31	**17,94**	**0,23**	2,66	**10,29**	**0**
300	10,36	**17,99**	**0,24**	2,45	**10,08**	**0**
360	10,39	**18,02**	**0,24**	2,29	**9,92**	**0**
420	10,42	**18,05**	**0,21**	2,13	**9,76**	**0**
480	10,45	**18,08**	**0,2**	2,04	**9,67**	**0**
540	10,48	**18,11**	**0,22**	1,86	**9,49**	**0**
600	10,5	**18,13**	**0,23**	1,4	**9,03**	**0**
720	10,53	**18,16**	**0,24**			**0**
840						
960						
1080						
1200						
1320						
1440						
2280						
2880						
3480						
3900						
4320						

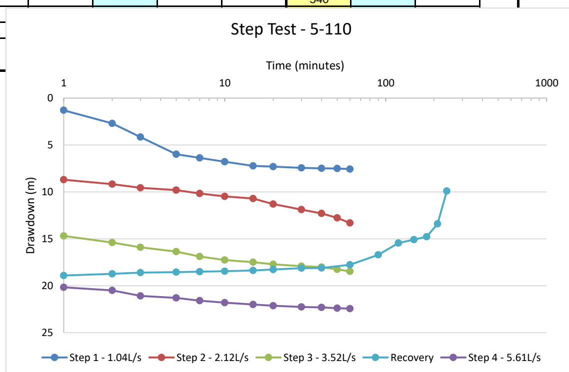


Borehole Number	5-110	**Lat**	26,16145
BH Diameter	170mm	**Long**	30,00941
Collar Height	0,52		
BH Depth	48		
Pump Depth	44,18		

STEP DRAWDOWN

Static W/L **4,99**

	step 1			step 2			step 3			step 4				recovery	
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**time**		**WL rec**
1	1,3	**6,29**		8,7	**13,69**		14,69	**19,68**		20,17	**25,16**		1	18,91	**23,9**
2	2,7	**7,69**		9,17	**14,16**	**1,99**	15,4	**20,39**		20,49	**25,48**		2	18,74	**23,73**
3	4,15	**9,14**	**1,06**	9,56	**14,55**		15,9	**20,89**	**3,46**	21,08	**26,07**		3	18,6	**23,59**
5	5,99	**10,98**	**1,05**	9,8	**14,79**	**2,16**	16,37	**21,36**	**3,57**	21,3	**26,29**	**5,61**	5	18,56	**23,55**
7	6,37	**11,36**	**1,02**	10,16	**15,15**	**2,11**	16,89	**21,88**	**3,55**	21,6	**26,59**	**5,6**	7	18,51	**23,5**
10	6,79	**11,78**	**1,03**	10,47	**15,46**	**2,14**	17,26	**22,25**	**3,54**	21,8	**26,79**	**5,61**	10	18,45	**23,44**
15	7,22	**12,21**	**1,04**	10,7	**15,69**	**2,13**	17,49	**22,48**	**3,53**	22	**26,99**	**5,58**	15	18,37	**23,36**
20	7,3	**12,29**	**1,04**	11,3	**16,29**	**2,15**	17,72	**22,71**	**3,54**	22,14	**27,13**	**5,61**	20	18,27	**23,26**
30	7,43	**12,42**	**1,04**	11,89	**16,88**	**2,16**	17,91	**22,9**	**3,54**	22,26	**27,25**	**5,62**	30	18,12	**23,11**
40	7,49	**12,48**	**1,03**	12,29	**17,28**	**2,13**	18,02	**23,01**	**3,55**	22,31	**27,3**	**5,59**	40	18,11	**23,1**
50	7,51	**12,5**	**1,04**	12,76	**17,75**	**2,12**	18,26	**23,25**	**3,52**	22,39	**27,38**	**5,61**	60	17,76	**22,75**
60	7,57	**12,56**	**1,05**	13,31	**18,3**	**2,12**	18,47	**23,46**	**3,54**	22,44	**27,43**	**5,6**	90	16,7	**21,69**
70													120	15,44	**20,43**
80													150	15,09	**20,08**
90													180	14,78	**19,77**
100													210	13,4	**18,39**
110													240	9,9	**14,89**
120													300		
130													360		
140													420		
150													480		
160													540		
170															
180															

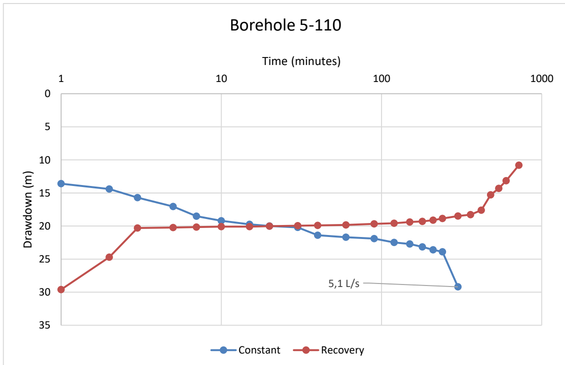


CONSTANT DISCHARGE

WL at start of test **14,89**

Monitoring Borehole
BH No 5-110
SWL 6,44

				recovery			
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL rec**	**Drawdown**	Recovery
1	13,6	**28,49**		29,6	**44,49**	**0**	
2	14,4	**29,29**		24,71	**39,6**	**0**	
3	15,7	**30,59**		20,3	**35,19**	**0**	
5	17,05	**31,94**	**5,26**	20,22	**35,11**	**0**	
7	18,52	**33,41**	**5,19**	20,17	**35,06**	**0**	0
10	19,2	**34,09**	**5,13**	20,1	**34,99**	**0**	0
15	19,75	**34,64**	**5,14**	20,08	**34,97**	**0**	0
20	20	**34,89**	**5,12**	20,03	**34,92**	**0**	0
30	20,21	**35,1**	**5,11**	19,96	**34,85**	**0**	0
40	21,39	**36,28**	**5,1**	19,91	**34,8**	**0**	0
60	21,68	**36,57**	**5,13**	19,84	**34,73**	**0**	0
90	21,9	**36,79**	**5,14**	19,68	**34,57**	**0**	0
120	22,49	**37,38**	**5,1**	19,57	**34,46**	**0**	0
150	22,71	**37,6**	**5,13**	19,4	**34,29**	**0**	0
180	23,15	**38,04**	**5,14**	19,29	**34,18**	**0**	0
210	23,59	**38,48**	**5,12**	19,11	**34**	**0**	0
240	23,9	**38,79**	**5,11**	18,86	**33,75**	**0**	0
300	29,19	**44,08**	**5,1**	18,5	**33,39**	**0**	0
360				18,29	**33,18**	**0**	0
420				17,61	**32,5**	**0**	0
480				15,29	**30,18**	**0**	0
540				14,3	**29,19**	**0**	0
600				13,16	**28,05**	**0**	0
720				10,81	**25,7**	**0**	0
840							
960							
1080							
1200							
1320							
1440							
2280							
2880							
3480							
3900							
4320							

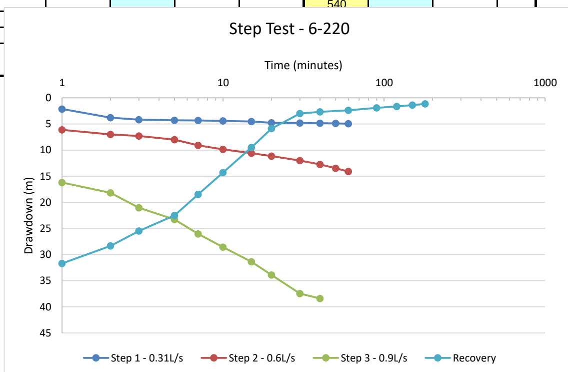


Borehole Number	6-220	**Lat**	26,18233
BH Diameter	170mm	**Long**	30,016
Collar Height	0,48		
BH Depth	49,61		
Pump Depth	44,18		

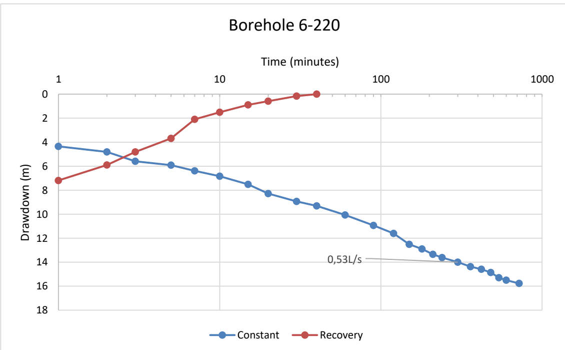
STEP DRAWDOWN

Static W/L **5,3**

	step 1			step 2			step 3			step 4				recovery	
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**time**		**WL rec**
1	2,14	**7,44**		6,13	**11,43**		16,21	**21,51**					1	31,69	**36,99**
2	3,81	**9,11**		7	**12,3**		18,19	**23,49**					2	28,34	**33,64**
3	4,18	**9,48**		7,3	**12,6**	**0,44**	21,04	**26,34**					3	25,47	**30,77**
5	4,3	**9,6**	**0,32**	8,02	**13,32**		23,29	**28,59**	**0,81**				5	22,5	**27,8**
7	4,34	**9,64**	**0,28**	9,1	**14,4**	**0,66**	26,04	**31,34**	**0,93**				7	18,49	**23,79**
10	4,41	**9,71**	**0,3**	9,86	**15,16**	**0,61**	28,57	**33,87**	**0,86**				10	14,3	**19,6**
15	4,53	**9,83**	**0,27**	10,59	**15,89**	**0,57**	31,36	**36,66**	**0,92**				15	9,51	**14,81**
20	4,76	**10,06**	**0,33**	11,17	**16,47**	**0,62**	33,9	**39,2**	**0,91**				20	5,89	**11,19**
30	4,83	**10,13**	**0,32**	12	**17,3**	**0,6**	37,46	**42,76**	**0,9**				30	3	**8,3**
40	4,86	**10,16**	**0,3**	12,74	**18,04**	**0,58**	38,4	**43,7**	**0,86**				40	2,69	**7,99**
50	4,9	**10,2**	**0,31**	13,49	**18,79**	**0,6**							60	2,38	**7,68**
60	4,95	**10,25**	**0,39**	14,11	**19,41**	**0,61**							90	1,91	**7,21**
70													120	1,64	**6,94**
80													150	1,39	**6,69**
90													180	1,16	**6,46**
100													210		
110													240		
120													300		
130													360		
140													420		
150													480		
160													540		
170															
180															



