FINAL REPORT

LUSTHOF COLLIERY

EIA SCOPING REPORT & PLAN OF STUDY

VOLUME 1 OF 2

Date: 21 January 2013
JMA Ref: 10429
JMA File Ref: Prj5620
DMR Ref: MP 30/5/1/2/3/2/1/ (66) EM
DEDET Ref: 17/2/3 GS-149

COMPILED FOR

Black Gold Coal Estates (Pty) Ltd
P O Box 3185
WITBANK

COMPILED BY

JMA Consulting (Pty) Ltd
Sustainable Environmental Solutions
through
Integrated Science and Engineering

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

APPENDICES

APPENDIX 1.4 (A):	**Land Claims Commissioner Correspondence**
APPENDIX 1.6 (A):	**Copies of the Title Deeds**
APPENDIX 1.10 (A):	**Proof of Notifications send to IA&P's**
APPENDIX 1.11 (A):	**CV's of EAP and Project Specialists**
APPENDIX 1.12 (A):	**Copies of Existing Authorizations**
APPENDIX 2.6 (A):	**Socio-Economic Specialist Report**
APPENDIX 3.1.5.1 (A):	**Large Scale Map of Mine Area and Project Infrastructure**
APPENDIX 6 (A):	**Draft Public Participation Programme Report**

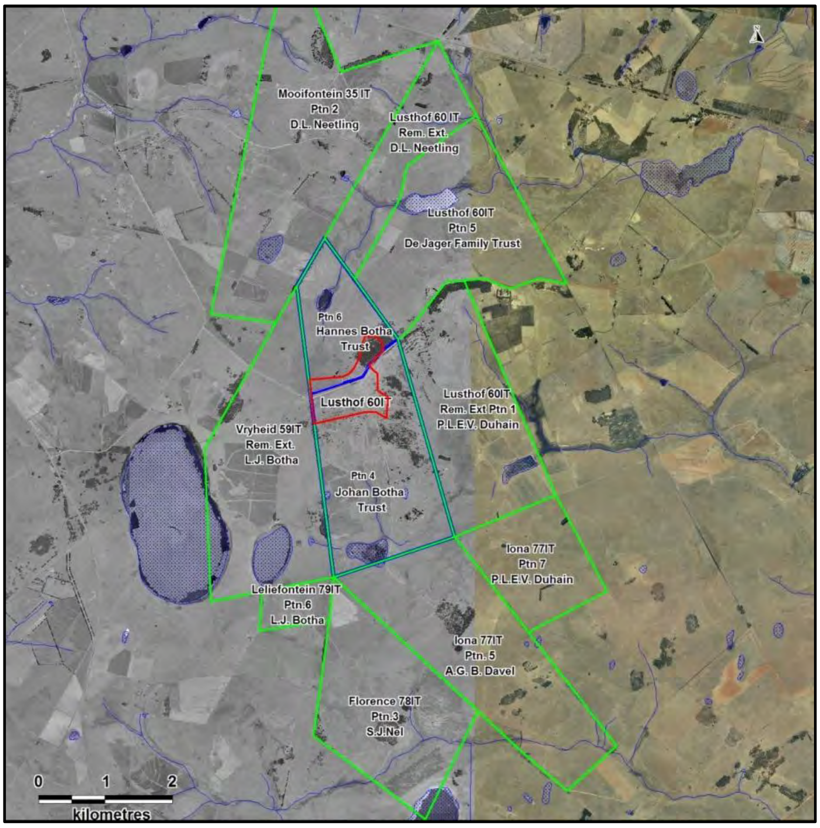
EXECUTIVE SUMMARY

This Report represents the **Final Scoping Report and Plan of Study** compiled in support of the Environmental Authorisations required for the **Lusthof Colliery Project**. The Draft version of this report was subjected to a 30 days public review period and was finalized to include all issues and comments, as well as responses thereto – see the formal Issues, Comments and Response Register in Appendix 6(A).

The Scoping Report as well as this Executive Summary was compiled to support the information requirements as detailed in the most recent **DMR Guideline for the Compilation of a Scoping Report**, amended with sections to provide for information required by DEDET and which is not part of the DMR Guideline. The **EIA** and **EMP** following on this report will also be compiled in strict compliance with the new format required by DMR.

The following information, as requested in the DMR Guideline, is provided in this summary:

1. The Methodology Applied to Conduct Scoping
2. A Description of the Existing Status of the Cultural, Socio-economic and Biophysical Environment
3. An Identification of the Anticipated Environmental, Social or Cultural Impacts
4. A Description of any Proposed Land Use or Development Alternatives
5. A Description of the most Appropriate Procedure to Plan and Develop the Proposed Mining Operation
6. A Description of the Process of Engagement
7. Plan of Study for the EIA Phase
8. Identification of Report



The Lusthof Colliery Project Area

1. The Methodology Applied to Conduct Scoping

The information generated during the Scoping Phase of the project confirmed that no **"communities"** as defined in the MPRDA are directly affected by the proposed Lusthof Colliery development. Although farm labourers do live within the affected area, they have confirmed that they are aware that they will be relocated.

According to information at our disposal, there are no land claims on the relevant properties, and no Traditional Authority has any jurisdiction on any of the properties.

The land on which the proposed Lusthof Colliery is located, is owned by parties which hold formal Title Deeds in respect of the properties. The current land owners also represent the lawful land occupiers at present.

The project is located in the Albert Luthuli Local Municipalities which form part of the Gert Sibande District Municipality. Relevant authorities and institutions involved in the project include DWEA, DWA, DMR, DEDET, DARDLA, DHSD, MTPA and SAHRA.

Proof of project notifications to all stakeholders is attached as APPENDIX 1.11(A) of this report.

2. A Description of the Existing Status of the Cultural, Socio-Economic and Biophysical Environment

Several Specialist Consultants were appointed by JMA Consulting, the project EAP, to compile Environmental Base Line Descriptions for all relevant Environmental Components. The information generated was assimilated in full into Chapter 2 of the the Scoping Report. The following aspects were covered:

Socio-Cultural Aspects
Heritage Aspects
Current Land Use
Socio-Economic Aspects
Climate/Meteorology
Topography
Soils
Land Capability
Geology/Geochemistry
Ground Water
Surface Water
Plant Life
Animal Life
Aquatic Ecosystems (Wetlands, Streams and Pans)
Air Quality
Noise
Visual Aspects
Blasting and Vibration

The base line information generated into the Scoping Report was made available to all I&AP's after the Scoping Phase Public Meeting. During the Public Meeting I&AP's were requested to review the base line information and to submit any comments which they may have to the project EAP. A review period of 30 days was allowed. All comments received were dealt with via the formal Public Participation Comments and Response Register – see Appendix 6(A).

The comments received which related to the Environmental Base Line descriptions were all addressed and/or updated into this final Scoping Report, and **it is therefore deemed that the I&AP's have Confirmed the Status of the Existing Environment**.

3. An Identification of the Anticipated Environmental, Social or Cultural Impacts

A fully detailed Life Cycle Project Activity Description is contained in section 3.1 of the Scoping Report.

Using this information as reference, a comprehensive list of potential impacts (including cumulative impacts) on the Environment (Cultural, Heritage, Socio-Economic, Infrastructure and Biophysical) was compiled and included in section 3.4 of the Scoping Report.

A full list of other listed activities and water uses occurring in the project is also included in section 3.2 of the Scoping Report.

This information was made available to the I&AP's during the 30 day review period.

All comments which were received from I&AP's were dealt with extensively in the Comments and Response Register.

The potential impacts are therefore deemed to have been fully consulted and confirmed with the I&AP's – see section 3.3 of the Final Scoping Report.

4. Description of any Proposed Land Use or Development Alternatives

Chapter 4 of the Scoping Report deals with Project Alternatives and how they will be assessed during the EIA Phase of the Project – this includes the No-Go Option.

5. A Description of the most Appropriate Procedure to Plan and Develop the Proposed Mining Operation

Planning options which stemmed from consultation, as well as the dynamics of the planning and development procedure is addressed in Chapter 5 of the Scoping Report.

6. A Description of the Process of Engagement

Chapter 6 of the Scoping Report gives a detailed record of the Public Participation Process conducted to date. The Draft Public Participation Programme Report, which includes the current Comments and Response Register, is attached as APPENDIX 6(A).

7. Plan of Study for the EIA Phase

A comprehensive Plan of Study for the EIA Phase of the Project is included in Chapter 7 of the Scoping Report and was also consulted with the I&AP's. The Plan of Study was also made available during the 30 day review period, and is **therefore deemed to have been consulted with stakeholders**. All comments related to proposed work for the EIA Phase were recorded in the Comments and Response Register attached as APPENDIX 6(A).

8. Identification of Report

Herewith I, the person whose name and identity number is stated below, confirm that I am the person authorized to act as representative of the applicant in terms of the resolution submitted with the application, and confirm that the above report comprises the results of consultation as contemplated in Section 16(4)(b) or 27(5)(b) of the Act, as the case may be.	
Full Names and Surname	Jasper Lodewyk Muller (Pr.Sci.Nat.)
Identity Number	571116 5104 081
Signature	

1. METHODOLOGY APPLIED FOR SCOPING

1.1 IDENTIFIED COMMUNITIES

Following the guideline for the compilation of a Scoping Report published by the Department Mineral Resources (DMR), a community refers to a group of historically disadvantaged persons with interests or rights in a particular area of land on which members have or exercise communal rights in terms of an agreement, custom or law: provided that,

where as a consequence of the provisions of the Act negotiations or consultations with the community are required, the community shall include the members or part of the community, directly affected by prospecting or mining, on land occupied by such members or part of the community.

Following this definition, no defined communities are present in the project area.

1.2 COMMUNITY LANDOWNER STATUS

Community Landowner Status is not relevant in the Lusthof Colliery project area.

1.3 INVOLVEMENT STATUS OF DEPARTMENT OF LAND AFFAIRS

The Department of Land Affairs was consulted with regard to possible Land Claims but is not otherwise actively involved in this project.

1.4 LAND CLAIM STATUS

JMA Consulting formally requested the Land Claim Status of the two relevant properties from the Land Claims Commissioner.

The two properties in question, which are located in the Mpumalanga Province, are as follows:

- Portion 4 of the farm Lusthof 60 IT
- Portion 6 of the farm Lusthof 60 IT

Both are located within the Albert Luthuli Local Municipality.

Confirmation was received from the Acting Regional Land Claims Commissioner Mpumalanga; Mr LH Maphutha; Department of Rural Development and Land Reform that according to their Landbase, currently no registered land claims have been lodged on the mentioned properties.

A copy of the confirmation letter received from the Land Claims Commissioner is attached as APPENDIX 1.4 (A).

1.5 RELEVANT TRADITIONAL AUTHORITY

No traditional authority has jurisdiction on the land on which the Lusthof Colliery operations will be conducted and to which this application has relevance.

1.6 DESCRIPTION OF LAND OWNERS

The proposed project will be located on the following properties:

No	Property Name	Title Deed No	Owner		Zoning Status
1.	Lusthof 60 IT Portion 4	T4279/1986	Name	Johan Botha Trust	Agricultural
			Contact Person	Hannes Botha	
			Tel	(017) 843 3189	
			Fax	(017) 843 3189	
			Cellular	083 630 1251	
			Postal Address	P O Box 1145, Carolina, 1185	
			e-mail	hanribotha@mweb.co.za	
2.	Lusthof 60 IT Portion 6	T21964/968	Name	Hannes Botha Trust	Agricultural
			Contact Person	Hannes Botha	
			Tel	(017) 843 3189	
			Fax	(017) 843 3189	
			Cellular	083 630 1251	
			Postal Address	P O Box 1145, Carolina, 1185	
			e-mail	hanribotha@mweb.co.za	

Copies of the actual Title Deeds for the two properties are attached as APPENDIX 1.6 (A) to this report. Both properties are zoned Agricultural. Agreements have been reached with both land owners that Black Gold Coal Estates (Pty) Ltd (BGCE) will purchase both properties prior to project commencement.

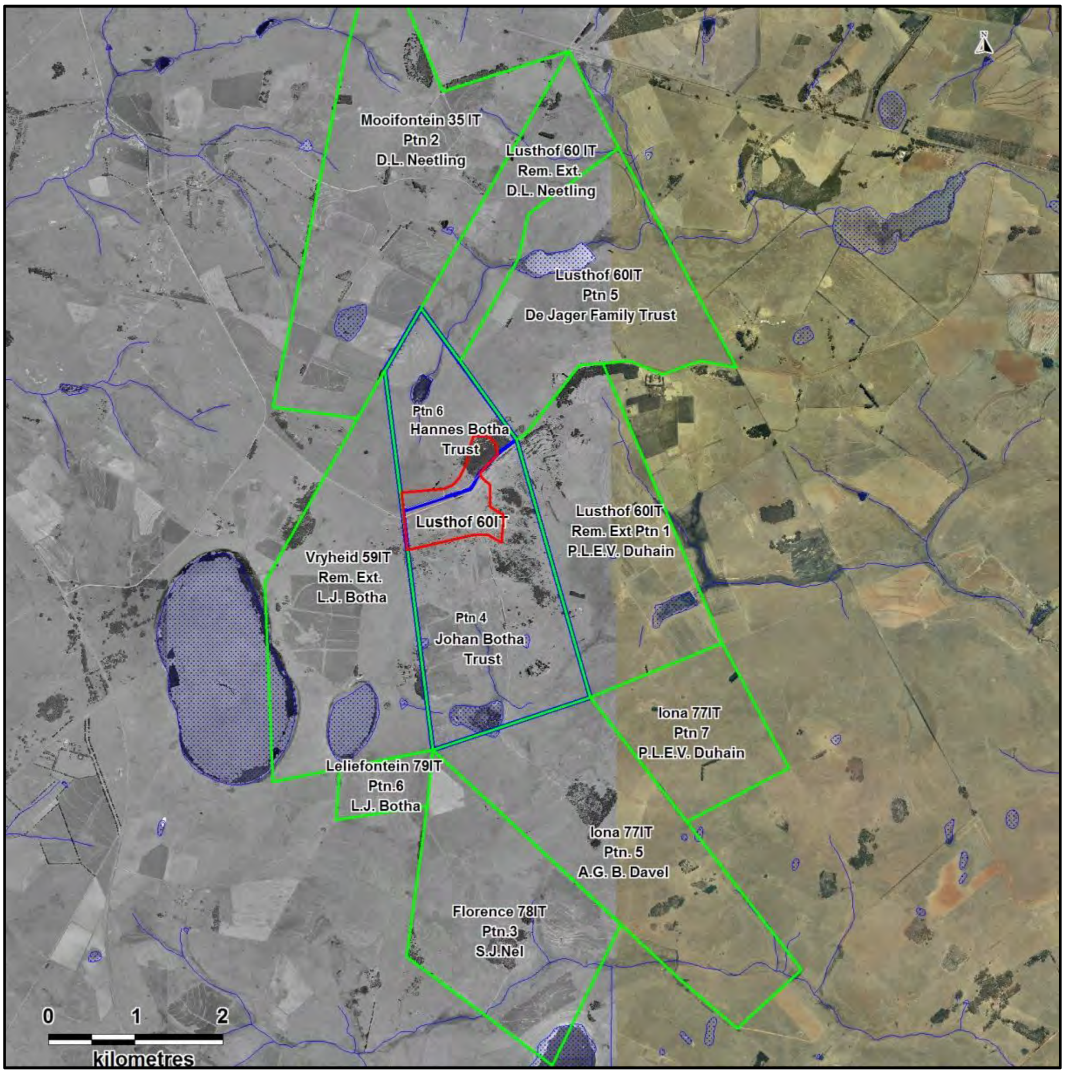


Figure 1.6 (a): Project and Surrounding Land Owners Property Delineation

1.7 LAWFUL LAND OCCUPIERS

The only lawful land occupiers on the Lusthof Colliery property are the abovementioned (section 1.6) property owners.