CONSTANT DISCHARGE						**Monitoring Borehole**	
WL at start of test	**6,46**					**BH No**	6-220
						SWL	3,13
				recovery			
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL rec**	**Drawdown**	Recovery
1	4,35	**10,81**		7,19	**11,5**	**0**	
2	4,81	**11,27**		5,9	**10,35**	**0**	
3	5,6	**12,06**		4,81	**9,74**	**0**	
5	5,91	**12,37**	**0,23**	3,69	**8,63**	**0**	
7	6,39	**12,85**		2,1	**7,51**	**0**	0,2
10	6,84	**13,3**	**0,5**	1,51	**6,67**	**0**	0,18
15	7,51	**13,97**	**0,54**	0,89	**6,07**	**0**	0,17
20	8,29	**14,75**	**0,55**	0,58	**5,96**	**0**	0,15
30	8,94	**15,4**	**0,54**	0,166	**5,89**	**0**	0,145
40	9,31	**15,77**	**0,46**	0	**5,71**	**0**	0,14
60	10,06	**16,52**	**0,53**		**5,65**	**0**	0,136
90	10,94	**17,4**	**0,49**		**5,46**	**0**	0,131
120	11,6	**18,06**	**0,55**		**5,29**	**0,03**	0,127
150	12,51	**18,97**	**0,54**		**5,14**	**0,05**	0,125
180	12,9	**19,36**	**0,53**		**5**	**0,08**	0,123
210	13,34	**19,8**	**0,51**		**4,8**	**0,09**	0,121
240	13,61	**20,07**	**0,53**		**4,71**	**0,11**	0,119
300	14	**20,46**	**0,54**		**4,43**	**0,13**	0,116
360	14,37	**20,83**	**0,53**		**4,31**	**0,16**	0,113
420	14,59	**21,05**	**0,55**		**4,07**	**0,17**	0,112
480	14,86	**21,32**	**0,53**		**3,81**	**0,19**	0,11
540	15,29	**21,75**	**0,54**		**3,6**	**0,21**	0,096
600	15,5	**21,96**	**0,53**		**3,39**	**0,23**	0,094
720	15,77	**22,23**	**0,55**		**3,19**	**0,25**	0,091
840							
960							
1080							
1200							
1320							
1440							
2280							
2880							
3480							
3900							
4320							

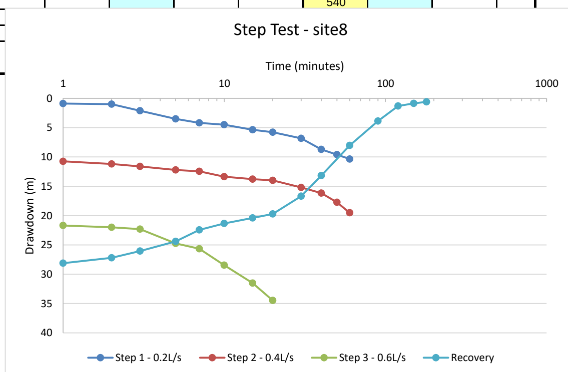


Borehole Number	8 Site	**Lat**	26,15827
BH Diameter	170mm	**Long**	30,00564
Collar Height	0,4		
BH Depth	49,03		
Pump Depth	44,18		

STEP DRAWDOWN

Static W/L **9,71**

	step 1			step 2			step 3			step 4				recovery	
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**time**		**WL rec**
1	0,89	**10,6**		10,74	**20,45**		21,69	**31,4**					1	28,12	**37,83**
2	0,99	**10,7**		11,2	**20,91**		22	**31,71**	**0,61**				2	27,19	**36,9**
3	2,12	**11,83**		11,61	**21,32**		22,31	**32,02**					3	26,06	**35,77**
5	3,51	**13,22**	**0,21**	12,21	**21,92**	**0,36**	24,73	**34,44**	**0,6**				5	24,4	**34,11**
7	4,19	**13,9**	**0,22**	12,45	**22,16**	**0,4**	25,66	**35,37**	**0,53**				7	22,44	**32,15**
10	4,51	**14,22**	**0,2**	13,36	**23,07**	**0,41**	28,46	**38,17**	**0,64**				10	21,35	**31,06**
15	5,37	**15,08**	**0,22**	13,79	**23,5**	**0,36**	31,51	**41,22**	**0,59**				15	20,39	**30,1**
20	5,79	**15,5**	**0,23**	13,99	**23,7**	**0,39**	34,47	**44,18**	**0,6**				20	19,71	**29,42**
30	6,82	**16,53**	**0,2**	15,19	**24,9**	**0,41**							30	16,69	**26,4**
40	8,71	**18,42**	**0,21**	16,17	**25,88**	**0,4**							40	13,17	**22,88**
50	9,59	**19,3**	**0,2**	17,72	**27,43**	**0,39**							60	8,02	**17,73**
60	10,35	**20,06**	**0,2**	19,52	**29,23**	**0,4**							90	3,86	**13,57**
70													120	1,31	**11,02**
80													150	0,86	**10,57**
90													180	0,6	**10,31**
100													210		
110													240		
120													300		
130													360		
140													420		
150													480		
160													540		
170															
180															

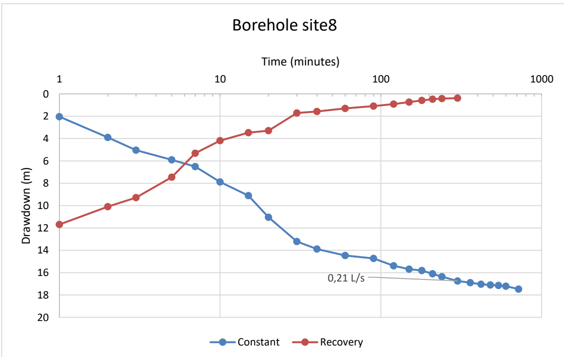


CONSTANT DISCHARGE

WL at start of test **10,31**

Monitoring Borehole
BH No PM-3
SWL 5,54

				recovery			
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL rec**	**Drawdown**	Recovery
1	2,04	**12,35**		11,69	**22**	**0**	0
2	3,9	**14,21**		10,1	**20,41**	**0**	0
3	5,04	**15,35**	**0,31**	9,29	**19,6**	**0**	0
5	5,91	**16,22**		7,46	**17,77**	**0**	0
7	6,51	**16,82**	**0,26**	5,31	**15,62**	**0**	0
10	7,89	**18,2**	**0,2**	4,19	**14,5**	**0**	0
15	9,1	**19,41**	**0,25**	3,47	**13,78**	**0**	0
20	11,04	**21,35**	**0,24**	3,29	**13,6**	**0**	0
30	13,21	**23,52**	**0,2**	1,71	**12,02**	**0**	0
40	13,89	**24,2**	**0,21**	1,57	**11,88**	**0**	0
60	14,47	**24,78**	**0,22**	1,3	**11,61**	**0**	0
90	14,72	**25,03**	**0,17**	1,09	**11,4**	**0**	0
120	15,39	**25,7**	**0,24**	0,91	**11,22**	**0**	0
150	15,69	**26**	**0,23**	0,74	**11,05**	**0**	0
180	15,81	**26,12**	**0,2**	0,59	**10,9**	**0**	0
210	16,1	**26,41**	**0,23**	0,47	**10,78**	**0**	0
240	16,36	**26,67**	**0,24**	0,42	**10,73**	**0**	0
300	16,74	**27,05**	**0,23**	0,38	**10,69**	**0**	0
360	16,9	**27,21**	**0,22**			**0**	0
420	17,04	**27,35**	**0,2**			**0**	0
480	17,11	**27,42**	**0,23**			**0**	0
540	17,15	**27,46**	**0,21**			**0**	0
600	17,21	**27,52**	**0,21**			**0**	0
720	17,47	**27,78**	**0,24**			**0**	0
840							
960							
1080							
1200							
1320							
1440							
2280							
2880							
3480							
3900							
4320							

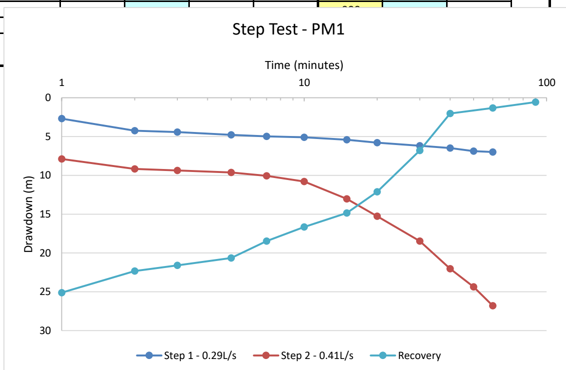


Borehole Number	PM-1	**Lat**	26,17026
BH Diameter	170mm	**Long**	29,99402
Collar Height	0,56		
BH Depth	39,7		
Pump Depth	27,88		

STEP DRAWDOWN

Static W/L **0,9**

	step 1			step 2			step 3			step 4				recovery	
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**time**		**WL rec**
1	2,69	3,59		7,89	8,79								1	25,11	26,01
2	4,25	5,15		9,18	10,08	0,49							2	22,32	23,22
3	4,42	5,32		9,36	10,26	0,45							3	21,6	22,5
5	4,78	5,68	0,34	9,62	10,52	0,41							5	20,65	21,55
7	4,97	5,87	0,31	10,06	10,96	0,46							7	18,47	19,37
10	5,09	5,99	0,29	10,79	11,69	0,4							10	16,64	17,54
15	5,42	6,32	0,34	13,02	13,92	0,42							15	14,85	15,75
20	5,78	6,68	0,33	15,26	16,16	0,41							20	12,12	13,02
30	6,19	7,09	0,28	18,47	19,37	0,44							30	6,8	7,7
40	6,48	7,38	0,29	22,02	22,92	0,39							40	2,03	2,93
50	6,87	7,77	0,29	24,36	25,26	0,4							60	1,31	2,21
60	6,99	7,89	0,28	26,8	27,7	0,41							90	0,56	1,46
70													120		
80													150		
90													180		
100													210		
110													240		
120													300		
130													360		
140													420		
150													480		
160													540		
170															
180															

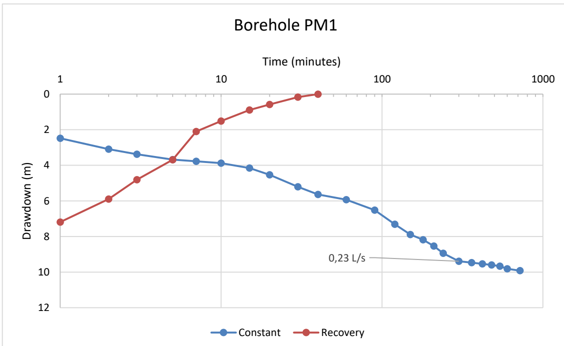


CONSTANT DISCHARGE

WL at start of test **1,46**

Monitoring Borehole
BH No PM-1
SWL 1,04

				recovery		
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL rec**	**Drawdown**
1	2,48	3,94		7,19	8,65	0
2	3,09	4,55		5,9	7,36	0
3	3,38	4,84	0,31	4,81	6,27	0
5	3,68	5,14	0,26	3,69	5,15	0
7	3,77	5,23	0,22	2,1	3,56	0
10	3,88	5,34	0,21	1,51	2,97	0
15	4,15	5,61	0,2	0,89	2,35	0
20	4,53	5,99	0,21	0,58	2,04	0
30	5,21	6,67	0,24	0,166	1,626	0
40	5,64	7,1	0,2	0	1,46	0
60	5,93	7,39	0,21			0
90	6,52	7,98	0,2			0
120	7,31	8,77	0,24			0
150	7,89	9,35	0,2			0
180	8,18	9,64	0,21			0
210	8,54	10	0,22			0
240	8,94	10,4	0,23			0
300	9,39	10,85	0,21			0
360	9,47	10,93	0,23			0
420	9,54	11	0,24			0
480	9,6	11,06	0,21			0
540	9,67	11,13	0,22			0
600	9,81	11,27	0,23			0
720	9,92	11,38	0,24			0
840						
960						
1080						
1200						
1320						
1440						
2280						
2880						
3480						
3900						
4320						

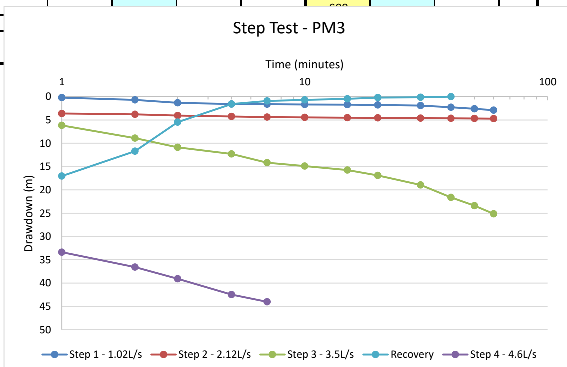


Borehole Number	PM-3	**Lat**	26,16337
BH Diameter	170mm	**Long**	30,0267
Collar Height	0,82		
BH Depth	47,61		
Pump Depth	44,18		

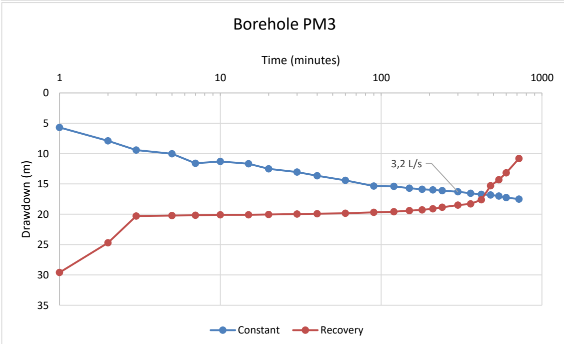
STEP DRAWDOWN

Static W/L **4,98**

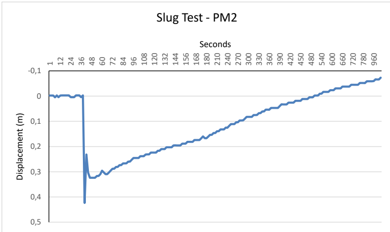
	step 1			step 2			step 3			step 4				recovery	
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**drawdown**	**WL**	**Yield**	**time**		**WL rec**
1	0,2	**5,18**		3,61	**8,59**		6,17	**11,15**		28,39	**33,37**		1	17,04	**22,02**
2	0,69	**5,67**		3,8	**8,78**		8,9	**13,88**		31,61	**36,59**		2	11,69	**16,67**
3	1,31	**6,29**		4,04	**9,02**	**1,89**	10,86	**15,84**	**3,46**	34,09	**39,07**	**4,67**	3	5,47	**10,45**
5	1,59	**6,57**	**0,98**	4,26	**9,24**	**1,99**	12,3	**17,28**	**3,41**	37,49	**42,47**	**4,6**	5	1,57	**6,55**
7	1,63	**6,61**		4,4	**9,38**	**2,19**	14,16	**19,14**	**3,53**	39,04	**44,02**	**4,39**	7	0,91	**5,89**
10	1,68	**6,66**	**1,04**	4,46	**9,44**	**2,16**	14,91	**19,89**	**3,46**				10	0,69	**5,67**
15	1,71	**6,69**	**1,03**	4,5	**9,48**	**2,17**	15,74	**20,72**	**3,55**				15	0,47	**5,45**
20	1,79	**6,77**	**1,02**	4,55	**9,53**	**2,16**	16,91	**21,89**	**3,48**				20	0,2	**5,18**
30	1,92	**6,9**	**0,96**	4,61	**9,59**	**2,1**	18,96	**23,94**	**3,5**				30	0,13	**5,11**
40	2,26	**7,24**	**1,03**	4,66	**9,64**	**2,13**	21,61	**26,59**	**3,52**				40	0	
50	2,62	**7,6**	**1,02**	4,69	**9,67**	**2,14**	23,39	**28,37**	**3,5**				60		
60	2,9	**7,88**	**1,04**	4,72	**9,7**	**2,12**	25,14	**30,12**	**3,57**				90		
70													120		
80													150		
90													180		
100													210		
110													240		
120													300		
130													360		
140													420		
150													480		
160													540		
170													[illegible]		
180															



CONSTANT DISCHARGE						Monitoring Borehole	
WL at start of test	**4,98**					**BH No**	PM-3
				recovery		**SWL**	5,54
time	**drawdown**	**WL**	**Yield**	**drawdown**	**WL rec**	**Drawdown**	Recovery
1	5,69	**10,67**		29,6	**34,58**	**0**	2,1
2	7,9	**12,88**		24,71	**29,69**	**0**	1,86
3	9,41	**14,39**		20,3	**25,28**	**0**	1,6
5	10,04	**15,02**	**3,57**	20,22	**25,2**	**0**	1,04
7	11,61	**16,59**		20,17	**25,15**	**0**	0,86
10	11,29	**16,27**	**3,39**	20,1	**25,08**	**0**	0,71
15	11,68	**16,66**	**3,26**	20,08	**25,06**	**0,29**	0,6
20	12,51	**17,49**	**3,27**	20,03	**25,01**	**0,52**	0,55
30	13,04	**18,02**	**3,25**	19,96	**24,94**	**0,64**	0,51
40	13,64	**18,62**	**3,26**	19,91	**24,89**	**0,93**	0,46
60	14,42	**19,4**	**3,23**	19,84	**24,82**	**1,08**	0,4
90	15,34	**20,32**	**3,21**	19,68	**24,66**	**1,36**	0,37
120	15,4	**20,38**	**3,23**	19,57	**24,55**	**1,61**	0,34
150	15,7	**20,68**	**3,2**	19,4	**24,38**	**1,85**	0,31
180	15,87	**20,85**	**3,22**	19,29	**24,27**	**1,97**	0,28
210	15,98	**20,96**	**3,23**	19,11	**24,09**	**2,08**	0,27
240	16,1	**21,08**	**3,24**	18,86	**23,84**	**2,15**	0,25
300	16,3	**21,28**	**3,23**	18,5	**23,48**	**2,24**	0,22
360	16,54	**21,52**	**3,24**	18,29	**23,27**	**2,4**	0,19
420	16,73	**21,71**	**3,21**	17,61	**22,59**	**2,69**	0,18
480	16,82	**21,8**	**3,23**	15,29	**20,27**	**2,91**	0,16
540	17	**21,98**	**3,2**	14,3	**19,28**	**3,09**	0,15
600	17,26	**22,24**	**3,21**	13,16	**18,14**	**3,16**	0,13
720	17,5	**22,48**	**3,23**	10,81	**15,79**	**3,29**	0,1
840							
960							
1080							
1200							
1320							
1440							
2280							
2880							
3480							
3900							
4320							



Casing Height	0.48m
Casing Diameter	177mm
Slug Diameter	80mm
Slug Length	1.05m
Comments	
Sensor SN	2815007
Sensor Type	Data
Sensor Name	In-Situ Sensor -1
File Name	PM2
# Records	191



Statistical Data		Pressure(m H2O)	Temperature(degC)
	Sensor Range	300 psia	-40 - +125 degC
	Minimum	-0,0731	17,25
	Maximum	0,4236	17,75
	Mean	0,1043	17,51
	Variance	0,0143	0,021
	Std Deviation	0,11959	0,145