1.8 DIRECT SOCIO-ECONOMIC IMPACT ZONE

The proposed Lusthof Colliery is situated in the Mpumalanga Province, Gert Sibande District, 17 km south east from the town of Carolina (part of Albert Luthuli local municipality) and 10 km north of Chrissiesmeer (part of Msukaligwa local municipality).

The proposed site is situated within the administrative boundaries of the Albert Luthuli local municipality in the Gert Sibande district in the south west part of Mpumalanga close to the Swaziland border. Apart from Carolina (the administrative seat of the municipality) other towns and areas that form part of the municipality are Badplaas (43 km from the site), Eerstehoek and Lochiel.

Msukaligwa Local Municipality is just south of Albert Luthuli and comprises seven administrative units which are:

- Ermelo/Wesselton (the Seat of the municipality)
- Breyten (27 km from the site)
- Davel/Kwadela.
- Breyten/Kwazanele.
- Chrissiesmeer/Kwachibikhulu.
- Warburton/Nganga.
- Lothair/Silindile.
- Sheepmoor.

It is expected that the proposed Lusthof Colliery could potentially impact on the economies of both these local municipalities with the major impacts focussed on Carolina and Chrissiesmeer and to a minor extent on Badplaas, Breyten and Warburton.

1.9 DETAILS OF MUNICIPALITY

District Municipality

District Authority:	Gert Sibande (Eastvaal) District Muncipality
Contact Person:	Lucky Hadebe
Cellular Phone::	083 336 4930
E-mail:	lucky.hadebe@gsibande.gov.za

Local Municipality

Local Authority:	Albert Luthuli Local Municipality
Contact Person:	Me Nthabiseng Thabethe
Telephone no:	017 843 4072
Cellular Phone:	082 546 4151
E-mail:	thabethenp@albertluthuli.gov.za

1.10 DETAILS OF RELEVANT GOVERNMENT AUTHORITIES

The following national, regional and local authorities will be consulted during the obtainment of the required Environmental Authorizations for the Project.

1.10.1 National Authorities/Agencies/Institutions

Department of Environmental Affairs (DEA)

National Department:	DEA Head Office - Pretoria
Directorate:	Authorizations and Waste Disposal Management
Postal Address:	Private Bag X447, Pretoria, 0001
Contact Person:	Mpho Tshitangoni
Telephone no:	012 310 3380
Cellular Phone:	083 233 5926
E-mail:	mtshitangoni@environment.gov.za

1.10.2 Provincial/Regional Authorities/Agencies/Institutions

Department of Mineral Resources (DMR)

Regional Department:	Witbank Office
Directorate/Designation:	Deputy Director
Contact Person:	Martha Makhonyane
Postal Address:	Private Bag X7279, Witbank, 1035
Telephone no:	013 653 0500
Cellular Phone:	082 447 2400
E-mail:	Martha.Mokonyane@dme.gov.za

Department of Economic Development, Environment and Tourism (DEDET)

Regional Department:	Mpumalanga
Directorate/Designation:	Ermelo
Contact Person:	Surgeon Marebane
Postal Address:	P O Box 2777, Ermelo, 2350
Telephone no:	+ 27 17 811 4815
Fax no:	0 86 516 3658
Cellular Phone:	+ 27 79 841 9582
E-mail:	stmarebane@mpg.gov.za

Department of Water Affairs (DWA)

Regional Department:	Dundee Office
Contact Person:	Halaliswe Mdletshe
Telephone no:	034 212 1158
Cellular Phone:	082 325 9741
E-mail:	mdletsheh@dwaf.gov.za
Water Management Area	W 55 A

Department of Agriculture, Rural Development and Land Administration (DARDLA)

Regional Department:	Nelspruit Office
Contact Person:	Frans Mashabela
Postal Address:	P O Box 8906, Nelspruit, 1200
Telephone no:	013 754 0730
E-mail:	Fransmas@nda.agric.za

Mpumalanga Department of Health and Social Development (DHSD)

Regional Department:	Nelspruit Office
Contact Person:	Careen Swart
Postal Address:	Private Bag X 11285, Nelspruit, 1200
Telephone no:	013 766 3448
Fax no:	013 766 3473 / 086 549 2969
Cellular Phone:	082 820 7950
E-mail:	careens@social.mpu.co.za

Mpumalanga Tourism & Parks Agency (MTPA)

Regional Department:	Dullstroom
Contact Person:	Frans Krige
Telephone no:	013 254 0279
E-mail:	franskrige@telkomsa.net
Regional Department:	Ermelo
Contact Person:	Vaino Prinsloo
Telephone no:	082 468 5447
E-mail:	vaino@vodamail.co.za

South African Heritage Resources Agency (SAHRA)

Agency/Authority:	Mpumalanga Provincial Office
Designation:	Provincial Manager
Contact Person:	Nkosazana Machete
Postal Address:	PO Box 18403, Nelspruit, 1200
Telephone no:	013 752 2884
Fax no:	013 752 8498
E-mail:	nmachete@mp.sahra.org.za

1.11 PROOF OF NOTIFICATIONS TO RELEVANT PARTIES

Notification of all identified I&APs regarding this project was done via formal letters, press advertisements, e-mails, sms's and site notices that were put up in the surrounding area adjacent to the mine.

1.11.1 Land Owner

For proof of notifications sent to the relevant land owner please refer to APPENDIX 1.11 (A).

1.11.2 Land Occupier

For proof of notifications sent to the relevant land occupier please refer to APPENDIX 1.11 (A).

1.11.3 Interested and Affected Parties

For proof of notifications sent to the different I&AP's please refer to APPENDIX 1.11 (A).

1.12 DETAILS OF AND DECLARATION BY THE EAP

The EIA and associated EMP for this project will be compiled by fully qualified and duly registered Professional Scientists and Engineers. Synoptic CV's of all personnel which contributed to the project are attached in APPENDIX 1.12 (A) to this report.

The duly appointed **EAP for the Project is JMA Consulting (Pty) Ltd**. JMA Consulting sub-contracted the services of the following Professional Consultancies for specialist inputs into the project:

<u>Sub-Consultancies</u>

Airshed Planning Professionals (Pty) Ltd
Acusolv – Ben Van Zyl Acoustic Consulting Engineer
Blast Management & Consulting
Geostratum CC
Independent Economic Researchers
Inprocon Consulting Engineers CC
Proxa (Pty) Ltd
Roos Social Risk Solutions Ltd (RS^2)
Wetland Consulting Services (Pty) Ltd
Zeli Design

EAP Contact and Accreditation Details:

Table 1.11 (a): Details of Project Consultancy

Project Consultancy:	JMA Consulting (Pty) Ltd
Company Registration:	2005/039663/07
Professional Affiliations:	South African Council for Natural Scientific Professions (SACNASP)
Contact Person:	Mr Jasper Muller (Pr.Sci.Nat.)
Physical Address:	15 Vickers Street DELMAS 2210
Postal Address:	P O Box 883 DELMAS 2210
Telephone no:	+27 13 665 1788
Fax no:	+27 13 665 2364
E-mail:	jasper@jmaconsult.co.za

1.12.1 Details and Expertise of the Principal EAP

The principle Environmental Assessment Practioner on this project is Mr Jasper L Muller (Pr.Sci.Nat.). Jasper Muller holds a M.Sc. (cum laude) in Geohydrology from the University of the Free State and has been active as an earth scientist and environmental scientist since 1986. He has, since 1993, been involved in the compilation of more than 200 EMPR's, EIA's, IWWMP's and EMP's.

Jasper L Muller (Pr.Sci.Nat.)
(M.Sc. Geohydrology)

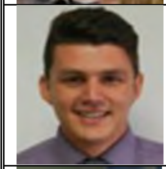
Jasper Muller is responsible for the overall project and specifically for EIA Process and Time Line Management, Project Technical Management (commissioning of specialist studies), and finally all the EIA/EMP Report Compilation including the full integration of all specialist study findings into the EIA/EMP.

1.12.2 Details and Expertise of the EIA and EMP Team

The following Scientists and Engineers were directly (specific inputs into this project) and indirectly (inputs incorporated from previous studies) involved with the Environmental Impact Assessment for this project:

Photo	Name Qualification Registration	Consultancy	Responsibility
	**Jasper Muller M.Sc. Geohydrology Pr.Sci.Nat.**	**JMA Consulting**	**Ground Water AMD Seepage AMD Decant Surface Water Waste Management**
	**Jaco van der Berg M.Sc. Geohydrology Pr.Sci.Nat.**	**JMA Consulting**	**Geology Ground Water Mine Planning Materials Balance Ground Water Balance**
	**Riaan Grobbelaar M.Sc. Geohydrology Pr.Sci.Nat.**	**JMA Consulting**	**Principal EAP**
	**Genevieve Cloete B.Sc.Hons. Environmental Sciences Pr.Sci.Nat.**	**JMA Consulting**	**GIS Topography**

	**Shane Turner M.Sc. Geohydrology Geology Cand.Sci.Nat.**	**JMA Consulting**	**Geology Ground Water Meteorology**
	**René Wolmarans M.Sc. Zoology Pr.Sci.Nat.**	**JMA Consulting**	**Project EAP**
	**Kobus du Plessis B.Sc. Conservation Ecology Cand.Sci.Nat.**	**JMA Consulting**	**Public Participation**
	**Nicolette von Reiche**	**Airshed Planning Professionals**	**Air Quality**
	**Ben van Zyl**	**Acusolv**	**Noise**
	**Danie Zeeman**	**Blast Management & Consulting**	**Ground Vibration and Air Blast**
	**Johan Fourie M.Sc. Geohydrology Pr.Sci.Nat.**	**Geostratum**	**Geochemistry Geochemical Modelling Ground Water Modelling**
	**Pierre du Toit**	**Inprocon**	**Civil Designs**
	**Koos Jonck**	**Inprocon**	**Surface Water Balances**
	**Cor Langhout**	**Inprocon**	**Surface Hydrology**
	**Wimpie van der Merwe**	**Proxa**	**Water Treatment**

	**Marisa du Toit**	**Roos Social Risk Solutions Ltd (RS^2)**	**Socio - Cultural Aspects**
	**Johan Oosthuizen**	**Roos Social Risk Solutions Ltd (RS^2)**	**Socio - Cultural Aspects**
	**An Kritzinger**	**Roos Social Risk Solutions Ltd (RS^2)**	**Socio-Economics**
	**Dieter Kassier**	**Wetland Consulting Services**	**Soils Terrestrial Ecology Aquatic Ecology**
	**Izelle Muller**	**Zeli Design**	**Visuals**

1.12.3 Declaration by EAP

I, **Jasper Lodewyk Muller**, declare that:

- I act as the independent environmental practitioner in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting environmental impact assessments, including knowledge of the National Environmental Management Act (107 of 1998), the Environmental Impact Assessment Regulations of 2010, and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in regulation **8** of the regulations when preparing the application and any report relating to the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I will ensure that information containing all relevant facts in respect of the application is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;
- I will ensure that the comments of all interested and affected parties are considered and recorded in reports that are submitted to the competent authority in respect of the application, provided that comments that are made by interested and affected parties in respect of a final report that will be submitted to the competent authority may be attached to the report without further amendment to the report;
- I will keep a register of all interested and affected parties that participated in a public participation process; and
- I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not
- all the particulars furnished by me in this form are true and correct;
- will perform all other obligations as expected from an environmental assessment practitioner in terms of the Regulations; and
- I realise that a false declaration is an offence in terms of regulation 71 and is punishable in terms of section 24F of the Act.

Disclosure of Vested Interest

- I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2010.