Rec #	Date/Time	Pressure(m H2O)	Temperature(degC)	
1	1/17/2019 14:01:38	-0,0022	17,31	1
2	1/17/2019 14:01:40	-0,0024	17,38	2
3	1/17/2019 14:01:42	-0,0024	17,38	4
4	1/17/2019 14:01:44	0,0047	17,38	6
5	1/17/2019 14:01:46	-0,0026	17,44	8
6	1/17/2019 14:01:48	0,0045	17,44	10
7	1/17/2019 14:01:50	-0,0024	17,38	12
8	1/17/2019 14:01:52	-0,0026	17,44	14
9	1/17/2019 14:01:54	-0,0026	17,44	16
10	1/17/2019 14:01:56	-0,0026	17,44	18
11	1/17/2019 14:01:58	-0,0026	17,44	20
12	1/17/2019 14:02:00	-0,0026	17,44	22
13	1/17/2019 14:02:02	0,0045	17,44	24
14	1/17/2019 14:02:04	0,0045	17,44	26
15	1/17/2019 14:02:06	0,0045	17,44	28
16	1/17/2019 14:02:08	-0,0026	17,44	30
17	1/17/2019 14:02:10	-0,0028	17,5	32
18	1/17/2019 14:02:12	-0,0028	17,5	34
19	1/17/2019 14:02:14	0,0043	17,5	36
20	1/17/2019 14:02:16	-0,0028	17,5	38
21	1/17/2019 14:02:18	0,4236	17,5	40
22	1/17/2019 14:02:20	0,2317	17,5	42
23	1/17/2019 14:02:22	0,3028	17,5	44
24	1/17/2019 14:02:24	0,3241	17,5	46
25	1/17/2019 14:02:26	0,3241	17,5	48
26	1/17/2019 14:02:28	0,3239	17,56	50
27	1/17/2019 14:02:30	0,3241	17,5	52
28	1/17/2019 14:02:32	0,3168	17,56	54
29	1/17/2019 14:02:34	0,3168	17,56	56
30	1/17/2019 14:02:36	0,3097	17,56	58
31	1/17/2019 14:02:38	0,2955	17,56	60
32	1/17/2019 14:02:40	0,3024	17,63	62
33	1/17/2019 14:02:42	0,3095	17,63	64
34	1/17/2019 14:02:44	0,3095	17,63	66
35	1/17/2019 14:02:46	0,3024	17,63	68
36	1/17/2019 14:02:48	0,2953	17,63	70
37	1/17/2019 14:02:50	0,2882	17,63	72
38	1/17/2019 14:02:52	0,2882	17,63	74
39	1/17/2019 14:02:54	0,2809	17,69	76
40	1/17/2019 14:02:56	0,2809	17,69	78
41	1/17/2019 14:02:58	0,2738	17,69	80
42	1/17/2019 14:03:00	0,2738	17,69	82
43	1/17/2019 14:03:02	0,2669	17,63	84
44	1/17/2019 14:03:04	0,2669	17,63	86
45	1/17/2019 14:03:06	0,2667	17,69	88
46	1/17/2019 14:03:08	0,2598	17,63	90
47	1/17/2019 14:03:10	0,2598	17,63	92
48	1/17/2019 14:03:12	0,2527	17,63	94
49	1/17/2019 14:03:14	0,2454	17,69	96
50	1/17/2019 14:03:16	0,2454	17,69	98
51	1/17/2019 14:03:18	0,2454	17,69	100
52	1/17/2019 14:03:20	0,2456	17,63	102
53	1/17/2019 14:03:22	0,2383	17,69	104
54	1/17/2019 14:03:24	0,2383	17,69	106
55	1/17/2019 14:03:26	0,2383	17,69	108
56	1/17/2019 14:03:28	0,2314	17,63	110
57	1/17/2019 14:03:30	0,2312	17,69	112
58	1/17/2019 14:03:32	0,2312	17,69	114
59	1/17/2019 14:03:34	0,2241	17,69	116
60	1/17/2019 14:03:36	0,2241	17,69	118
61	1/17/2019 14:03:38	0,2241	17,69	120
62	1/17/2019 14:03:40	0,2241	17,69	122
63	1/17/2019 14:03:42	0,217	17,69	124
64	1/17/2019 14:03:44	0,217	17,69	126
65	1/17/2019 14:03:46	0,2099	17,69	128
66	1/17/2019 14:03:48	0,2099	17,69	130
67	1/17/2019 14:03:50	0,2099	17,69	132
68	1/17/2019 14:03:52	0,2027	17,69	134
69	1/17/2019 14:03:54	0,2027	17,69	136
70	1/17/2019 14:03:56	0,2027	17,69	138
71	1/17/2019 14:03:58	0,2027	17,69	140
72	1/17/2019 14:04:00	0,1956	17,69	142
73	1/17/2019 14:04:02	0,1955	17,75	144
74	1/17/2019 14:04:04	0,1956	17,69	146
75	1/17/2019 14:04:06	0,1956	17,69	148
76	1/17/2019 14:04:08	0,1956	17,69	150
77	1/17/2019 14:04:10	0,1885	17,69	152
78	1/17/2019 14:04:12	0,1885	17,69	154
79	1/17/2019 14:04:14	0,1885	17,69	156
80	1/17/2019 14:04:16	0,1814	17,69	158
81	1/17/2019 14:04:18	0,1814	17,69	160
82	1/17/2019 14:04:20	0,1814	17,69	162
83	1/17/2019 14:04:22	0,1814	17,69	164
84	1/17/2019 14:04:24	0,1743	17,69	166
85	1/17/2019 14:04:26	0,1743	17,69	168
86	1/17/2019 14:04:28	0,1743	17,69	170
87	1/17/2019 14:04:30	0,1743	17,69	172

88	1/17/2019 14:04:32	0,1672	17,69	174
89	1/17/2019 14:04:34	0,1601	17,69	176
90	1/17/2019 14:04:36	0,1672	17,69	178
91	1/17/2019 14:04:38	0,1672	17,69	180
92	1/17/2019 14:04:43	0,1603	17,63	185
93	1/17/2019 14:04:48	0,1534	17,56	190
94	1/17/2019 14:04:53	0,1534	17,56	195
95	1/17/2019 14:04:58	0,1463	17,56	200
96	1/17/2019 14:05:03	0,1463	17,56	205
97	1/17/2019 14:05:08	0,1392	17,56	210
98	1/17/2019 14:05:13	0,1393	17,5	215
99	1/17/2019 14:05:18	0,1322	17,5	220
100	1/17/2019 14:05:23	0,1322	17,5	225
101	1/17/2019 14:05:28	0,1322	17,5	230
102	1/17/2019 14:05:33	0,1251	17,5	235
103	1/17/2019 14:05:38	0,1253	17,44	240
104	1/17/2019 14:05:43	0,1182	17,44	245
105	1/17/2019 14:05:48	0,1111	17,44	250
106	1/17/2019 14:05:53	0,1111	17,44	255
107	1/17/2019 14:05:58	0,1109	17,5	260
108	1/17/2019 14:06:03	0,104	17,44	265
109	1/17/2019 14:06:08	0,104	17,44	270
110	1/17/2019 14:06:13	0,0969	17,44	275
111	1/17/2019 14:06:18	0,0965	17,56	280
112	1/17/2019 14:06:23	0,0963	17,63	285
113	1/17/2019 14:06:28	0,0896	17,5	290
114	1/17/2019 14:06:33	0,0825	17,5	295
115	1/17/2019 14:06:38	0,0825	17,5	300
116	1/17/2019 14:06:43	0,0823	17,56	305
117	1/17/2019 14:06:48	0,0823	17,56	310
118	1/17/2019 14:06:53	0,075	17,63	315
119	1/17/2019 14:06:58	0,075	17,63	320
120	1/17/2019 14:07:03	0,0748	17,69	325
121	1/17/2019 14:07:08	0,0677	17,69	330
122	1/17/2019 14:07:13	0,0677	17,69	335
123	1/17/2019 14:07:18	0,0608	17,63	340
124	1/17/2019 14:07:23	0,061	17,56	345
125	1/17/2019 14:07:28	0,0539	17,56	350
126	1/17/2019 14:07:33	0,0539	17,56	355
127	1/17/2019 14:07:38	0,054	17,5	360
128	1/17/2019 14:07:43	0,0469	17,5	365
129	1/17/2019 14:07:48	0,0469	17,5	370
130	1/17/2019 14:07:53	0,0469	17,5	375
131	1/17/2019 14:07:58	0,0469	17,5	380
132	1/17/2019 14:08:03	0,0469	17,5	385
133	1/17/2019 14:08:08	0,0398	17,5	390
134	1/17/2019 14:08:13	0,0327	17,5	395
135	1/17/2019 14:08:18	0,0329	17,44	400
136	1/17/2019 14:08:23	0,0329	17,44	405
137	1/17/2019 14:08:28	0,0329	17,44	410
138	1/17/2019 14:08:33	0,0258	17,44	415
139	1/17/2019 14:08:38	0,0258	17,44	420
140	1/17/2019 14:08:43	0,0258	17,44	425
141	1/17/2019 14:08:48	0,0258	17,44	430
142	1/17/2019 14:08:53	0,0187	17,44	435
143	1/17/2019 14:08:58	0,0187	17,44	440
144	1/17/2019 14:09:03	0,0187	17,44	445
145	1/17/2019 14:09:08	0,0187	17,44	450
146	1/17/2019 14:09:13	0,0116	17,44	455
147	1/17/2019 14:09:18	0,0116	17,44	460
148	1/17/2019 14:09:23	0,0116	17,44	465
149	1/17/2019 14:09:28	0,0116	17,44	470
150	1/17/2019 14:09:33	0,0047	17,38	475
151	1/17/2019 14:09:38	0,0047	17,38	480
152	1/17/2019 14:09:48	0,0047	17,38	490
153	1/17/2019 14:09:58	-0,0024	17,38	500
154	1/17/2019 14:10:08	-0,0024	17,38	510
155	1/17/2019 14:10:18	-0,0024	17,38	520
156	1/17/2019 14:10:28	-0,0095	17,38	530
157	1/17/2019 14:10:38	-0,0093	17,31	540
158	1/17/2019 14:10:48	-0,0165	17,31	550
159	1/17/2019 14:10:58	-0,0165	17,31	560
160	1/17/2019 14:11:08	-0,0165	17,31	570
161	1/17/2019 14:11:18	-0,0165	17,31	580
162	1/17/2019 14:11:28	-0,0236	17,31	590
163	1/17/2019 14:11:38	-0,0236	17,31	600
164	1/17/2019 14:11:48	-0,0236	17,31	610
165	1/17/2019 14:11:58	-0,0307	17,31	620
166	1/17/2019 14:12:08	-0,0307	17,31	630
167	1/17/2019 14:12:18	-0,0307	17,31	640
168	1/17/2019 14:12:28	-0,0305	17,25	650
169	1/17/2019 14:12:38	-0,0378	17,31	660
170	1/17/2019 14:12:48	-0,0376	17,25	670
171	1/17/2019 14:12:58	-0,0378	17,31	680
172	1/17/2019 14:13:08	-0,0378	17,31	690
173	1/17/2019 14:13:18	-0,0378	17,31	700
174	1/17/2019 14:13:28	-0,0449	17,31	710
175	1/17/2019 14:13:38	-0,0447	17,25	720
176	1/17/2019 14:13:48	-0,0449	17,31	730
177	1/17/2019 14:13:58	-0,0449	17,31	740
178	1/17/2019 14:14:08	-0,0447	17,25	750
179	1/17/2019 14:14:18	-0,052	17,31	760
180	1/17/2019 14:14:28	-0,052	17,31	770
181	1/17/2019 14:14:38	-0,052	17,31	780
182	1/17/2019 14:15:08	-0,0518	17,25	810
183	1/17/2019 14:15:38	-0,0589	17,25	840
184	1/17/2019 14:16:08	-0,0589	17,25	870
185	1/17/2019 14:16:38	-0,0589	17,25	900
186	1/17/2019 14:17:08	-0,0589	17,25	930
187	1/17/2019 14:17:38	-0,0595	17,44	960
188	1/17/2019 14:18:08	-0,0662	17,31	990
189	1/17/2019 14:18:38	-0,066	17,25	1020
190	1/17/2019 14:19:08	-0,066	17,25	1050
191	1/17/2019 14:19:38	-0,0731	17,25	1080

Appendix 5 – Laboratory Certificates of Analyses

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

23B De Havilland Crescent
Persequor Techno Park
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Pretoria

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e-mail: admin@waterlab.co.za

sanas Testing Laboratory T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2019 - 01 - 21 **Date completed:** 2019 - 02 – 13

Project number: 1000 **Report number: 80221** **Order number:**

Client name: Irene Lea Environmental and Hydrogeology cc **Contact person: Ms. I. Lea**

Address: P.O Box 343 Dunnotter 1590 **e-mail:** irene@ileh.co.za

Telephone: 011 363 2926 **Facsimile:** **Mobile:**

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification				
		BH 2-50	1-130B	KR3	KR11	KR12
Sample Number		52697	52698	52699	52700	52701
pH – Value at 25°C	WLAB065	9.2	8.9	7.9	8.0	7.7
Electrical Conductivity in mS/m at 25°C	WLAB002	53.4	25.0	31.0	48.5	41.9
Total Dissolved Solids at 180°C	WLAB003	425	215	216	375	365
Total Alkalinity as $CaCO_3$	WLAB007	284	120	116	156	128
P-Alkalinity as $CaCO_3$	WLAB023	52	15	<5	<5	<5
Bicarbonate as HCO_3	WLAB023	219	109	141	190	156
Total Hardness as $CaCO_3$	WLAB051	<5	75	47	139	27
Chloride as Cl	WLAB046	9	5	16	58	35
Sulphate as SO_4	WLAB046	<2	9	22	8	20
Fluoride as F	WLAB014	0.9	1.0	0.6	0.2	0.6
Nitrate as N	WLAB046	0.1	0.1	0.5	0.1	2.7
Nitrite as N	WLAB046	<0.05	<0.05	<0.05	<0.05	<0.05
Total Nitrogen as N*	WLAB025	1.0	0.6	0.8	0.9	3.2
Ortho Phosphate as P	WLAB046	<0.1	<0.1	<0.1	<0.1	0.2
Kjeldahl Nitrogen *	WLAB025	0.8	0.6	<0.5	0.8	0.6
Free & Saline Ammonia as N	WLAB046	0.7	0.6	0.2	0.5	0.6
ICP-MS Scan *	WLAB050	See Attached Report: 80221-A				
% Balancing *	---	97.2	96.3	96.2	97.6	96.4

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e-mail: admin@waterlab.co.za

sanas Testing Laboratory
T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2019 - 01 - 21 **Date completed:** 2019 - 02 – 13
Project number: 1000 **Report number: 80221** **Order number:**

Client name: Irene Lea Environmental and Hydrogeology cc **Contact person: Ms. I. Lea**
Address: P.O Box 343 Dunnotter 1590 **e-mail: irene@ileh.co.za**
Telephone: 011 363 2926 **Facsimile:** **Mobile:**

Analyses in mg/ℓ (Unless specified otherwise)	**Method Identification**	**Sample Identification**			
		KR14	**KR18**	**KR19**	**KR Spring 3**
Sample Number		52702	52703	52704	52705
pH – Value at 25°C	WLAB065	8.8	8.6	7.7	5.7
Electrical Conductivity in mS/m at 25°C	WLAB002	25.2	26.3	31.2	4.8
Total Dissolved Solids at 180°C	WLAB003	255	177	285	21
Total Alkalinity as $CaCO_3$	WLAB007	100	136	80	<5
P-Alkalinity as $CaCO_3$	WLAB023	10	10	<5	<5
Bicarbonate as HCO_3	WLAB023	99	142	98	5
Total Hardness as $CaCO_3$	WLAB051	42	71	94	7
Chloride as Cl	WLAB046	14	3	2	7
Sulphate as SO_4	WLAB046	14	5	69	3
Fluoride as F	WLAB014	0.2	0.2	0.7	<0.2
Nitrate as N	WLAB046	0.3	0.7	0.2	0.2
Nitrite as N	WLAB046	0.2	<0.05	<0.05	<0.05
Total Nitrogen as N*	WLAB025	1.6	1.4	1.4	0.5
Ortho Phosphate as P	WLAB046	<0.1	<0.1	<0.1	<0.1
Kjeldahl Nitrogen *	WLAB025	1.1	0.7	1.1	<0.5
Free & Saline Ammonia as N	WLAB046	1.1	0.2	0.2	0.2
ICP-MS Scan *	WLAB050	See Attached Report: 80221-A			
% Balancing *	---	95.2	98.3	99.8	97.9

*** = Not SANAS Accredited**
Tests marked "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this Laboratory.

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T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2019 - 02 - 05 **Date completed:** 2019 - 02 – 26
Project number: 1000 **Report number: 80642** **Order number:**

Client name: Irene Lea Environmental and Hydrogeology cc **Contact person: Ms. I. Lea**
Address: P.O Box 343 Dunnotter 1590 **e-mail: irene@ileh.co.za**
Telephone: 011 363 2926 **Facsimile:** **Mobile:**

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification		
		PM1	PM2	PM3
Sample Number		54202	54203	54204
pH – Value at 25°C	WLAB065	5.7	8.8	6.6
Electrical Conductivity in mS/m at 25°C	WLAB002	25.0	74.9	32.5
Total Dissolved Solids at 180°C	WLAB003	113	453	300
Total Alkalinity as $CaCO_3$	WLAB007	12	304	136
P-Alkalinity as $CaCO_3$	WLAB023	<5	48	<5
Bicarbonate as HCO_3	WLAB023	15	253	166
Total Hardness as $CaCO_3$	WLAB051	53	27	55
Chloride as Cl	WLAB046	44	68	22
Sulphate as SO_4	WLAB046	28	6	6
Fluoride as F	WLAB014	<0.2	1.7	0.4
Nitrate as N	WLAB046	2.5	<0.1	<0.1
Nitrite as N	WLAB046	<0.05	0.6	<0.05
Total Nitrogen as N*	WLAB025	2.5	0.6	<0.5
Ortho Phosphate as P	WLAB046	<0.1	<0.1	0.1
Kjeldahl Nitrogen *	WLAB025	<0.5	<0.5	<0.5
Free & Saline Ammonia as N	WLAB046	<0.1	<0.1	<0.1
ICP-MS Scan *	WLAB050	See Attached Report: 80642-A		
% Balancing *	---	96.4	94.5	97.0

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sanas Testing Laboratory
T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2019 - 02 - 05 **Date completed:** 2019 - 02 – 26
Project number: 1000 **Report number: 80642** **Order number:**

Client name: Irene Lea Environmental and Hydrogeology cc **Contact person: Ms. I. Lea**
Address: P.O Box 343 Dunnotter 1590 **e-mail:** irene@ileh.co.za
Telephone: 011 363 2926 **Facsimile:** **Mobile:**

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification		
		Site 08	5-110	6-220
Sample Number		54205	54206	54207
pH – Value at 25°C	WLAB065	7.2	7.6	7.6
Electrical Conductivity in mS/m at 25°C	WLAB002	28.4	29.3	26.3
Total Dissolved Solids at 180°C	WLAB003	200	180	120
Total Alkalinity as $CaCO_3$	WLAB007	120	160	128
P-Alkalinity as $CaCO_3$	WLAB023	<5	<5	<5
Bicarbonate as HCO_3	WLAB023	146	195	156
Total Hardness as $CaCO_3$	WLAB051	95	105	20
Chloride as Cl	WLAB046	8	5	12
Sulphate as SO_4	WLAB046	19	3	<2
Fluoride as F	WLAB014	0.2	0.2	1.0
Nitrate as N	WLAB046	<0.1	<0.1	<0.1
Nitrite as N	WLAB046	0.4	<0.05	<0.05
Total Nitrogen as N*	WLAB025	<0.5	<0.5	<0.5
Ortho Phosphate as P	WLAB046	<0.1	<0.1	<0.1
Kjeldahl Nitrogen *	WLAB025	<0.5	<0.5	<0.5
Free & Saline Ammonia as N	WLAB046	<0.1	<0.1	0.1
ICP-MS Scan *	WLAB050	See Attached Report: 80642-A		
% Balancing *	---	97.8	96.7	93.0

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WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSIS

Project Number : **1000**
Client : **Irene Lea Environmental**
Report Number : **80221-A**

Sample Origin	Sample ID	Ag (mg/L)	Al (mg/L)	As (mg/L)	Au (mg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Bi (mg/L)	Ca (mg/L)	Cd (mg/L)	Ce (mg/L)	Co (mg/L)
BH2-50	52697	< 0.010	0,115	< 0.010	< 0.010	0,079	0,014	< 0.010	< 0.010	1	< 0.010	< 0.010	< 0.010
1-130B	52698	< 0.010	0,895	< 0.010	< 0.010	0,059	0,190	< 0.010	< 0.010	15	< 0.010	< 0.010	< 0.010
KR3	52699	< 0.010	0,183	< 0.010	< 0.010	0,042	0,042	< 0.010	< 0.010	11	< 0.010	< 0.010	< 0.010
KR11	52700	< 0.010	< 0.100	< 0.010	< 0.010	0,016	0,261	< 0.010	< 0.010	29	< 0.010	< 0.010	< 0.010
KR12	52701	< 0.010	< 0.100	< 0.010	< 0.010	0,026	0,195	< 0.010	< 0.010	6	< 0.010	< 0.010	< 0.010
KR14	52702	< 0.010	0,150	< 0.010	< 0.010	0,060	0,135	< 0.010	< 0.010	10	< 0.010	< 0.010	< 0.010
KR18	52703	< 0.010	< 0.100	< 0.010	< 0.010	0,030	0,093	< 0.010	< 0.010	18	< 0.010	< 0.010	< 0.010
KR19	52704	< 0.010	< 0.100	< 0.010	< 0.010	0,024	0,089	< 0.010	< 0.010	20	< 0.010	< 0.010	< 0.010
KR Spring 3	52705	< 0.010	1,44	< 0.010	< 0.010	< 0.010	0,060	< 0.010	< 0.010	1	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Cr (mg/L)	Cs (mg/L)	Cu (mg/L)	Dy (mg/L)	Er (mg/L)	Eu (mg/L)	Fe (mg/L)	Ga (mg/L)	Gd (mg/L)	Ge (mg/L)	Hf (mg/L)	Hg (mg/L)
BH2-50	52697	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,058	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
1-130B	52698	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	5,89	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR3	52699	< 0.010	< 0.010	0,052	< 0.010	< 0.010	< 0.010	3,27	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR11	52700	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,210	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR12	52701	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,033	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR14	52702	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,161	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR18	52703	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,177	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR19	52704	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,350	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR Spring 3	52705	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,257	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Ho (mg/L)	In (mg/L)	Ir (mg/L)	K (mg/L)	La (mg/L)	Li (mg/L)	Lu (mg/L)	Mg (mg/L)	Mn (mg/L)	Mo (mg/L)	Na (mg/L)	Nb (mg/L)
BH2-50	52697	< 0.010	< 0.010	< 0.010	1,2	< 0.010	< 0.010	< 0.010	< 1	< 0.025	< 0.010	127	< 0.010
1-130B	52698	< 0.010	< 0.010	< 0.010	8,0	< 0.010	< 0.010	< 0.010	10	0,186	< 0.010	17	< 0.010
KR3	52699	< 0.010	< 0.010	< 0.010	3,1	< 0.010	< 0.010	< 0.010	5	< 0.025	< 0.010	46	< 0.010
KR11	52700	< 0.010	< 0.010	< 0.010	4,1	< 0.010	< 0.010	< 0.010	18	0,084	< 0.010	38	< 0.010
KR12	52701	< 0.010	< 0.010	< 0.010	5,2	< 0.010	< 0.010	< 0.010	3	< 0.025	< 0.010	73	< 0.010
KR14	52702	< 0.010	< 0.010	< 0.010	3,2	< 0.010	< 0.010	< 0.010	5	< 0.025	< 0.010	32	< 0.010
KR18	52703	< 0.010	< 0.010	< 0.010	4,2	< 0.010	< 0.010	< 0.010	8	< 0.025	< 0.010	27	< 0.010
KR19	52704	< 0.010	< 0.010	< 0.010	7,6	< 0.010	< 0.010	< 0.010	13	0,160	< 0.010	20	< 0.010
KR Spring 3	52705	< 0.010	< 0.010	< 0.010	1,9	< 0.010	< 0.010	< 0.010	1	< 0.025	< 0.010	4	< 0.010