____
Signature of the environmental practitioner:

JMA CONSULTING (PTY) LTD_______
Name of company:

____
Date:

____
Signature of the Commissioner of Oaths:

____
Date:

____
Designation:

1.13 LEGISLATION AND GUIDELINES CONSIDERED

1.13.1 Listing of Relevant Acts, Regulations and Technical Guidance

Act 1
Constitution of the Republic of South Africa No. 108 of 1996

Act 2
Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA)
Regulations
GNR 527 of 23 April 2004: Mineral and Petroleum Resources Development Regulations
GNR 564 of 30 April 2004: Division of the Republic into Regions for the purposes of the Mineral and Petroleum Resources Development Act No. 28 of 2002
GNR 287 of 31 March 2011: Moratorium under Section 49(3)(b) of the MPRDA on Receiving of New Applications for Prospecting Right in terms of Section 16 of the Act
Guidelines
DMR Guideline for the Compilation of a Scoping Report
DMR Guideline for Consultation with Communities and Interested and Affected Parties
DMR Guideline for the Compilation of an Environmental Impact Assessment and an Environmental Management Programme
DMR Guideline for A Mining and Work Programme to be submitted for Applications for a Mining Right
DMR Guideline for the Submission of a Social and Labour Plan

Act 3	
National Water Act 36 of 1998 (NWA)	
Regulations	
GNR 3208 of 29 August 1969 – Regional Standards for Industrial Effluents	
GNR 2274 of 23 October 1981 – Regulation Promulgated in terms of Section 30(2) of the Water Act 54 of 1956 in respect of Subterranean Water Control Areas	
GNR 991 of 18 May 1984 – Requirements for the Purification of Waste Water or Effluent	
GNR 1560 of 25 July 1986 – Regulations in terms of Section 9C (6) of the Water Act, 1956, Relating to Dams with a Safety Risk	
GNR 704 of 4 June 1999 – Regulations on Use of Water for Mining and Related Activities aimed at the Protection of Water Resources	
GNR 1160 of 1 October 1999 – Establishment of the Water Management Areas and their Boundaries as a Component of the National Water Resource Strategy in terms of Section 5(1) of the National Water Act (Act No 36 of 1998)	
GNR 1352 of 12 November 1999 – Regulations Requiring that a Water Use be Registered	
GNR 398 of 26 March 2004 – General Authorisations in terms of Section 39 of the National Water Act	
GNR 399 of 26 March 2004 – General Authorisations in terms of Section 39 of the National Water Act	
GNR 1198 of 18 December 2009 – General Authorisation in terms of Section 39 of the National Water Act, 1998 (Act No 36 of 1998) in terms of Section 21(c) and (i) for the purpose of Rehabilitating a Wetland for Conservation Purposes	
GNR 810 of 17 September 2010 – Regulations for the Establishment of a Water Resource Classification System	
Guidelines	
1.	External Guideline: Generic Water Use Authorisation Application Process, 2007
2.	Internal Guideline: Generic Water Use Authorisation Application Process, 2007
3.	External Guideline: Section 21(c) and (i) Water Use Authorisation Application Process (impeding or diverting the flow of water in a watercourse and /or altering the bed, banks, course or characteristics of a watercourse)
4.	Internal Guideline: Section 21(a) and (b) Water Use Authorisation Application Process (taking and/or storing water)

5.	Internal Guideline: Section 21(c) and (i) Water Use Authorisation Application Process (impeding or diverting the flow of water in a watercourse and /or altering the bed, banks, course or characteristics of a watercourse)
6.	Internal Guideline: Section 21(e), (f), (g), (h) and (j) Water Use Authorisation Application Process (waste discharge related)
7.	Operational Guideline: Integrated Water and Waste Management Plan, 2010
8.	Best Practice Guideline A1 – Small-Scale Mining (Standard format); 2006
9.	Best Practice Guideline A1.1 – Small-Scale Mining (User Format); 2006
10.	Best Practice Guideline A2 – Water Management for Mine Residue Deposits; 2008
11.	Best Practice Guideline A3 – Water Management in Hydrometallurgical Plants; 2007
12.	Best Practice Guideline A4 – Pollution Control Dams; 2007
13.	Best Practice Guideline A5 – Water Management for Surface Mines; 2008
14.	Best Practice Guideline A6 – Water Management for Underground Mines; 2008
15.	Best Practice Guideline G1 – Storm Water Management; 2006
16.	Best Practice Guideline G2 – Water and Salt Balances; 2006
17.	Best Practice Guideline G3 – Water Monitoring Systems; 2007
18.	Best Practice Guideline G4 – Impact Prediction; 2008
19.	Best Practice Guideline G5 – Water Management Aspects for Mine Closure; 2008
20.	Best Practice Guideline H1 – Integrated Mine Water Management; 2008
21.	Best Practice Guideline H2 – Pollution Prevention and Minimization of Impacts; 2008
22.	Best Practice Guideline H3 – Water Reuse and Reclamation; 2006
23.	Best Practice Guideline H4 – Water Treatment; 2007

Act 4	
National Environmental Management Act 107 of 1998 (NEMA)	
Regulations	
GNR 543 of 18 June 2010: Environmental Impact Assessment Regulations	
GNR 544 of 18 June 2010: Environmental Impact Assessment Regulations - Listing Notice 1 of 2010 – Basic Assessment	
GNR 545 of 18 June 2010: Environmental Impact Assessment Regulations - Listing Notice 2 of 2010 – Scoping and EIA	
GNR 546 of 18 June 2010: Environmental Impact Assessment Regulations - Listing Notice 3 of 2010 – Basic Assessment in Geographical Areas	
Guidelines	
1.	Integrated Environmental Management, Information Series 0, Overview of Integrated Environmental Management
2.	Integrated Environmental Management, Information Series 1, Screening
3.	Integrated Environmental Management, Information Series 2, Scoping
4.	Integrated Environmental Management, Information Series 3, Stakeholder Engagement
5.	Integrated Environmental Management, Information Series 4, Specialist Studies
6.	Integrated Environmental Management, Information Series 5, Impact Significance
7.	Integrated Environmental Management, Information Series 6, Ecological Risk Assessment
8.	Integrated Environmental Management, Information Series 7, Environmental Resource Economics
9.	Integrated Environmental Management, Information Series 8, Cost Benefit Analyses
10.	Integrated Environmental Management, Information Series 9, Project Alternatives in EIA
11.	Integrated Environmental Management, Information Series 10, Environmental Impact Reporting
12.	Integrated Environmental Management, Information Series 11, Review in EIA
13.	Integrated Environmental Management, Information Series 12, Environmental Management Plans
14.	Integrated Environmental Management, Information Series 13, Environmental Auditing
15.	Integrated Environmental Management, Information Series 14, Life Cycle Assessment
16.	Integrated Environmental Management, Information Series 15, Strategic Environmental Assessment
17.	Integrated Environmental Management, Information Series 16, Cumulative Effects Assessment

18.	Integrated Environmental Management, Information Series 17, Environmental Reporting
19.	Integrated Environmental Management, Information Series 18, Environmental Assessment of Trade Related Agreements and Policies in South Africa
20.	Integrated Environmental Management, Information Series 19, Environmental Assessment of International Agreements
21.	Integrated Environmental Management, Information Series 20, Linking EIA and EMS
22.	Integrated Environmental Management, Information Series 21, Environmental Monitoring Committees
23.	Integrated Environmental Management, Information Series 22, Socio-Economic Impact Assessment
24.	Integrated Environmental Management, Information Series 23, Risk Management
25.	Guideline 3: General Guide to the Environmental Impact Assessment Regulations
26.	Guideline 4: Public Participation
27.	Guideline 5: Assessment of Alternatives and Impacts
28.	Guideline 6: Environmental Management Frameworks
29.	Guideline 7: Detailed Guide to Implementation of the EIA Regulations

Act 5
National Environmental Management : Protected Areas Act 57 of 2003 (NEMPAA)
Regulations
GNR 1061 of 28 October 2005 – Regulations for the Proper Administration of Special Nature Reserves, National Parks and World Heritage Sites

Act 6
National Environmental Management : Biodiversity Act 10 of 2004 (NEMBA)
Regulations
GNR 151 of 23 February 2007 – Publication of Lists of Critically Endangered, Endangered, Vulnerable and Protected Species

Act 7
National Environmental Management : Air Quality Act 39 of 2004 (NEMAQA)
Regulations
GNR 365 of 21 April 2006 – Declaration of the Vaal Triangle Air-Shed Priority Area in Terms of Section 18(1) of the National Environmental Management : Air Quality Act, No. 39 of 2004
GNR 1138 of 11 September 2007 – Notice to Establish the National framework in Terms of Section 7(1) of the National Environmental Management : Air Quality Act, No. 39 of 2004
GNR 1123 of 23 November 2007 – Declaration of the Highveld as Priority Area in Terms of Section 18(1) of the National Environmental Management : Air Quality Act, No. 39 of 2004
GNR 1210 of 24 December 2009 – National Ambient Air Quality Standards
GNR 248 of 31 March 2010 – List of Activities which result in Atmospheric Emissions which have or may have a Significant Detrimental Effect on the Environment, including Health, Social Conditions, Economic Conditions, Ecological Conditions or Cultural Heritage

Act 8	
National Environmental Management : Waste Act 59 of 2008 (NEMWA)	
Regulations	
GNR 718 of 3 July 2009 – List of Waste Management Activities that have, or are likely to have, a Detrimental Effect on the Environment	
Guidelines	
1.	Waste License Application Process for Waste Activities in terms of the National Environmental Management : Waste Act No.59 of 2008

2.	Framework for the Management of Contaminated Land. DEA 2010
3.	DWAF, Second Edition, 1998. Waste Management Series. Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste.
4.	DWAF, Second Edition, 1998. Waste Management Series. Minimum Requirements for Waste Disposal by Landfill.
5.	DWAF, Second Edition, 1998. Waste Management Series. Minimum Requirements for Water Monitoring at Waste Management Facilities.

1.13.2 Existing Authorizations

All existing Environmental Authorizations for the project are listed below, whilst copies of the relevant authorization documents are attached in APPENDIX 1.13 (A) to this report.

Sequential Number	Existing Environmental Authorizations
1	Approved EMPR for Lusthof Colliery – Black Gold Coal Estates (Pty) Ltd
2	Issued Mining Right

1.13.3 Other Environmental Authorizations Required for this Project

Based on the Enviro-Legal framework and having regard to the relevant and specific project attributes, a number of authorizations will be applied for during the course of the Environmental Authorization Phase of this Project.

1.13.4 Authorizations in terms of NEMA

National Environmental Management Act, Act No. 107 of 1998		
Section 24	**Environmental Authorisation Application**	
GNR 544		
Identification of the competent authority	The competent authority in respect of the activities listed in this part of the schedule is the environmental authority in the province in which the activity is to be undertaken unless it is an application for an activity contemplated in section 24C(2) of the Act, in which case the competent authority is the Minister or an organ of state with delegated powers in terms of section 42(1) of the Act, as amended.	
Activity 11	The construction of: (i) canals; (ii) channels; (iii) bridges; (iv) dams; (v) weirs; (vi) bulk storm water outlet structures; (vii) marinas; (viii) jetties exceeding 50 square metres in size; (ix) slipways exceeding 50 square metres in size; (x) buildings exceeding 50 square metres in size; or (xi) infrastructure or structures covering 50 square metres or more where such construction occurs within a watercourse or within 32 metres of a watercourse, measured from the edge of a watercourse, excluding where such construction will occur behind the development setback line.	Storm Water Management System around Mine and Marsh Area immediately south of the Open Pit
Activity 12	The construction of facilities or infrastructure for the off-stream storage of water, including dams and reservoirs, with a combined capacity of 50000 cubic metres or more, unless such storage falls within the ambit of activity 19 of Notice 545 of 2010;	Clean Water Diversion Pond (9800m^3) Pollution Control Dam (19000m^3) Dirty Water Dam (37000m^3) Total:65800m^3
Activity 18	The infilling or depositing of any material of more than 5 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock from (i) a watercourse; (ii) the sea; (iii) the seashore; (iv) the littoral active zone, an estuary or a	Mining of Marsh Area in the centre of the Open Pit

	distance of 100 metres inland of the high-water mark of the sea or an estuary, whichever distance is the greater- but excluding where such infilling, depositing, dredging, excavation, removal or moving (i) is for maintenance purposes undertaken in accordance with a management plan agreed to by the relevant environmental authority; or (ii) occurs behind the development setback line.	
Activity 22	The construction of a road, outside urban areas, (i) with a reserve wider than 13,5 meters or, (ii) where no reserve exists where the road is wider than 8 metres, or (iii) for which an environmental authorisation was obtained for the route determination in terms of activity 5 in Government Notice 387 of 2006 or activity 18 in Notice 545 of 2010.	Construction of internal Mine Access Road and Haul Roads from Open Pit to ROM Stockpile Area.