Sample Origin	Sample ID	Nd (mg/L)	Ni (mg/L)	Os (mg/L)	P (mg/L)	Pb (mg/L)	Pd (mg/L)	Pr (mg/L)	Pt (mg/L)	Rb (mg/L)	Rh (mg/L)	Ru (mg/L)	Sb (mg/L)
BH2-50	52697	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
1-130B	52698	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR3	52699	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR11	52700	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR12	52701	< 0.010	< 0.010	< 0.010	0,116	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR14	52702	< 0.010	< 0.010	< 0.010	0,015	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR18	52703	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR19	52704	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR Spring 3	52705	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Sc (mg/L)	Se (mg/L)	Si (mg/L)	Sm (mg/L)	Sn (mg/L)	Sr (mg/L)	Ta (mg/L)	Tb (mg/L)	Te (mg/L)	Th (mg/L)	Ti (mg/L)	Tl (mg/L)
BH2-50	52697	< 0.010	< 0.010	9,1	< 0.010	< 0.010	0,034	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
1-130B	52698	< 0.010	< 0.010	2,0	< 0.010	< 0.010	0,187	< 0.010	< 0.010	< 0.010	< 0.010	0,013	< 0.010
KR3	52699	< 0.010	< 0.010	5,3	< 0.010	< 0.010	0,089	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR11	52700	< 0.010	< 0.010	14,3	< 0.010	< 0.010	0,410	< 0.010	< 0.010	< 0.010	< 0.010	0,010	< 0.010
KR12	52701	< 0.010	< 0.010	5,8	< 0.010	< 0.010	0,188	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR14	52702	< 0.010	< 0.010	21	< 0.010	< 0.010	0,106	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR18	52703	< 0.010	< 0.010	21	< 0.010	< 0.010	0,179	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR19	52704	< 0.010	< 0.010	9,8	< 0.010	< 0.010	0,220	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
KR Spring 3	52705	< 0.010	< 0.010	6,9	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,021	< 0.010

Sample Origin	Sample ID	Tm (mg/L)	U (mg/L)	V (mg/L)	W (mg/L)	Y (mg/L)	Yb (mg/L)	Zn (mg/L)	Zr (mg/L)
BH2-50	52697	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,029	< 0.010
1-130B	52698	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,033	< 0.010
KR3	52699	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,068	< 0.010
KR11	52700	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,062	< 0.010
KR12	52701	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,032	< 0.010
KR14	52702	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,028	< 0.010
KR18	52703	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,065	< 0.010
KR19	52704	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,056	< 0.010
KR Spring 3	52705	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,029	< 0.010

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSIS

Project Number : **1000**
Client : **Irene Lea Environmental and Hydrogeology**
Report Number : **80642-A**

Sample Origin	Sample ID	Ag (mg/L)	Al (mg/L)	As (mg/L)	Au (mg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Bi (mg/L)	Ca (mg/L)	Cd (mg/L)	Ce (mg/L)	Co (mg/L)
PM1	54202	< 0.010	0,124	< 0.010	< 0.010	< 0.010	0,228	< 0.010	< 0.010	9	< 0.010	< 0.010	< 0.010
PM2	54203	< 0.010	0,350	< 0.010	< 0.010	0,048	0,106	< 0.010	< 0.010	6	< 0.010	< 0.010	< 0.010
PM3	54204	< 0.010	< 0.100	< 0.010	< 0.010	< 0.010	0,107	< 0.010	< 0.010	12	< 0.010	< 0.010	< 0.010
Site 8	54205	< 0.010	0,171	< 0.010	< 0.010	0,011	0,167	< 0.010	< 0.010	22	< 0.010	< 0.010	< 0.010
5-110	54206	< 0.010	< 0.100	< 0.010	< 0.010	0,013	0,156	< 0.010	< 0.010	28	< 0.010	< 0.010	< 0.010
6-220	54207	< 0.010	< 0.100	< 0.010	< 0.010	0,032	0,136	< 0.010	< 0.010	5	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Cr (mg/L)	Cs (mg/L)	Cu (mg/L)	Dy (mg/L)	Er (mg/L)	Eu (mg/L)	Fe (mg/L)	Ga (mg/L)	Gd (mg/L)	Ge (mg/L)	Hf (mg/L)	Hg (mg/L)
PM1	54202	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	2,77	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PM2	54203	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	1,34	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PM3	54204	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	1,44	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Site 8	54205	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	7,47	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
5-110	54206	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,077	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
6-220	54207	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,197	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

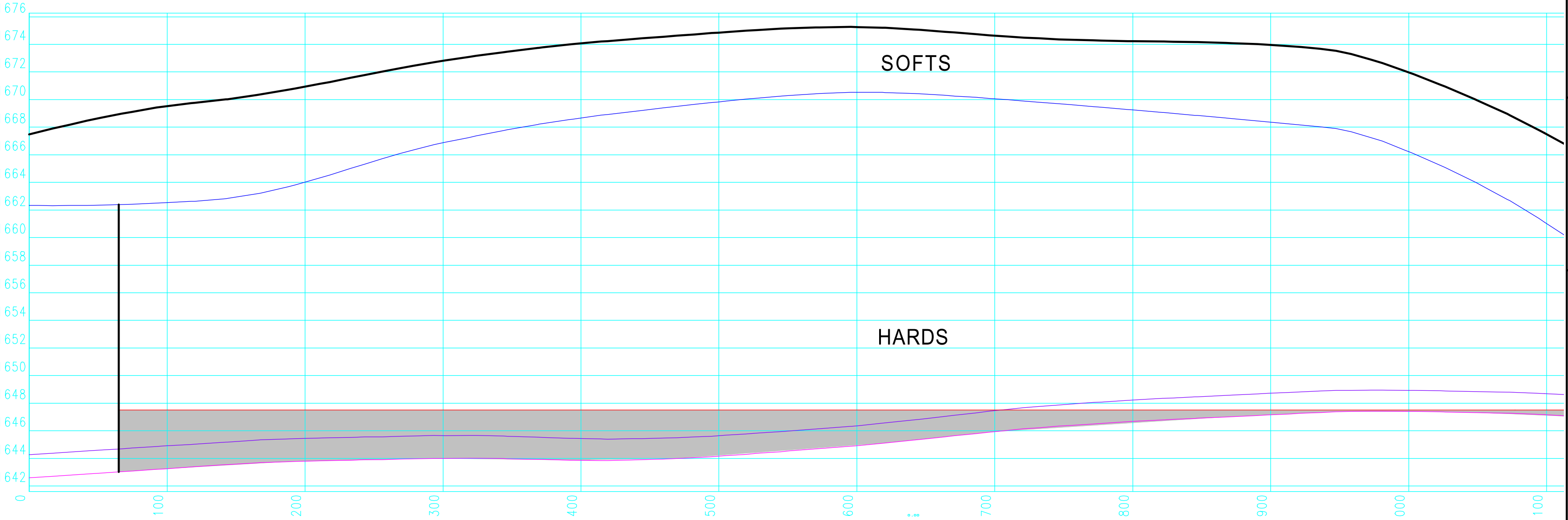
Sample Origin	Sample ID	Ho (mg/L)	In (mg/L)	Ir (mg/L)	K (mg/L)	La (mg/L)	Li (mg/L)	Lu (mg/L)	Mg (mg/L)	Mn (mg/L)	Mo (mg/L)	Na (mg/L)	Nb (mg/L)
PM1	54202	< 0.010	< 0.010	< 0.010	3,7	< 0.010	< 0.010	< 0.010	9	0,067	< 0.010	18	< 0.010
PM2	54203	< 0.010	< 0.010	< 0.010	17,7	< 0.010	< 0.010	< 0.010	4	0,065	< 0.010	144	< 0.010
PM3	54204	< 0.010	< 0.010	< 0.010	7,4	< 0.010	< 0.010	< 0.010	9	0,110	< 0.010	40	< 0.010
Site 8	54205	< 0.010	< 0.010	< 0.010	6,6	< 0.010	< 0.010	< 0.010	13	0,096	< 0.010	13	< 0.010
5-110	54206	< 0.010	< 0.010	< 0.010	3,3	< 0.010	< 0.010	< 0.010	14	0,079	< 0.010	13	< 0.010
6-220	54207	< 0.010	< 0.010	< 0.010	3,6	< 0.010	< 0.010	< 0.010	3	0,030	< 0.010	45	< 0.010

Sample Origin	Sample ID	Nd (mg/L)	Ni (mg/L)	Os (mg/L)	P (mg/L)	Pb (mg/L)	Pd (mg/L)	Pr (mg/L)	Pt (mg/L)	Rb (mg/L)	Rh (mg/L)	Ru (mg/L)	Sb (mg/L)
PM1	54202	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PM2	54203	< 0.010	< 0.010	< 0.010	0,013	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PM3	54204	< 0.010	< 0.010	< 0.010	0,215	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Site 8	54205	< 0.010	< 0.010	< 0.010	0,053	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
5-110	54206	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
6-220	54207	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Sc (mg/L)	Se (mg/L)	Si (mg/L)	Sm (mg/L)	Sn (mg/L)	Sr (mg/L)	Ta (mg/L)	Tb (mg/L)	Te (mg/L)	Th (mg/L)	Ti (mg/L)	Tl (mg/L)
PM1	54202	< 0.010	< 0.010	3,9	< 0.010	< 0.010	0,050	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PM2	54203	< 0.010	< 0.010	1,6	< 0.010	< 0.010	0,141	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
PM3	54204	< 0.010	< 0.010	34,8	< 0.010	< 0.010	0,054	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Site 8	54205	< 0.010	< 0.010	15,8	< 0.010	< 0.010	0,150	< 0.010	< 0.010	< 0.010	< 0.010	0,011	< 0.010
5-110	54206	< 0.010	< 0.010	12,0	< 0.010	< 0.010	0,112	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
6-220	54207	< 0.010	< 0.010	7,5	< 0.010	< 0.010	0,041	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Origin	Sample ID	Tm (mg/L)	U (mg/L)	V (mg/L)	W (mg/L)	Y (mg/L)	Yb (mg/L)	Zn (mg/L)	Zr (mg/L)
PM1	54202	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,055	< 0.010
PM2	54203	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,028	< 0.010
PM3	54204	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,027	< 0.010
Site 8	54205	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,038	< 0.010
5-110	54206	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,020	< 0.010
6-220	54207	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0,021	< 0.010

APPENDIX 4: IN-PIT DISPOSAL



SECTION C1 - C2

ILIMA COAL (PTY) LTD

KRANPAN COLLIERY

PIT 5
SECTION C1 - C2

NOTES

BLACK = ORIGINAL GROUND LEVEL
BLUE = LIMIT OF WEATHERING
PURPLE = TOP OF COAL
PINK = BOTTOM OF COAL

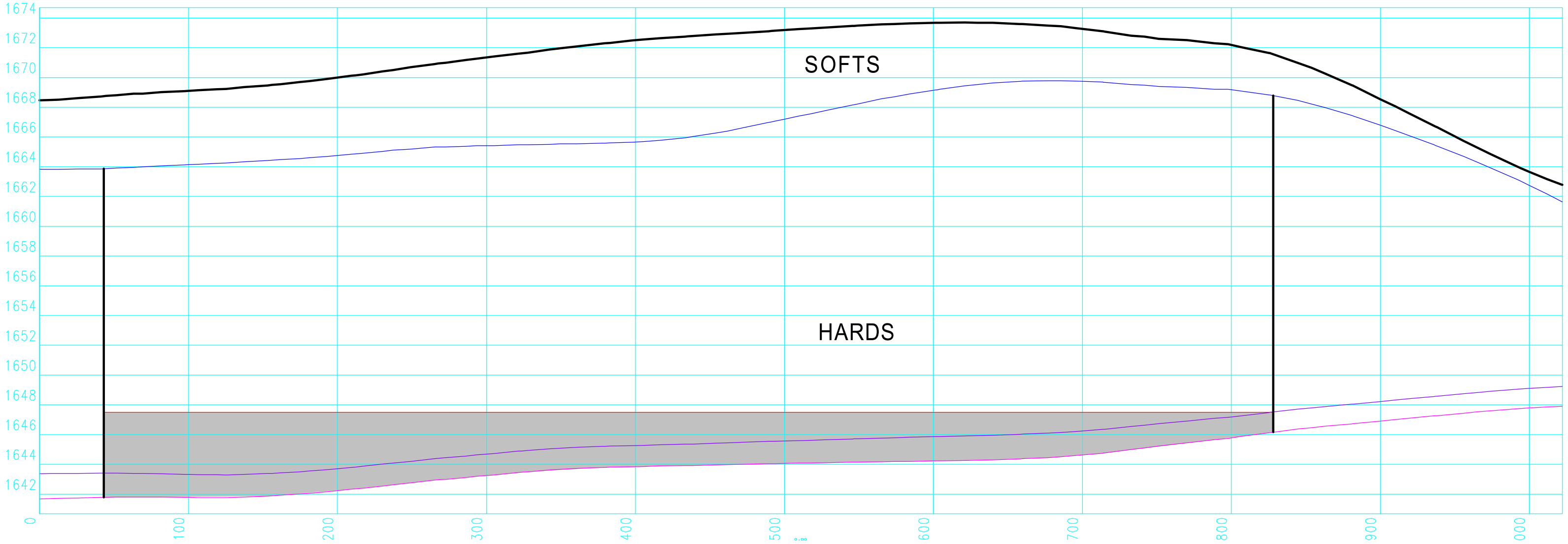
GREY HATCH = DISCARD BACKFILL

5000

13/5/2019

PLAN REFERENCE
190513_KRANSPAN SECTION C1-C2

EUGENE PRETORIUS
& ASSOCIATES (PTY) LTD
TEL : (013) 243 5864/5
FAX : (013) 243 5866
E-MAIL : stephan@epasurvey.co.za
Website : www.epasurvey.co.za
30 LITER STREET, MIDDELBURG, 1050



SECTION B1 - B2

ILIMA COAL (PTY) LTD

KRANPAN COLLIERY

PIT 5 SECTION B1 - B2

NOTES

BLACK = ORIGINAL GROUND LEVEL

BLUE = LIMIT OF WEATHERING

PURPLE = TOP OF COAL

PINK = BOTTOM OF COAL

GREY HATCH = DISCARD BACKFILL

5000

13/5/2019

PLAN REFERENCE

190513_KRANSPAN SECTION B1-B2

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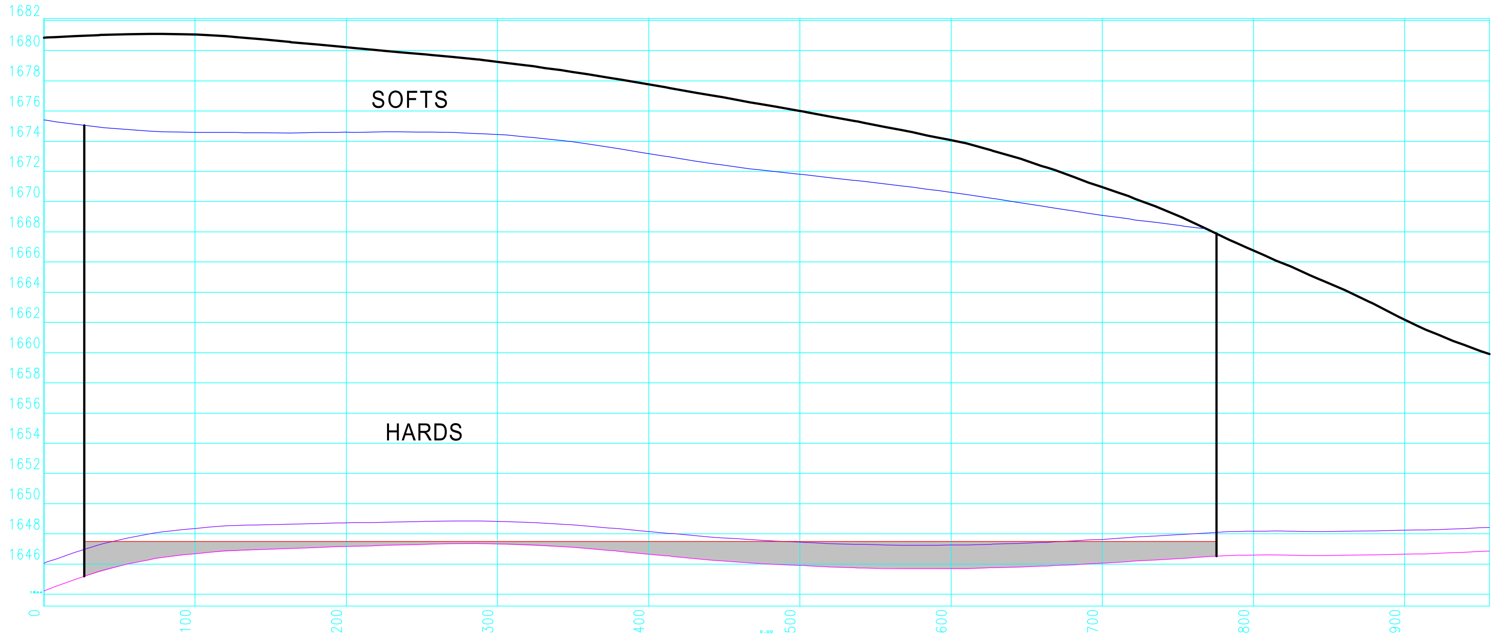
30 LITER STREET, MIDDELBURG, 1050



SECTION A1 - A2

ILIMA COAL (PTY) LTD

KRANPAN COLLIERY

PIT 5

SECTION A1 - A2

NOTES

BLACK = ORIGINAL GROUND LEVEL

BLUE = LIMIT OF WEATHERING

PURPLE = TOP OF COAL

PINK = BOTTOM OF COAL

GREY HATCH = DISCARD BACKFILL

5000

13/5/2019

PLAN REFERENCE

190513_KRANSPAN SECTION A1-A2

EUGENE PRETORIUS
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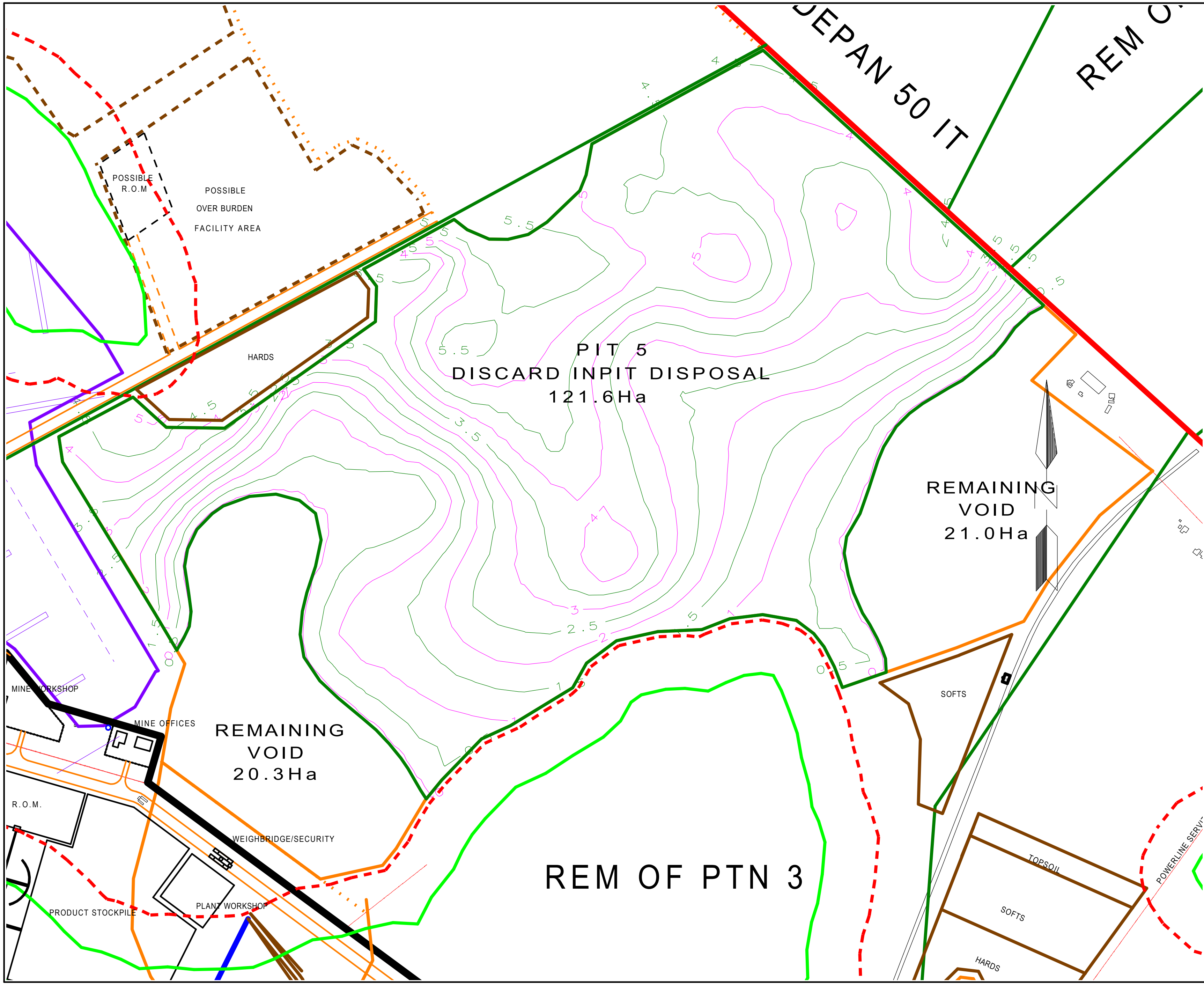