National Environmental Management Act, Act No. 107 of 1998		
Section 24	**Environmental Authorisation Application**	
GNR 545		
Identification of the competent authority	The competent authority in respect of the activities listed in this part of the schedule is the environmental authority in the province in which the activity is to be undertaken, unless- (a) it is an application for an activity contemplated in section 24C(2) of the Act, in which case the competent authority is the Minister or an organ of state with delegated powers in terms of section 42(1) of the Act, as amended; or (b) the activity is to be conducted in or on a mining area or is to transform the area where the activity is to be conducted into a mining area in which case the competent authority is the Minister of Minerals and Energy. The exception mentioned in (b) above does not apply to the following activities contained in this Notice: 1; 2; 5; 8; 9; 10; 12; 13; 14; 17; 24; and 25.	
Activity 3	The construction of facilities or infrastructure for the storage, or storage and handling of a dangerous good, where such storage occurs in containers with a combined capacity of more than 500 cubic metres.	Construction of ROM Stockpile
Activity 5	The construction of facilities or infrastructure for any process or activity which requires a permit or license in terms of national or provincial legislation governing the generation or release of emissions, pollution or effluent and which is not identified in Notice No. 544 of 2010 or included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case that Act will apply.	Construction of Dirty Water Dam Construction of Pollution Control Dam Construction of ROM Stockpile Construction of Overburden Stockpiles.
Activity 18	The route determination of roads and design of associated physical infrastructure, including roads that have not yet been built for which routes have been determined before 03 July 2006 and which have not been authorised by a competent authority in terms of the Environmental Impact Assessment Regulations, 2006 or 2009, made under section 24(5) of the Act and published in Government Notice No. R. 385 of 2006,- (i) it is a national road as defined in section 40 of the South African National Roads Agency Limited and National Roads Act, 1998 (Act No. 7 of 1998); (ii) it is a road administered by a provincial authority; (iii) the road reserve is wider than 30 metres; or (iv) the road will cater for more than one lane of	Road diversion of Provincial Road to the north of mine

	traffic in both directions.	
Activity 19	The construction of a dam, where the highest part of the dam wall, as measured from the outside toe of the wall to the highest part of the wall, is 5 metres or higher or where the high-water mark of the dam covers an area of 10 hectares or more.	Construction of the Pollution Control Dam

National Environmental Management Act, Act No. 107 of 1998		
Section 24	**Environmental Authorisation Application**	
GNR 546		
Identification of competent authority	The competent authority in respect of the activities listed in this part of the schedule is the environmental authority in the province in which the activity is to be undertaken unless it is an application for an activity contemplated in section 24C(2) of the Act, in which case the competent authority is the Minister or an organ of state with delegated powers in terms of section 42(1)(d) of the Act, as amended.	
Activity 4	The construction of a road wider than 4 metres with a reserve less than 13,5 metres. **(a) In Eastern Cape, Free State, KwaZulu-Natal, Limpopo, Mpumalanga and Northern Cape provinces:** i. In an estuary; ii. Outside urban areas, in: (aa) A protected area identified in terms of NEMPAA, excluding conservancies; (bb) National Protected Area Expansion Strategy Focus areas; (cc) Sensitive areas as identified in an environmental management framework as contemplated in chapter 5 of the Act and as adopted by the competent authority; (dd) Sites or areas identified in terms of an International Convention; (ee) Critical biodiversity areas as identified in systematic biodiversity plans adopted by the competent authority or in bioregional plans; (ff) Core areas in biosphere reserves; (gg) Areas within 10 kilometres from national parks or world heritage sites or 5 kilometres from any other protected area identified in terms of NEMPAA or from the core areas of a biosphere reserve; (hh) Areas seawards of the development setback line or within 1 kilometre from the high-water mark of the sea if no such development setback line is determined. iii. In urban areas: (aa) Areas zoned for use as public open space; (bb) Areas designated for conservation use in Spatial Development Frameworks adopted by the competent authority or zoned for a conservation purpose; (cc) seawards of the development setback line or within urban protected areas.	Road diversion of Farm Road currently running north to south across the mining area to a new alignment to the west and south of the mining area Construction of a new Farm Road to the Lusthof Northern Surface Water Dam

Activity 10	The construction of facilities or infrastructure for the storage, or storage and handling of a dangerous good, where such storage occurs in containers with a combined capacity of 30 but not exceeding 80 cubic metres. **(a) In Eastern Cape, Free State, KwaZulu-Natal, Limpopo, Mpumalangaand Northern Cape provinces:** i. In an estuary; ii. Outside urban areas, in: (aa) A protected area identified in terms of NEMPAA, excluding conservancies; (bb) National Protected Area Expansion Strategy Focus areas; (cc) Sensitive areas as identified in an environmental management framework as contemplated in chapter 5 of the Act and as adopted by the competent authority; (dd) Sites or areas identified in terms of an International Convention; (ee) Critical biodiversity areas as identified in systematic biodiversity plans adopted by the competent authority or in bioregional plans; (ff) Core areas in biosphere reserves; (gg) Areas within 10 kilometres from national parks or world heritage sites or 5 kilometres from any other protected area identified in terms of NEMPAA or from the core areas of a biosphere reserve; (hh) Areas seawards of the development setback line or within 1 kilometre from the high-water mark of the sea if no such development setback line is determined; (ii) Areas on the watercourse side of the development setback line or within 100 metres from the edge of a watercourse where no such setback line has been determined; (jj) Within 500 metres of an estuary, iii. In urban areas: (aa) Areas zoned for use as public open space; (bb) Areas designated for conservation use in Spatial Development Frameworks adopted by the competent authority or zoned for a conservation purpose; (cc) Within 500 metres of an estuary.	Construction of Diesel Storage Tanks within the Contractors Yard at the mine (capacity 46 m^3)
Activity 12	The clearance of an area of 300 square metres or more of vegetation where 75% or more of the vegetative cover constitutes indigenous vegetation. (a) Within any critically endangered or endangered ecosystem listed in terms of section 52 of the NEMBA or prior to the publication of such a list, within an area that has been identified as critically endangered in the National Spatial Biodiversity Assessment 2004; (b) Within critical biodiversity areas identified in bioregional plans; (c) Within the littoral active zone or 100 metres inland from high water mark of the sea or an estuary, whichever distance is the greater, excluding where such removal will occur behind the development setback line on erven in urban areas.	Construction of Clean Water Diversion Pond

Activity 13	The clearance of an area of 1 hectare or more of vegetation where 75% or more of the vegetative cover constitutes indigenous vegetation, except where such removal of vegetation is required for: (1) the undertaking of a process or activity included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008), in which case the activity is regarded to be excluded from this list. (2) the undertaking of a linear activity falling below the thresholds mentioned in Listing Notice 1 in terms of GN No. 544 of 2010. (a) Critical biodiversity areas and ecological support areas as identified in systematic biodiversity plans adopted by the competent authority. (b) National Protected Area Expansion Strategy Focus areas. **(c) In Eastern Cape, Free State, KwaZulu-Natal, Limpopo, Mpumalanga, Northern Cape and Western Cape:** i. In an estuary; ii. Outside urban areas, the following: (aa) A protected area identified in terms of NEMPAA, excluding conservancies; (bb) National Protected Area Expansion Strategy Focus areas; (cc) Sensitive areas as identified in an environmental management framework as contemplated in chapter 5 of the Act and as adopted by the competent authority; (dd) Sites or areas identified in terms of an International Convention; (ee) Core areas in biosphere reserves; (ff) Areas within 10 kilometres from national parks or world heritage sites or 5 kilometres from any other protected area identified in terms of NEMPAA or from the core area of a biosphere reserve; (gg) Areas seawards of the development setback line or within 1 kilometre from the high-water mark of the sea if no such development setback line is determined. iii. In urban areas, the following: (aa) Areas zoned for use as public open space; (bb) Areas designated for conservation use in Spatial Development Frameworks adopted by the competent authority or zoned for a conservation purpose; (cc) Areas seawards of the development setback line; (dd) Areas on the watercourse side of the development setback line or within 100 metres from the edge of a watercourse where no such setback line has been determined.	Construction of Dirty Water Dam, Contractors Yard, Soil Stockpile/Berms, Overburden Stockpiles, ROM Stockpile and Pollution Control Dam
Activity 14	The clearance of an area of 5 hectares or more of vegetation where 75% or more of the vegetative cover constitutes indigenous vegetation, except where such removal of vegetation is required for. (1) purposes of agriculture or afforestation inside areas identified in spatial instruments adopted by the competent authority for agriculture or afforestation purposes; (2) the undertaking of a process or activity included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case the activity is regarded to be excluded from this list; (3) the undertaking of a linear activity falling below the thresholds in Notice 544 of 2010. **(a) In Eastern Cape, Free State, KwaZulu-Natal, Gauteng, Limpopo, Mpumalanga, Northern Cape, Northwest and Western Cape:** i. All areas outside urban areas.	Clearance of vegetation for all Mining Related Activities including the Haul Roads and Open Pit

1.13.5 Authorizations in terms of NEMWA

Applications in terms of the NEMWA will only be lodged at a later stage as the Water Treatment Plant which triggers these applications, will only be required during year 7 of the mine's operational phase.

National Environmental Management: Waste Act, Act No. 59 of 2008		
Section 19(3) and GN 718	**Waste License Application**	
CATEGORY A		
2	The storage including the temporary storage of hazardous waste at a facility that has the capacity to store in excess of 35m^3 of hazardous waste at any one time, excluding the storage of hazardous waste in lagoons.	The temporary storage of brine prior to removal and disposal elsewhere, originating from the Water Treatment Plant to be constructed and operated on-site.

National Environmental Management: Waste Act, Act No. 59 of 2008		
Section 19(3) and GN 718	**Waste License Application**	
CATEGORY B		
7	The treatment of effluent, wastewater or sewage with an annual throughput capacity of 15 000 cubic metres or more.	Water Treatment Plant to treat contaminated mine water.
11	The construction of facilities for activities listed in Category B of this Schedule (not in isolation to associated activity).	Construction of Water Treatment Plant and associated Brine Disposal Facility.

1.13.6 Authorizations in terms of NWA

National Water Act, Act No. 36 of 1998		
Section 40	**Integrated Water Use License Application (Includes Registrations)**	
Section 21(a)	Taking water from a water resource.	Abstraction of ground water from two (2) boreholes for potable use. Abstraction of contaminated ground water from five (5) boreholes to intercept ground water seepage from the open pit. Abstraction of mine water contained in the spoils of the open pit from three (3) boreholes to manage mine water decant and for treatment in the water treatment plant. Abstraction of water from the Lusthof Northern Surface Water Dam for dust suppression.
Section 21(b)	storing water;	Lusthof Colliery Clean Water Diversion Pond. Lusthof Colliery Northern Surface Water Dam.
Section 21(c)	impeding or diverting the flow of water in a watercourse;	Diverting of clean storm water originating from the marsh area south of the open pit, through a road culvert underneath the main mine access road. Lusthof Mining Activities including the Road Diversion within 500 m upgradient from a wetland.
Section 21(e)	Engaging in a controlled activity.	Dust suppression of all gravel roads within the mining area with clean water. Dust suppression of gravel roads used for coal transportation from the mine to the coal beneficiation plant at East Side Colliery with clean water. Dust suppression of open pit haul roads with mine water.
Section 21(g)	Disposing of water containing waste in a manner which may detrimentally impact on a water resource.	Lusthof Colliery Dirty Water Dam. Lusthof Colliery Pollution Control Dam. Lusthof Colliery Overburden Stockpiles. Lusthof Colliery ROM Stockpile.
Section 21(i)	altering the bed, banks, course or characteristics of a watercourse;	Diverting of clean storm water originating from the marsh area south of the open pit, through a road culvert underneath the main

		mine access road. Lusthof Mining Activities including the Road Diversion within 500 m upgradient from a wetland.
Section 21(j)	Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people	Abstraction of mine water contained in the spoils of the open pit from three (3) boreholes to manage mine water decant and for treatment in the water treatment plant.

National Water Act, Act No. 36 of 1998		
Section 39	**General Authorisations in terms of Section 39 of the National Water Act 36 of 1998**	
Section 21(a)	Taking water from a water resource.	Abstraction of ground water from two (2) boreholes for potable use form quaternary catchment W55A (Table 1.2 – Zone C).

National Water Act		
GNR 704	**Exemption from Requirements of Regulations**	
4.	**Restrictions on locality**	
4(a)	No person in control of a mine or activity may- locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse 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;	Location of Storm Water Berms, ROM Pad, Contractors' Yard and Mine Access Road in proximity to the marsh area immediately south of the mine.
4(b)	No person in control of a mine or activity may- 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 Mining Operations at Lusthof Colliery in proximity immediately south of the mine as well as the marsh area in the centre of the mine.
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; or	Placement of spoils in the Open Pit in a continuous manner during mining at Lusthof Colliery.
8.	**Security and additional measures**	
8(a)	Every person in control of a mine or activity must- cause any impoundment or dam containing any poisonous, toxic or injurious substance to be effectively fenced-off so as to restrict access thereto, and must erect warning notice boards at prominent locations so as to warn persons of the hazardous contents thereof;	Dirty Water Dams and PCDs are located within the mine fenced area and will not be provided with security fences around the individual facilities

1.13.7 Authorizations in terms of MPRDA

Mineral and Petroleum Resources Development Act, Act, Act No. 28 of 2002		
Section 39	**Environmental Management Programme and Environmental Management Plan**	
Section 39(1)	Every person who has applied for a mining right in terms of section 22 must conduct an environmental impact assessment and submit an environmental management programme within 180 days of the date on which he or she is notified by the Regional Manager to do so.	The overall Lusthof Colliery Mining and Associated Activities not regulated in terms of NEMA, NEMWA and NWA.

1.14 THE SCOPING & EIA PROCESS

The Scoping and EIA process is required for Environmental applications done in terms of the provisions of the National Environmental Management Act (NEMA), the National Environmental Management: Waste Act (NEMWA), the National Environmental Management: Air Quality Act (NEMAQA), as well as the Mineral and Petroleum Resources Development Act (MPRDA).

Detailed requirements for the Scoping and EIA process are defined in the provisions as contained in the Environmental Impact Assessment (EIA) Regulations published on 18 June 2010 (GNR 543 of 18 June 2010), as well as in the Mineral and Petroleum Resources Development (MPRDA) Regulations published on 23 April 2004 (GNR 527 of 23 April 2004).