ILIMA COAL (PTY) LTD

KRANSPAN
PIT 5

DISCARD BACKFILL DEPTH PLAN

NOTES

CONTOURS INDICATES DISCARD DEPTHS @ 0.5m INTERVALS

TOP OF DISCARD @ 1647.5m AOD

SCALE 1: 10000

DATE :7/5/2019

PLAN REFERENCE

190507 KRANSPAN DISCARD DEPTH PLAN

EUGENE PRETORIUS
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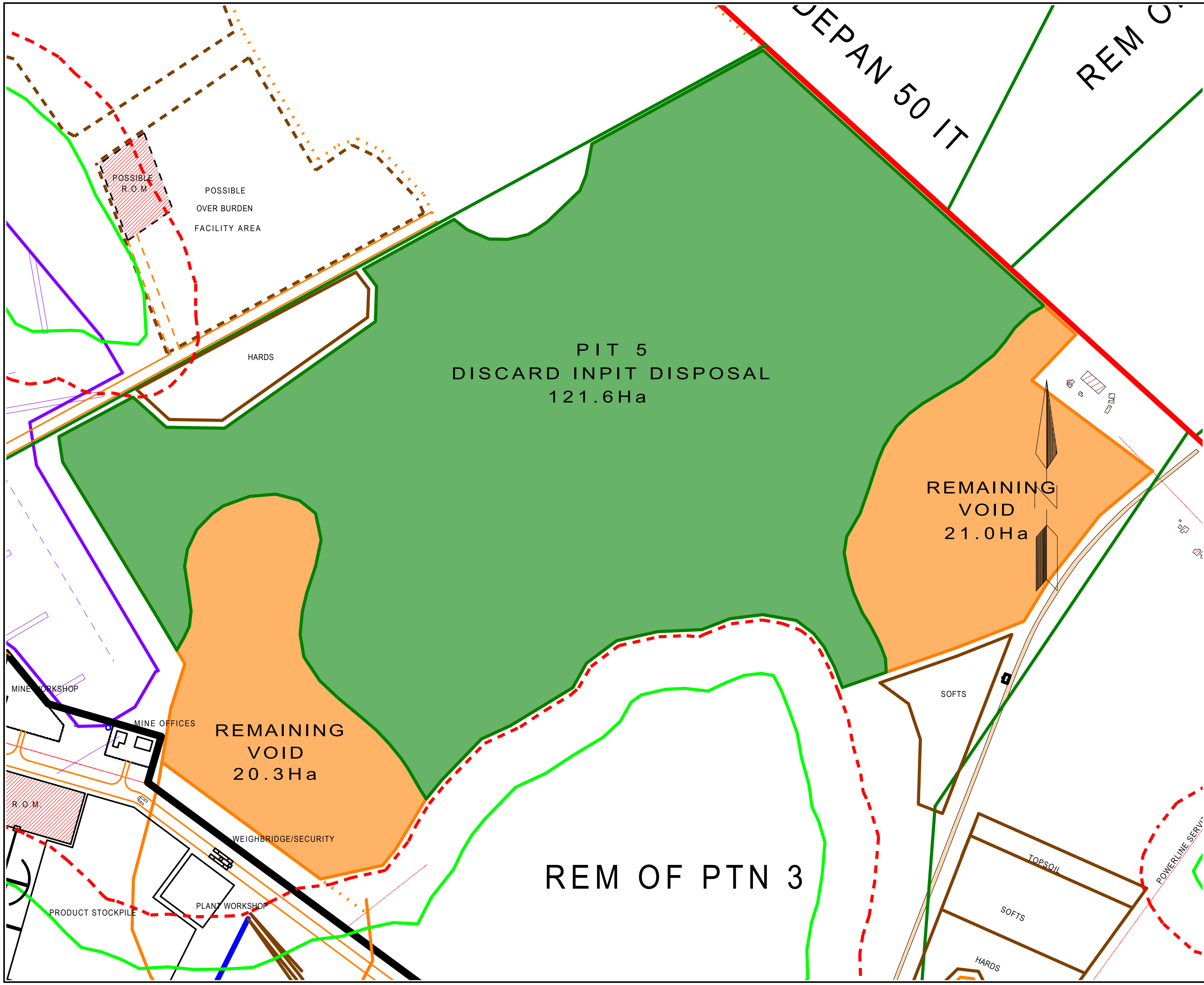

ILIMA COAL (PTY) LTD

KRANSPAN
PIT 5

DISCARD BACKFILL AREA PLAN

NOTES

HATCHED AREA = DISCARD INPIT BACKFILL AREA.

TOP OF DISCARD @ 1647.5m AOD

ESTIMATE VOLUME = 3,375,449m3

ESTIMATE AREA = 1,216,329m2

SCALE 1: 10000

DATE :7/5/2019

PLAN REFERENCE

190507 KRANSPAN DISCARD AREA PLAN

EPA

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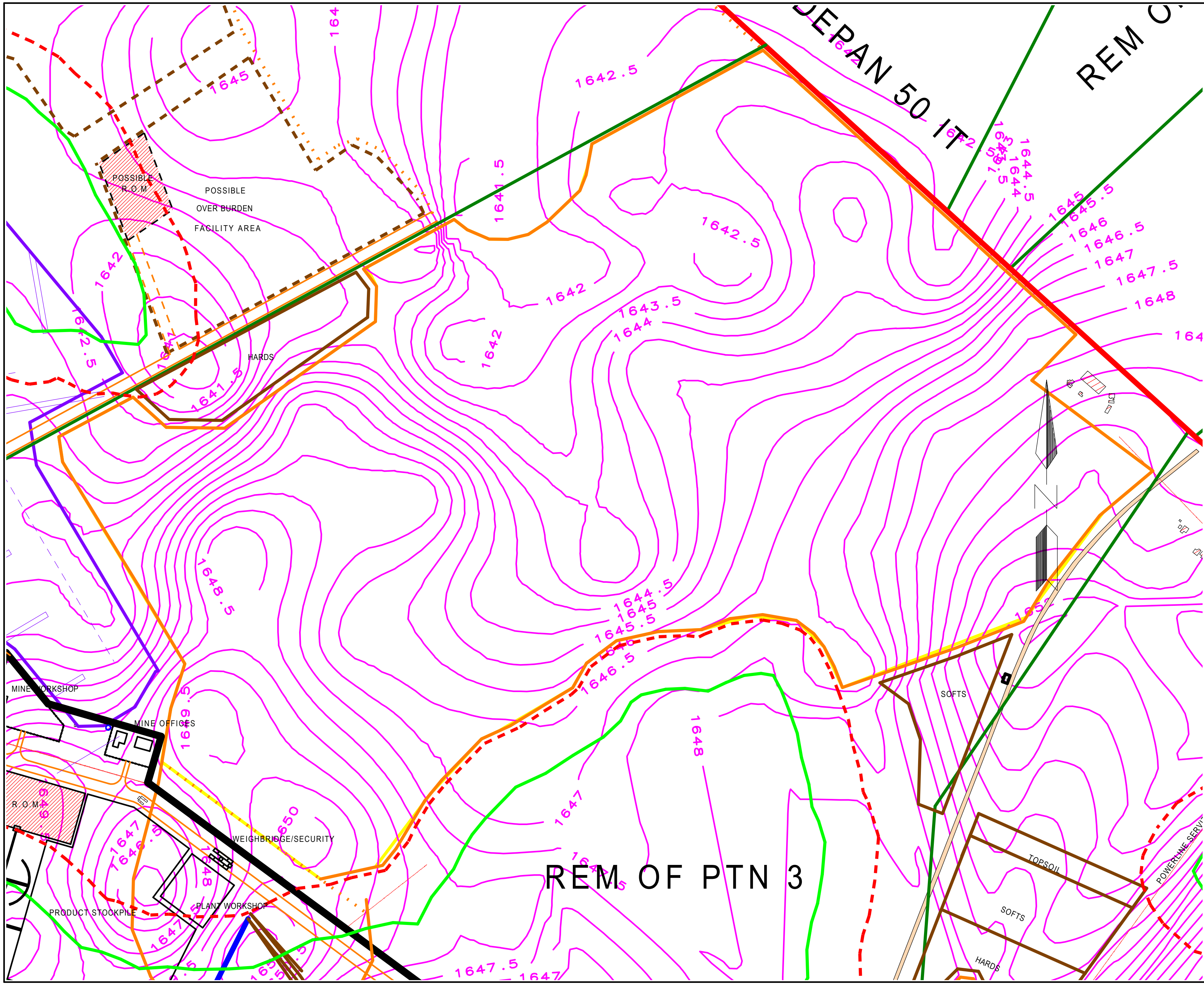

ILIMA COAL (PTY) LTD

KRANSPAN COLLIERY

COAL FLOOR PLAN

NOTES

CONTOURS INDICATES COAL FLOOR CONTOURS

CONTOURS @ 0.5m INTERVALS

SCALE 1: 10000

DATE :7/5/2019

PLAN REFERENCE

190507 KRANSPAN COAL FLOOR PLAN

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