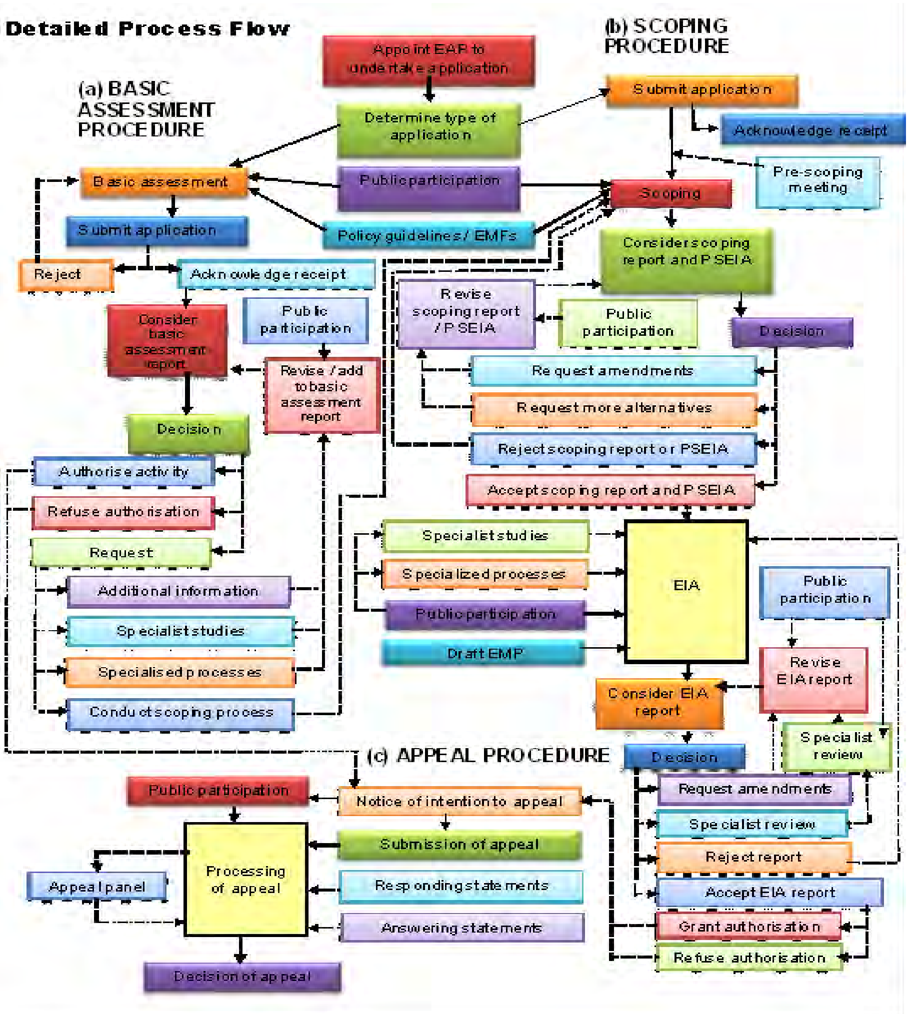


Figure 1.14 (a): Process flow Diagram for NEMA EIA Processes

Practical implementation of the Scoping and EIA Process, comprises five stages:

- Stage 1: Pre-Application and Application
- Stage 2: Scoping
- Stage 3: Environmental Impact Assessment
- Stage 4: Consideration and Decision
- Stage 5: Appeal

1.14.1 EIA Stage 1: Pre-Application & Application

This Stage comprises the following activities:

- Appointment of EAP by Applicant
- Determination of Type of Application
- Identification of the Competent Authority
- Pre-application Consultation with the Competent Authority
- Identify and Notify Property/Land Owners
- Submit Application to Competent Authority
- Notification of Decision on Application

1.14.2 EIA Stage 2: Scoping

- Initiate and Conduct Public Participation Process
- Compile Notification and Information Documents
- Notify all I&AP's of Project and Meetings (Newspapers, Site Notices, Letters, etc)
- Written Notification to Relevant Regulating Authorities
- Compilation of Scoping Report and Plan of Study as per Regulations and Guidelines
- Scoping Public Meeting
- Make Scoping Report available for Review
- Capture and Consider Comments from I&AP's and Relevant Authorities
- Finalize and Submit Scoping Report and Plan of Study to I&AP's and Authorities
- Authority Review & Decision
- Notification of Decision on Scoping Report

1.14.3 EIA Stage 3: Environmental Impact Assessment

- Commence to Implement Plan of Study
- Continue Public Participation Process
- Conduct Specialist Studies
- Prepare EIA Report (EIAR comprising EIA, EMPr as per Regulations and Guidelines
- EIA/EMP Public Meeting
- Make EIAR available for Review
- Capture and Consider Comments from I&AP's and Relevant Authorities
- Finalize and Submit EIAR to I&AP's and Authorities

1.14.4 EIA Stage 4: Consideration and Decision

- Authority Review & Decision
- Notification of Decision on the EIAR
- Granting of Environmental Authorization
- Inform I&AP's of Decision/Approval and of Opportunity to Appeal

1.14.5 EIA Stage 5: Appeal

- Appellant to give notice of intention to Appeal to Authority and Applicant
- Consultation between Applicant and Appellant to Resolve Issues
- Submission of appeal to Authority and Applicant
- Submission of Responding Statement from Respondent/Applicant to Authority and Appellant
- Submission of Answering Statement by Appellant to Authority and Applicant
- Acknowledgment of all by Authority within 10 days
- Processing of Appeal
- Decision on Appeal
- Notification of Decision on Appeal to Appellant and Respondents by Authority

2. EXISTING STATUS OF ENVIRONMENT

2.1 I&AP CONFIRMATION ON EXISTING ENVIRONMENTAL STATUS

I&AP's were presented with baseline information regarding the existing Socio-Cultural Environment, Heritage Environment, Current Land Use, Socio-Economic Conditions, Existing Infrastructure, the Existing Biophysical Environment; Meteorology, Topography, Soils, Land Capability, Geology, Ground Water, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals, Blasting and Vibration.

After they received it, they were duly consulted by JMA Consulting (Pty) Ltd by means of two Scoping Phase Public Meetings which was held on the 17 February 2010 and on 14 November 2012. Focus Group Meetings were held on 22 August 2009, 20 January 2011, 16 May 2012 and 21 June 2012. During the given time frame, JMA Consulting requested the I&AP's to review this information (review period of 30 days) and to submit any comments that they may have to the EAP (JMA Consulting). All comments received were reviewed and included in the Public Participation Comments and Response Register.

See Appendix 6.2.5 (A) of the Public Participation Report for an example of the customised JMA comment form and feedback/ comments received from I&AP's.

2.1.1 Socio-Cultural Environment (Report Section 2.2)

JMA Consulting received comments with regards to the Socio-Cultural Environment of the area. Local Tourism especially Eco-Tourism is a major concern and the effects that mining will have on the area relating to Eco-Tourism. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14 (A)) of the Public Participation Report (APPENDIX 6 (A) of the Final Scoping Report).

2.1.2 Heritage Environment (Report Section 2.3)

JMA Consulting received no comments with regards to the Heritage Environment; therefore it was assumed the current status of the Heritage Environment was confirmed.

2.1.3 Current Land Use (Report Section 2.4)

JMA Consulting received comments with regards to the Current Land Use of the area. Eco-Tourism is a major concern and the effects that mining will have on the area regarding Eco-Tourism. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.1.4 Socio-Economic Environment (Report Section 2.5)

JMA Consulting received comments with regards to the Socio-Economic Environment of the area. Eco-Tourism is a major concern and the effects that mining will have on the area regarding Eco-Tourism. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.1.5 Existing Infrastructure (Report Section 2.6)

JMA Consulting received comments with regards to the Existing Infrastructure. Roads are a major concern. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.1.6 Biophysical Environment (Report Sections 2.7 through 2.20)

2.1.6.1 Meteorology (Report Section 2.7)

JMA Consulting received no comments with regards to the Meteorology of the area. Therefore it was assumed the current status of the Meteorology was confirmed.

2.1.6.2 Topography (Report Section 2.8)

JMA Consulting received no comments with regards to the Topography of the area. Therefore it was assumed the current status of the Topography was confirmed.

2.1.6.3 Soils (Report Section 2.9)

JMA Consulting received no comments with regards to the Soils within the area. Therefore it was assumed the current status of the Soils was confirmed.

2.1.6.4 Land Capability (Report Section 2.10)

Several comments were received in terms of the Land Capability in terms of the Plant Life, Animal Life and Aquatic Systems that occurs within the area of study. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.1.6.5 Geology (Report Section 2.11)

JMA Consulting received no comments with regards to the Geology of the area. Therefore it was assumed the current status of the Geology was confirmed.

2.1.6.6 Ground Water (Report Section 2.12)

Several comments were received in terms of the Ground Water. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.1.6.7 Surface Water (Report Section 2.13)

Several comments were received in terms of the Surface Water. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.1.6.8 Plant Life (Report Section 2.14)

Several comments were received in terms of the Plant Life. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.1.6.9 Animal Life (Report Section 2.15)

Several comments were received in terms of the Animal life. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.1.6.10 Aquatic Ecosystems (Streams, Wetlands and Pans) (Report Section 2.16)

Several comments were received in terms of the Aquatic Ecosystems. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.1.6.11 Air Quality (Report Section 2.17)

Some comments were received in terms of the Air Quality. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.1.6.12 Noise (Report Section 2.18)

Some comments were received in terms of the Noise. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.1.6.13 Visuals (Report Section 2.19)

Some comments were received in terms of the Visual Impact that mining activities will and can have on Eco-Tourism in the area. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.1.6.14 Blasting and Vibration (Report Section 2.20)

Several comments were received in terms of the Blasting and Vibration regarding the impact that it can have on amphibians and livestock in the area as well as boreholes and historical buildings in the nearby town of Chrissiesmeer. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

2.2 SOCIO-CULTURAL BASE LINE

The socio-cultural environment is discussed with reference to the information generated by Socio-Cultural Specialists RS2. The socio-cultural base line description compiled by them is reproduced in its entirety in this section.

This baseline Social description was compiled using data and statistics from IHS Global Insight, the IDP of ALLM (2007 – 2011) and the findings of the Community Survey in 2007. The focus of the baseline description was the surroundings of the proposed Lusthof Colliery area, i.e. Albert Luthuli Local Municipality. However, in order to gain greater perspective of the area, statistics from the GSDM was included.

2.2.1 Geographical Process

Geographical processes are those that affect the land use patterns of a society and include the following (cf. Vanclay 2002:197). In order to better understand geographical change processes during the impact assessment phase and overwiew of the region where the project is to be lcoalted as well as the local municipality is provided here.

2.2.1.1 Regional Overview

Mpumalanga (see Figure 2.2.1.1(a) - green and yellow area) lies in eastern South Africa, north of KwaZulu-Natal and bordering Swaziland and Mozambique. It constitutes 6.5% of South Africa's land area. In the north it borders on Limpopo, to the west Gauteng, to the southwest the Free State and to the south KwaZulu-Natal. The capital is Mbombela (previously Nelspruit).

Gert Sibande District Municipality (GSDM) (see Figure 2.2.1.1(a) - green area) is one of the 3 districts of the Mpumalanga province. The seat of the GSDM is Secunda. Albert Luthuli Local Municipality (ALLM) (see Figure 2.2.1.1(a) - light green area) borders Swaziland to the East, Umjindi, Mbombela and Emakhazeni Local Municipalities to the north, Steve Tshwete Local Municipality to the West and Mkhondo and Msukaligwa Local Municipalities to the South.

The municipality consists of predominantly rural areas with most development taking place around the urbanised areas of Carolina, Chrissiesmeer and other surrounding towns. According to the IDP of ALLM (2007 – 2011), the municipality faces a number of challenges with regard to Land Ownership because most of the land is either owned by Traditional leaders or private farmers.

The municipality is required by law to implement a proper Land Use Management System for the whole municipal area but at the moment lacks sufficient funds to implement such a system.

Figure 2.2.1.1(a): Map of Mpumalanga

The area surrounding Lusthof is mainly rural with small scale socio-economic activities. According to the IDP of ALLM (2007 – 2011) the predominant land use in the area is for agricultural purposes which use approximately 80% of the total area. The remaining land use consists of scattered human settlements.

2.2.1.2 The Project area

Lusthof site locality (see Table 2.2.1.2(a) and Figure 2.2.1.2(a)), in relation to neigbouring towns/cities, is given in the Table below.

Table 2.2.1.2(a): Lusthof Site Relation

Town	Distance from Site (km)	Direction from Site
Carolina	17	North West
Chrissiesmeer	10	South
Breyten	27	West South West
Badplaas	43	North East

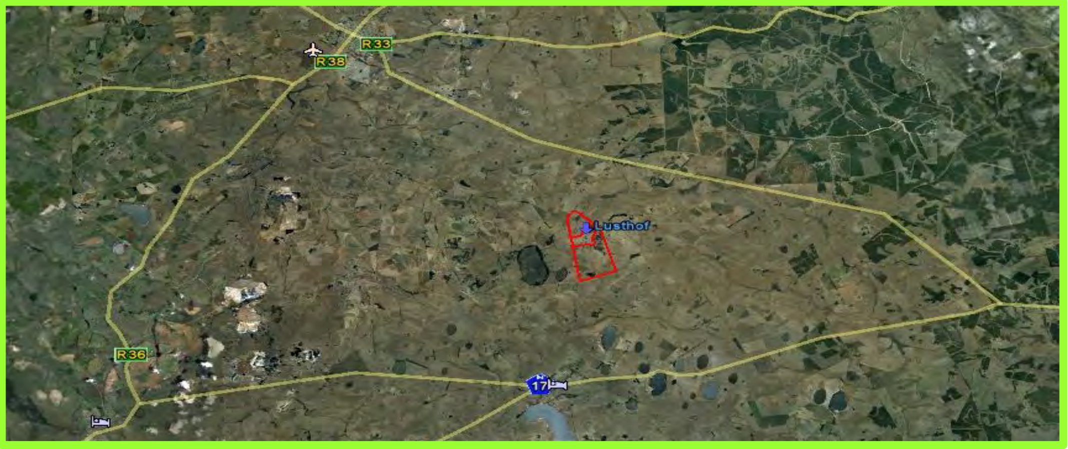


Figure 2.2.1.2(a): Lusthof Site Location and Surrounding Road Network

Figure 2.2.1.2(b): Lusthof Site Location

The mining activities are set to take place on portions 4 and 6 (see Figure 2.2.1.2(b) of the farm Lusthof. This portion of land is currently used for grazing; this is in line with the neighbouring properties as the predominant land use of the area.

Social Sensitive areas were identified within a 5 km range of the proposed project site (see Figure 2.2.1.2(c)).

Figure 2.2.1.2(c): Social Sensitive Areas within a 5 km Radius

It is expected that homesteads within the 5 km radius of the proposed project site will be affected the most by the change processes and would need to be consulted and monitored during the impact assessment phase.

Figure 2.2.1.2(d): Site Specific Sensitive Attributes

2.2.1.3 Importance to Study

Geographical processes refer to the processes that affect the land uses of the local area. Documenting the current state of the proposed project area including the land uses and socially sensitive areas is key to anticipating project impacts, and the people who these impacts would affect in a significant way. Possible impacts could include but are limited to:

- Disruption of daily movement patterns due to road diversion and fencing of the proposed mining site.
- Loss of agricultural land, sterilization of agricultural land and water quality and quantity issues impacting on livelihoods.

2.2.2 Demographical Process

Demographic processes refer to the population that will be affected by the project or development in a certain area. This includes age, composition (gender, race and culture groups) and movement patterns (cf. Vanclay 2002: 194-196).

2.2.2.1 Demographics

According to the IHS Global Insight data (2000, 2007, 2011) the total population of Albert Luthuli Local Municipality in 2000 was estimated to be around 187 536 people. After 2000 the population increased to 188 387 in 2007 and 191 831 in 2011. According to this data the average population growth was at 8.89% per year. In 2011 the African population was the predominant race in ALLM (97%). The population composition by gender in 2011 indicates that more than 52% of the total population are female and 47% are male. The predominant age group is from 15 to 19 years of age. A breakdown of the relevant data follows in the Table below:

Table 2.2.2.1(a): Population Numbers for the ALLM

	Albert Luthuli Local Municipality	
	2007	**2011**
Area (km^2)	5 559	
Total Population	188 387	191 831
Population Density	33.89	34.51
Total Households	44 740	47 144
Average Household Size	4.21	4.07
Predominant Population Groups	African (183 894/97.62%)	African (187 291/97.63%)
	White (3 862/ 2.05%)	White (3 886/ 2.03%)
Predominant Gender	Female (99 385/52.76%)	Female (101 478/52.89%)
Predominant Age Group	15-19 (27 137/14.48%)	15– 19 (25 554/13.32%)

In relation to GSDM:

GSDM population was estimated to be 1 043 197 in 2011 (StatsSA). Females were the predominant gender with over 51% of the population and Africans were the predominant race in the area at 88% of the population. ALLM contributed 18% of the total population of GSDM in 2009. With a surface area of 31 841 km^2, GSDM has a population density of 32.76/km^2.

2.2.2.2 Importance to Study

Demographical processes refer to the relational structures found with local communities. It is expected that most impacts generated by demographical processes would be due to the influx of people to the area in the form of the mining contractor. Due to the very small populations found in the surrounding local communities even a small influx may affect the demographic profiles locally. Understanding population size, distribution, composition and the processes driving the stability or change in population is crucial to anticipate the possible impacts of the proposed project on the local community.

Possible Impact(s)

The Proposed Lusthof Colliery will operate with a mining contractor for a period of approximately 8 years. The presence of project related labour forces can lead to problems like an increase in prostitution, drug trafficking and a rise in alcohol sales and consumption.

2.2.3 Institutional & Legal Baseline Processes

Institutional and legal processes can be described as a process that has either a negative or positive effect on service delivery that the population of a specific area finds necessary to maintain a healthy living environment. These services are usually provided by government authorities, private organisations or community initiatives (cf. Vanclay 2002 – 198).

2.2.3.1 Municipal Services

The following section provides an overview of the level of service delivery in the Albert Luthuli Local Municipality (also refer to Table 2.2.3.1(a)).

Table 2.2.3.1(a): Overview of Municipal Services

Summary of Municipal Services	Albert Luthuli Local Municipality	
	2007	2011
Electricity for Lighting	20 547	18 468
Electricity for Other Purposes	13 563	19 792
No Electricity	10 630	8 884
Refuse Removed Weekly	6 034	7 603
Refuse Removed Less Often than Weekly	871	1 363
Own Refuse Removal	27 534	26 650
No Refuse Removal	10 082	11 529
Water	25 265 at RDP Level	27 464 at RDP Level
Sanitation	11 138 at RDP Level	8 774 at RDP Level

In relation to GSDM:

- In 2011 over 83% of households had access to electricity for lighting in GSDM. This means that ALLM only accounted for 8% of the total households in GSDM that had access to electrical lighting. In GSDM, 8% of households had no form of electricity that could be used for heating and less than 1% had no electricity that could be used for cooking purposes.
- Of all 273 491 households, just under 82% of the households had access to water considered to be on par or above RDP level. The remaining 18% of households received water from boreholes, springs, water tankers, rivers, pools, dams or water vendors.
- According to StatsSA the number of households in GSDM with access to sanitation above RDP level was just over 70% of the total households had access to good toilet facilities.
- The number of households in GSDM with access to housing at or above RDP level was 72% of the total households with access to shelter. Over 27% of households lived in dwellings classified as below RDP level.
- A total of 63% had weekly removal of household refuse. The next 28% of households had to make use of communal refuse dumps, their own refuse dump or had refuse removed less than weekly by authority or a private company. Only 1% households had no access to refuse removal (StatsSA).

Water Supply

The region is currently experiencing a severe problem in water distribution due to the availability and the quality of the water being of below average standard (IHS Global Insight – 2007, 2011). The proportion of households that had no access to piped water increased from 10 918 in 2007 to 12 794 in 2011 illustrating the problem facing the region (IHS Global Insight – 2007, 2011).

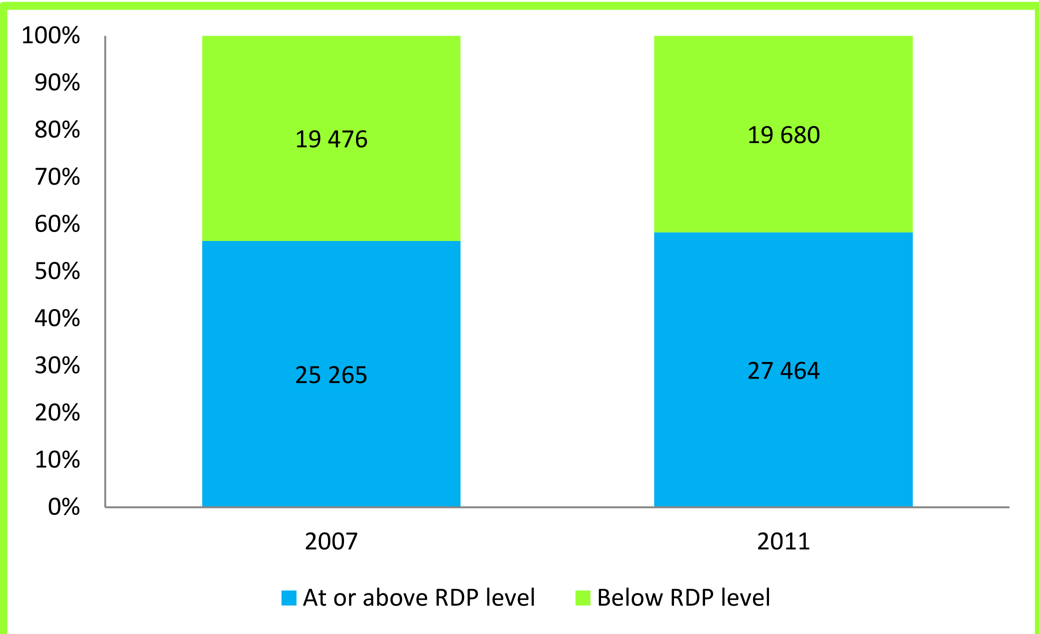


Figure 2.2.3.1(a): Households with access to water (below/above RDP level)

The number of households that do not have access to piped water is on the rise. IHS Global Insight data (2007, 2011) suggests that the number of households that are below RDP level in terms of water access have risen from 19 476 in 2007 to 19 680 in 2011 (see Figure 2.2.3.1*(a)*). The RDP level concerning access to water is as follows.

Table 2.2.3.1(b): Water Supply in terms of RDP Level

	At RDP-Level		Below RDP-Level	
	Piped Water In Yard	Communal Piped Water: Less than 200m from dwelling	Communal Piped Water: more than 200m from dwelling	No Formal Piped Water

Sanitation

According to the IDP of ALLM (2007 – 2011) there is a big sanitation backlog (see Figure 2.2.3.1**(b):**) that will require a huge financial injection to even begin to eradicate the backlog. The number of households that do not have toilets decreases year by year in Albert Luthuli Local Municipality. In 2007, the number of households without toilets was estimated to be at 2 880, that number decreased to 2 430in 2011.At the same time the number of people with below RDP-level toilets has risen from 30 725 in 2007 to 35 941 in 2011 (IHS Global Insight – 2007, 2011). The RDP level concerning acces to water is as follows.

Table 2.2.3.1(c): Sanitation in terms of RDP Level

At RDP-Level	Below RDP			
	Ventilation Improved Pit Sanitation	Pit Sanitation	Bucket System	No Sanitation

An indication of the backlog situation is given in the Figure below:

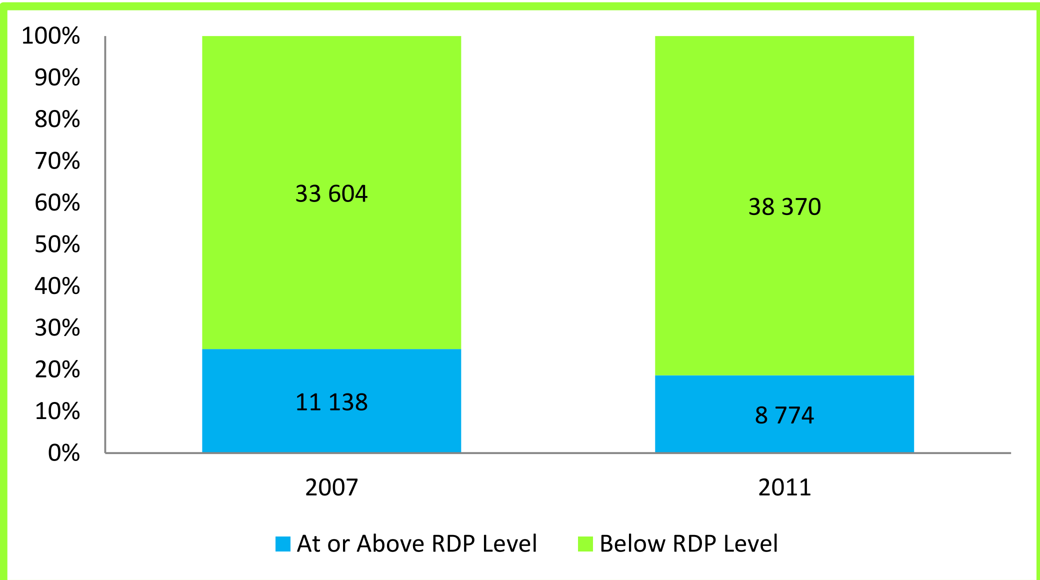
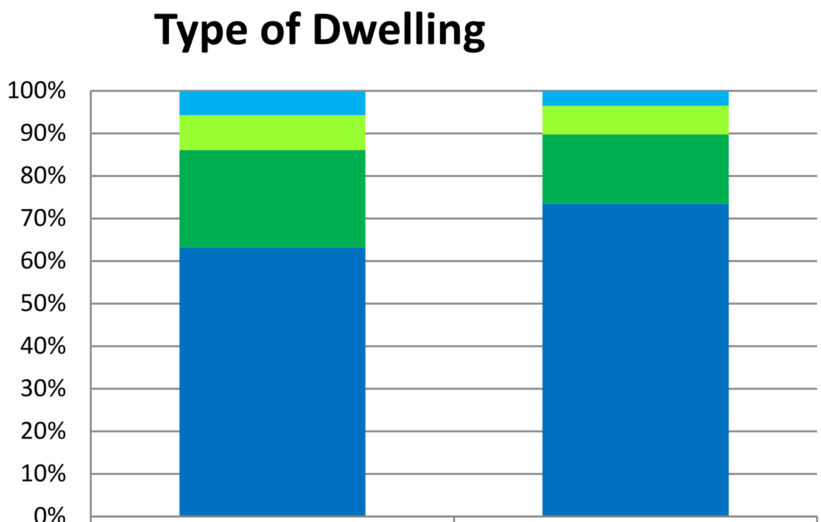


Figure 2.2.3.1(b): Sanitation

Housing

In Albert Luthuli Local Municipality the average household size is 4.2 persons as of 2001. The total number of households with housing stood at 47 144 in 2011. The majority of the population in Albert Luthuli Municipal area live in formal dwellings. According to the statistics in the IDP there was an increase in formal housing between 2001 and 2011 the increase was estimated to be at 5.73% per year, while informal housing has decreased by 5.44% per year (see Figure 2.2.3.1(c)). Informal housing only equates for a small percentage of the total housing of the area, and most informal housing patterns are an extension of existing formal areas like Carolina driven by the desire to be located closer to work opportunities and services.



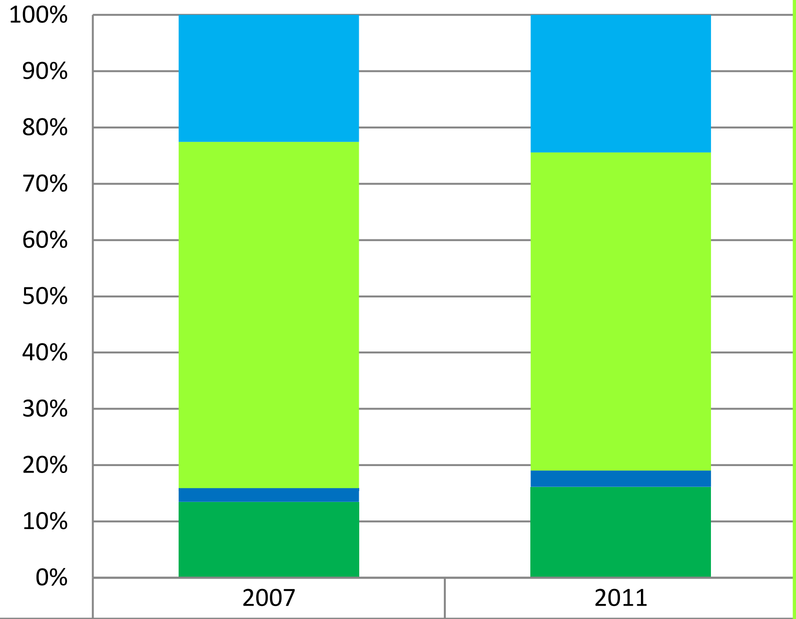
	2007	2011
Other dwelling type	0%	0%
Informal	6%	4%
Very Formal	8%	7%
Traditional	23%	16%
Formal	63%	73%

Figure 2.2.3.1(c): Dwelling Type

Waste Management

Waste management in Albert Luthuli Local Municipality has been found lacking due to the increasing size of the backlog. Although the responsibility of removing household waste is that of the municipality, many areas have to rely on community organisations or private companies to deliver such a service (IHS Global Insight – 2007, 2011). In Albert Luthuli the services delivered by community organisations or initiatives have decreased from 1 396 households in 2000, to 0 in 2011. The number of households with no refuse removal servicing rose from 6 250 in 2000, to 11 529 in 2011 (see Figure 2.2.3.1(d)).

Of the total number of households in Albert Luthuli, only 15.09% (5 915 households) had received household refuse removed on a weekly basis (IHS Global Insight – 2007, 2011).



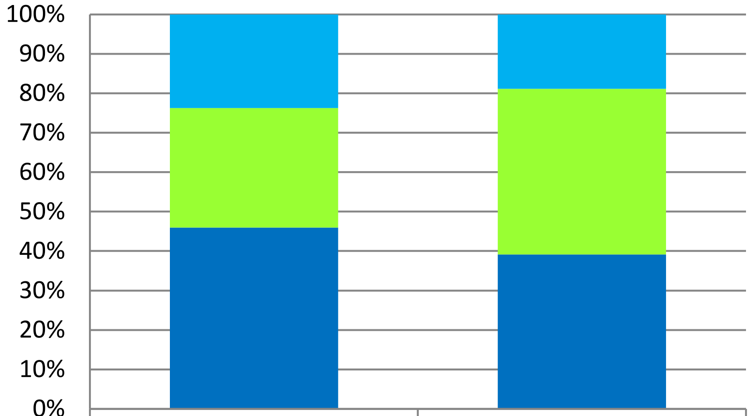
	2007	2011
No refuse removal	10 082	11 529
Personal removal (own dump)	27 534	26 650
Removed by community members	220	0
Removed less often than weekly by authority	871	1 363
Removed weekly by authority	6 034	7 603

Figure 2.2.3.1(d): Access to Waste Removal

Electricity

From the year 2000 the number of households with access to electricity has risen considerably. In 2000 the number of households with access to electricity was estimated to be 20 093 households. That number has steadily increased to 34 110 in 2007, with 76.24% of households having access to electricity.

In 2011, 38 260 (81.16%) people had access to electricity (IHS Global Insight – 2007, 2011). Bearing in mind that, between 2000 and 2011, the average increase in households per year in Albert Luthuli Local Municipality was 7.56%, the success of the electricity providers are evident (see Figure 2.2.3.1(e)).



	2007	2011
Not using electricity	10 630	8 884
Electricity for lighting and other purposes	13 563	19 792
Electricity for lighting only	20 547	18 468

Figure 2.2.3.1(e): Access to Electricity

Roads and Storm Water

The Albert Luthuli Municipality area consists mainly of gravel roads, having a combined length of roughly 800 kilometres. The towns in the region are linked by tarred roads stretching over considerable distances. These are mostly Provincial roads which are a responsibility of the Provincial Department of Roads and Transport.

Three prominent east west and north-south provincial routes cut through Albert Luthuli Local Municipality, namely R38, R36 and R33. Those three provincial routes play an important role in terms of facilitating economic and transport activities. These roads are the only provincial roads that lead in and out of Carolina with the R38 linking up with the N11. According to the IDP of ALLM the public transport system in Albert Luthuli consists of minibus taxis and some busses.

The deteriorating road network has proven to be a big problem according to the RDP of ALLM. Road access is of critical importance for the economy of the region, social fabric, safety and security and tourism. Carolina is located on the main route to Swaziland and carries a high flow of regional-traffic. It also carries a high volume of coal transporting and other trucks that has been known to cause a considerable amount of damage to the road surface (IDP ALLM – 2007, 2001). Most of the gravel roads in the area are not easily accessible with a normal car and the farmers in the area take it on themselves to maintain the roads on to their farms but the public dirt roads are still the responsibility of the municipality. According to IDP of ALLM the storm-water drainage system needs urgent attention as it is insufficient in terms of drainage. The municipality has a great challenge to upgrade or re-gravel these roads. Surface storm water causes soil erosion which damages dirt roads. The developed urban and peri-urban areas are provided with formal water drainage systems.

Health

Carolina has a hospital that has recently been transferred to the local government. Apart from the hospital there is a clinic in Silobela and an occupational health practice in Carolina (Mpumalanga Department of Health).

According to the IDP a Local AIDS Council (LAC) was established. The aim of setting up the LAC was to develop coherent strategy and action plan to deal with HIV/AIDS in the municipal area including:

- Prevention and Education
- Care, Support and Treatment for people with HIV/AIDS
- Care for children affected by HIV/AIDS

Security and Policing

Although Albert Luthuli is a small municipality, all crime has increased since 2000 except murder which has steadily decreased between 2000 and 2011. Sexual crimes increased from 160 in 2000 to 192 in 2010 (see Figure 2.2.3.1(f)). Being a rural area, Carolina does not enjoy the amount of policing that more urbanised towns/cities enjoy.

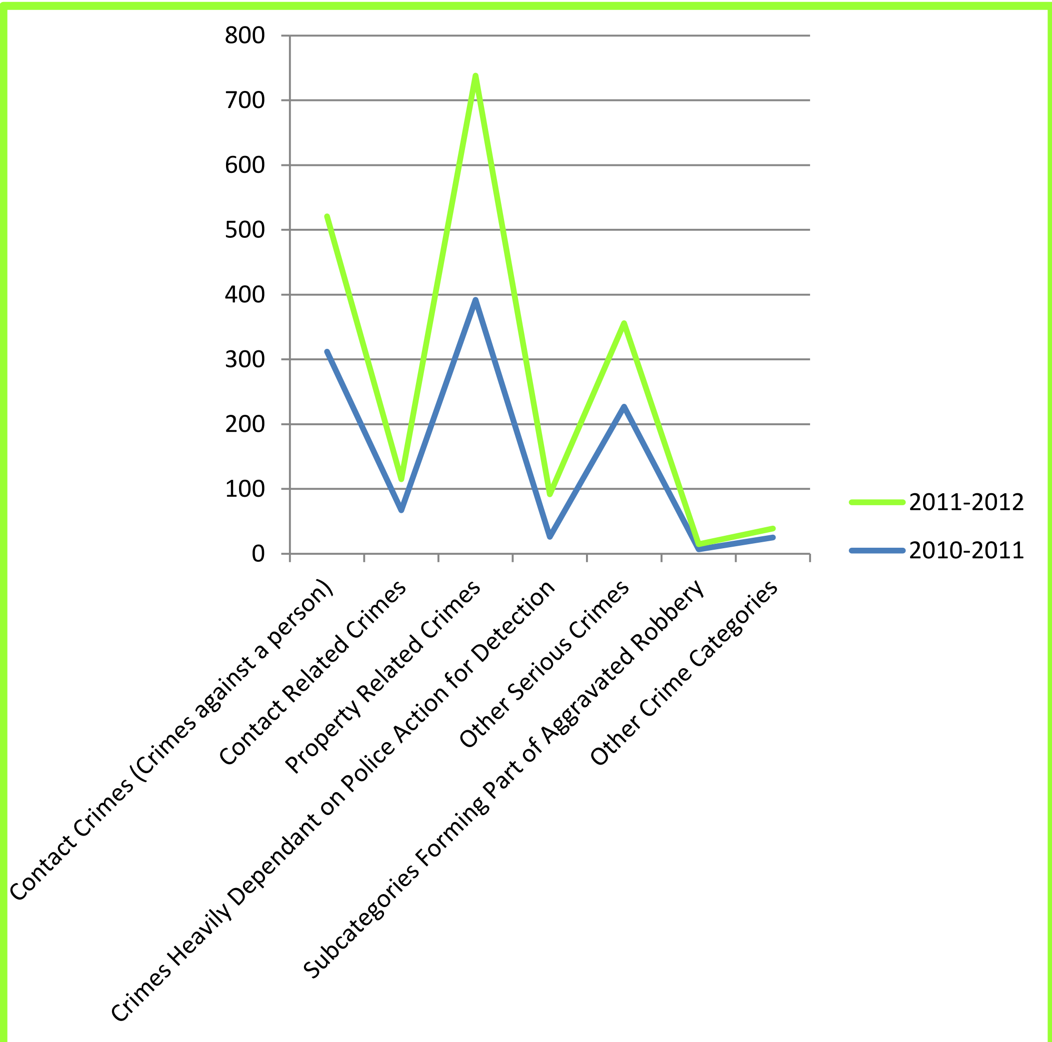


Figure 2.2.3.1(f): Crime Indicators

Legend:

- **Contact Crimes (Crimes against a Person)** – Refers to crimes such as murder, sexual crimes, attempted murder, assault with the intent to inflict grievous bodily harm, common assault, common robbery and robbery with aggravating circumstances.
- **Contact Related Crimes** – Refers to crimes such as arson and malicious damage to property.
- **Property Related Crimes -** Refers to crimes such as burglary and theft.
- **Crimes Heavily Dependent on Police Action for Detection** – Refers to crimes such as illegal possession of firearms and ammunition, drug related crime and driving under the influence.
- **Other Serious Crimes** – Refers to crimes such as commercial crime and shoplifting
- **Subcategories Forming Part of Aggravated Robbery –** Refers to crimes as carjacking, truck hijacking and robbery.
- **Other Crime Categories -** Refers to crimes such as culpable homicide, public violence, Crimen Injuria, neglect and ill-treatment of children and kidnapping.

2.2.3.2 Importance to Study

Institution and Legal processes refer to the processes that affect service delivery to the local area and could entail a change in housing needs, which in turn could cause an additional demand on municipal services. Information concerning the structure and dynamics of local services is critical to identifying and anticipating problems and community needs in addition to establishing short- and long-term project impacts. Possible impacts include but are limited to:

- High volumes of mine related traffic may lead to access roads being over used, impacting on road safety
- Pressure put on local infrastructure and services due to influx of people seeking employment and contractors.

2.2.4 Socio-Cultural Process

Socio-cultural process can be described as all aspects of the way that people live together. The following sections provide an overview of the status quo currently for socio-cultural processes.

2.2.4.1 Cultural History of the Area

Mpumalanga is known for having one of the richest cultural and environmental histories, that some scholars suggest dates back to even conceivably the first humans in Africa. Suporting this claim is the fact that scientists found Stromatolites in the hills near Baberton. Stromatolites are the fossilised remains of a blue coloured algae that scientists estimate formed about 3 500 years ago.

Mpumalanga has several examples of ancient San rock art that places. This places the San people in the area lengthy time before the arrival of other native peoples of the area. Remnants of old red ochre mines and iron and copper smelters have also been found placing the Nguni people in the area. In 1400 AD the second migration of Nguni people arrived in the Mpumalanga area. Nguni intellect was well developed as the Nguni had knowledge of advanced iron smelting and they were capable of building stone-walled houses.

The establishment of the Swazi people as we know it today started at the time of King Ngwane. The area, which was then demarcated by tribal boundaries, was referred to as KaNgwane, with that name still in use today. The movement and migration patterns of tribal chiefs in and around the province had a profound effect on the formation and cohesion of nations.

The Zulu king, Shaka had the most notable influence on the area. The Zulu empire under Shaka stretched from the Swaziland border to the Tugela River. Many other cultures sprung from these cultures and gave birth to the diverse area known as Mpumalanga.

White settlers came to the area in the 1800s as part of their migratory route up from the southern coast of South-Africa. Carolina the town was founded by Cornelius Coetzee as a permanent outspan for wagons when gold was discovered in 1883 in Barberton and named after his wife Carolina. It was rebuilt after it was razed during the Second Boer War.

2.2.4.2 Importance to Study

Socio-cultural processes refer to the processes that affect the local culture of an affected area, i.e. the way in which the local community go about their daily lives. Changes in the cultural composition of an area affect the current system that may lead to impacts on the local community. Possible impacts include but are limited to:

- Possible grievances and conflict situations between the contractor’s workers and the local community regarding perceived employment opportunities as well as landowners and developers of the proposed mine; and
- Presence of the mine related infrastructure can affect people's sense of place.

2.3 HERITAGE BASE LINE

In order to investigate the occurrence and current status of the Heritage Environment, JMA Consulting, conducted an onsite assessment at the proposed Lusthof Colliery Mining Site.

Heritage resources were classified as either 1) a graveyard; which could consist of one or more separate graves, 2) infrastructure i.e. buildings or structures of cultural significance or 3) a site of archaeological importance.

The site visit was conducted by foot after consultation with local residents. Three separate graveyards (GY01 – GY03) and two houses (H01 and H02) were identified (see Table 2.3(a) and Figures 2.3(a–g)).

Graveyard one (GY01) is situated on the border of the open cast pit and consists of the remains of what seems to be of approximately three or four graves, Graveyard two (GY02) is also on the boarder of the open cast pit and consists of the remains of what seems to be a single grave, and Graveyard three (GY03) is situated within the border of the open cast pit and consists out of stones from the area placed in one location and is surrounded by a stonewall consisting of similar type of rocks.

Both houses (H01 and H02) are in a highly deteriorated state. Currently a family is occupying H02 and will have to be relocated once the project has commenced.

Table 2.3 (a): GPS Co-ordinates of Heritage Resources

Heritage Resource	GPS Co-ordinates				Significance	In use/abandoned
GY01	S	26	11	0.185	High	Abandoned
	E	30	13	0.962		
GY02	S	26	11	0.266	High	Abandoned
	E	30	13	0.847		
GY03	S	26	11	0.209	High	Abandoned
	E	30	13	0.908		
H01	S	26	11	24.69	Low	Abandoned
	E	30	13	0.962		
H02	S	26	11	18.43	Low	In use
	E	30	13	52.45		

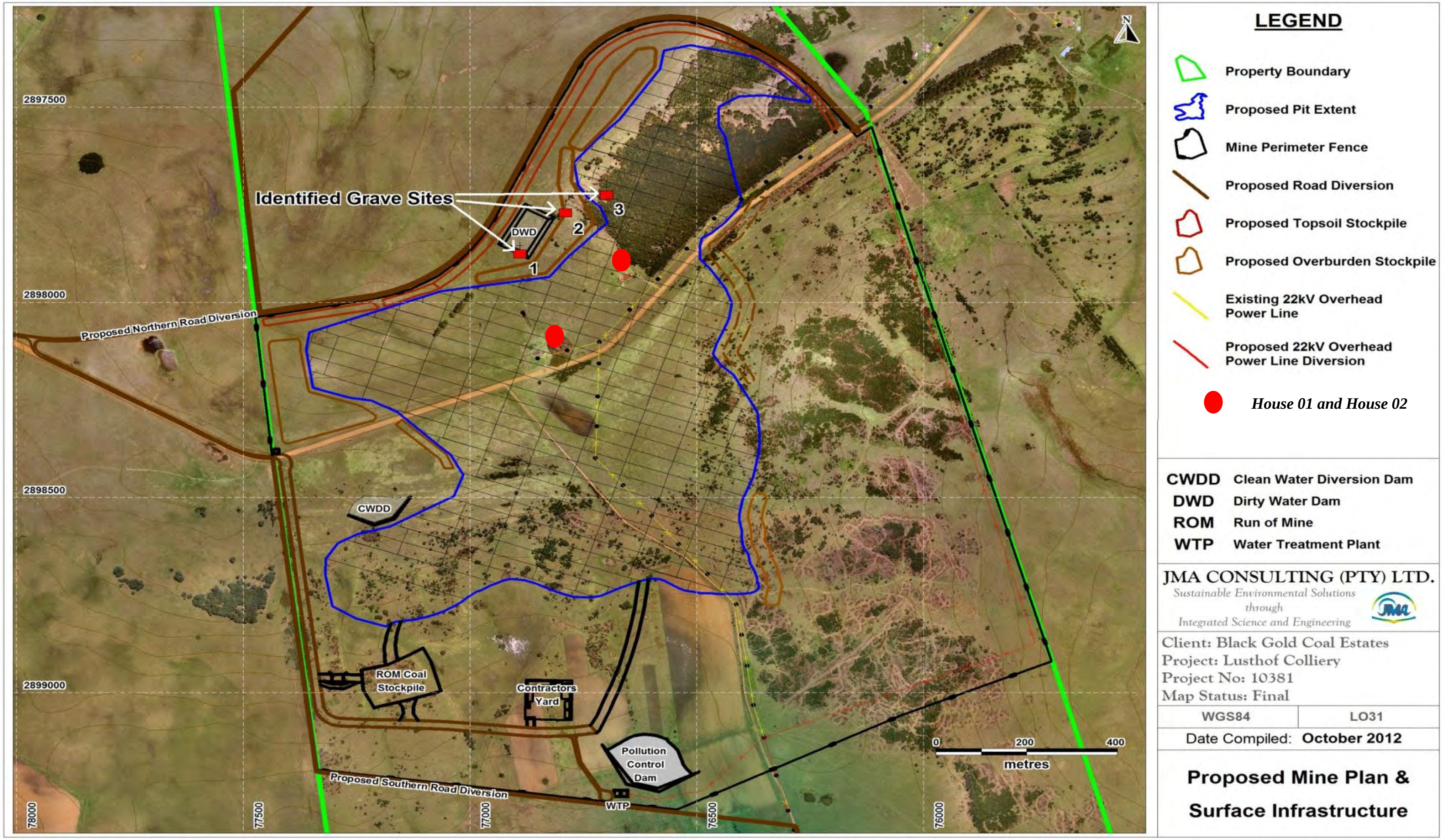


Figure 2.3(a): Map of Lusthof Colliery Operations and Identified Heritage Resources.

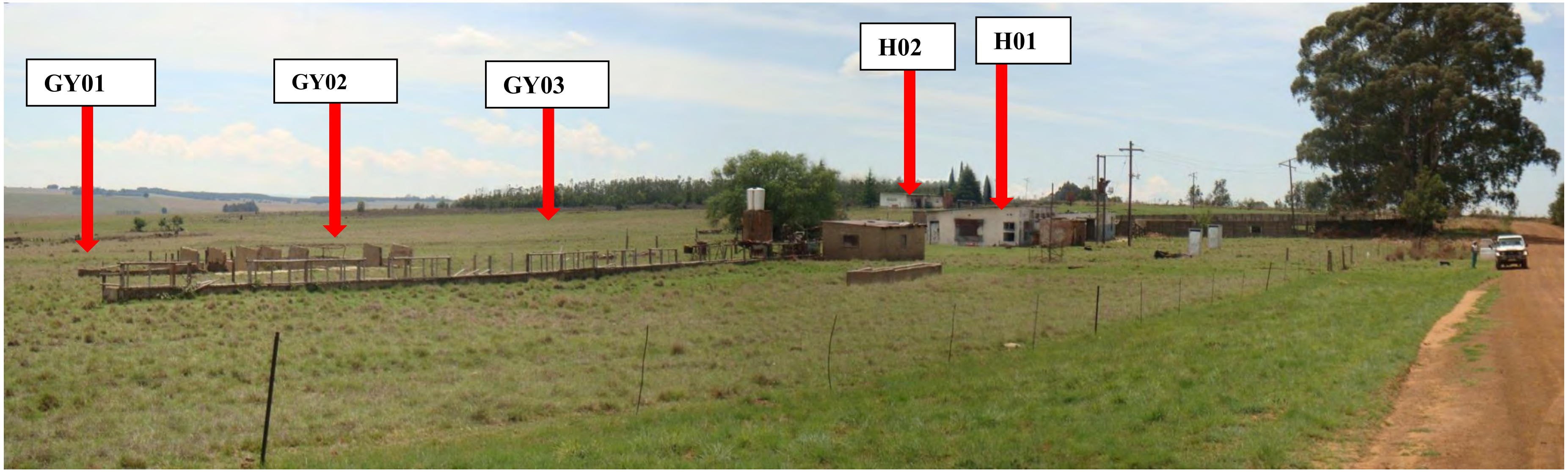


Figure 2.3(b): Panorama of the Entire Infrastructure that will be Influenced by Mining Activities. Grave 1 (GY01), Grave 2 (GY02), Grave 3 (GY03), House 1 (H01) and House 2 (H02) as Indicated in the Influenced Heritage Resources listed above.

Figure 2.3(c): Graveyard 01

Figure 2.3(d): Graveyard 02

Figure 2.3(e): Graveyard 03

Figure 2.3 (f): House 01

Figure 2.3(g): House 02

The relocation of the people living in House 2, as well as the graveyards identified, must be be dealt with in the EIA and EMP.

2.4 LAND USE BASE LINE

This discussion on the current land use was compiled by specialists Wetland Consulting Services during their soils assessment conducted for the study area and represent the entire content of their base line findings.

2.4.1 Lusthof Land Capability and Land Use

The area within the opencast pit comprises of land with arable, grazing and wilderness capabilities. Due to the shallow nature of the soil profile, the project area is currently used for livestock farming including cattle, sheep and small game. In the residential units that are still in use (occupied by between 10-20 people) there is evidence of subsistence activities including some poultry and fruit trees.

The greatest majority of the area is covered by natural vegetation, disused plow ridges occur, indicating a previous crop production use. Limited dry land maize production is also evident on the study area, as a couple of cultivated fields occur. This is however very small in relation to the total area. A Black Wattle plantation and a couple of isolated patches of Black Wattle also occur within the study area.

The current land uses identified within the Lusthof farm boundary are indicated on Figure 2.4.1(a) and are listed below:

- Cultivated lands; this includes old lands as well as current maize and soya croplands.
- Wetlands
- Hay pastures; these are predominantly *Eragrostis curvula* fields.
- Woodlot; *Acacia mearnsii* has been planted as a source of wood for farm inhabitants. These trees have expanded independently into a large portion of the grazing lands to the south of the road.
- Grazing lands; these are grasslands used as extensive grazing for beef cattle.

Within the area enclosed by the earthen berm the respective area of each landuse is as follows:

- Cultivated: 5.3ha
- Woodlot: 19.1ha
- Grazing: 91.7ha
- Wetland: 14.4ha
- Hay Pasture: 33ha

There is limited functional economic infrastructure left in the current project area. A dam was observed as well as two or three abandoned cattle herding pens.

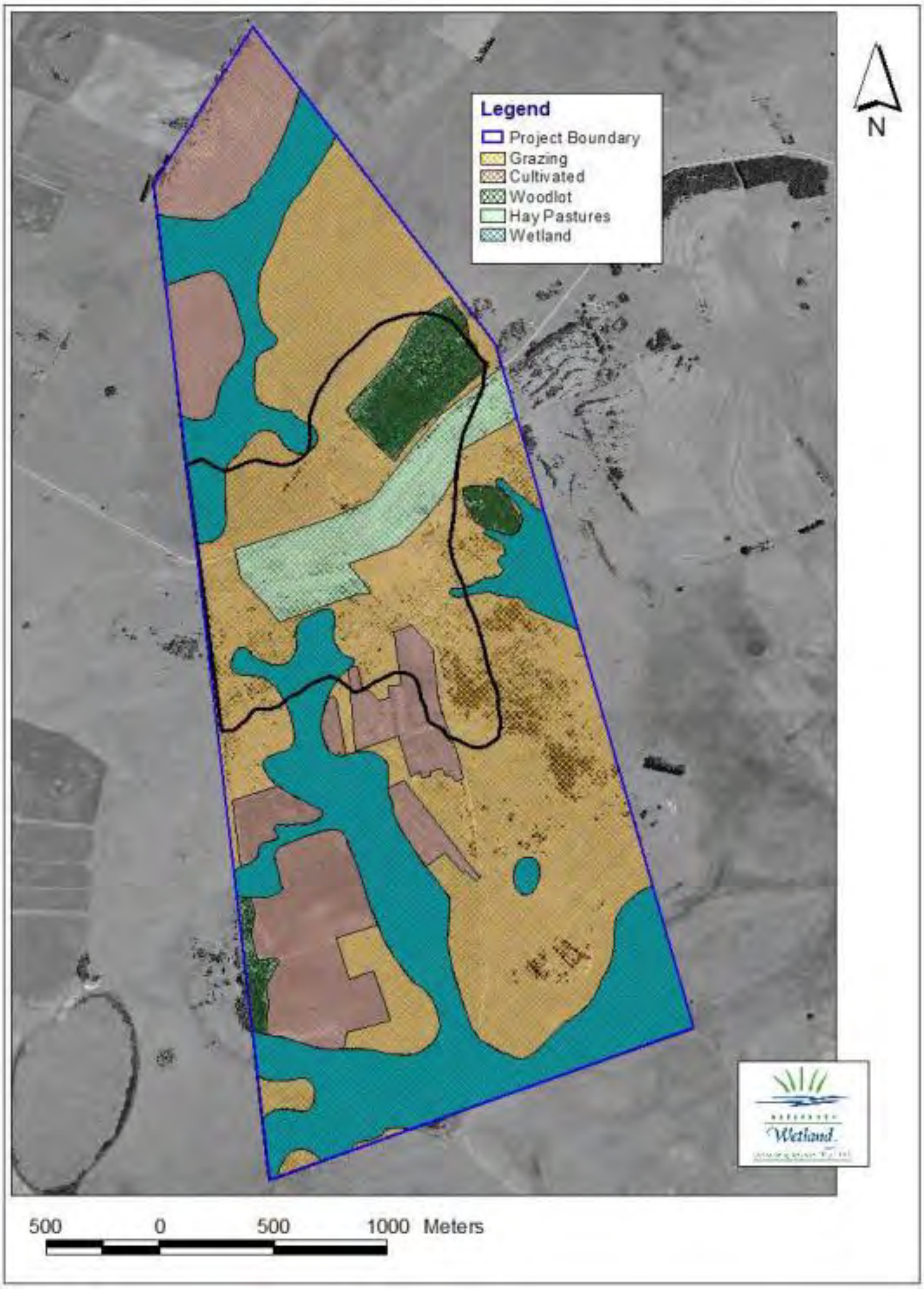


Figure 2.4.1(a): Current Land Uses within the Lusthof Study Area

A secondary Provincial gravel road runs through the proposed mining area. Two old farmhouses and a couple of out buildings occur on a small portion of the farm, they are still inhabited by farm labourers. No signs of erosion were observed during the survey.

2.5 INFRASTRUCTURE BASE LINE

Information on the current status of the infrastructure in the area was generated by several specialists during their base line assessments. The information in this section represents extracts from the various inputs obtained from the different specialists.

The discussion in this section will relate to the following:

- Roads
- Buildings on portion 4 and portion 6 of Lusthof
- Buildings and infrastructure surrounding the proposed mining site

2.5.1 Current Road Status

The Albert Luthuli Municipality area consists mainly of gravel roads, having a combined length of roughly 800 kilometres. The towns in the region are linked by tarred roads stretching over considerable distances. These are mostly Provincial roads which are a responsibility of the Provincial Department of Roads and Transport.

Three prominent east west and north-south provincial routes cut through Albert Luthuli Local Municipality, namely the R38, R36 and R33. Those three provincial routes play an important role in terms of facilitating economic and transport activities. These roads are the only provincial roads that lead in and out of Carolina with the R38 linking up with the N11. According to the IDP of ALLM the public transport system in Albert Luthuli consists of minibus taxis and some busses.

The deteriorating road network has proven to be a big problem according to the RDP of ALLM. Road access is of critical importance for the economy of the region, social fabric, safety and security and tourism.

Carolina is located on the main route to Swaziland and carries a high flow of regional-traffic. It also carries a high volume of coal transporting and other trucks that has been known to cause a considerable amount of damage to the road surface (IDP ALLM – 2007, 2001).

Most of the gravel roads in the area are not easily accessible with a normal car and the farmers in the area take it on themselves to maintain the roads on to their farms but the public dirt roads are still the responsibility of the municipality.

According to IDP of ALLM the storm-water drainage system needs urgent attention as it is insufficient in terms of drainage. The municipality has a great challenge to upgrade or re-gravel these roads. Surface storm water causes soil erosion which damages dirt roads.

The following aspects related to the current roads to be used by the mine are important to note as base line information:

- The northern tar road has a 30 ton weight limit
- The southern tar road has a 10 ton weight limit
- The southern and northern gravel roads will need to be upgraded to carry the 30 ton outgoing and 10 ton returning coal transport vehicles. A detailed geotechnical study will be conducted for the upgrade of these roads.
- The provincial gravel road dissecting the mining area from west to east will be diverted to the north. A Road Diversion Application, together with an EIA, will be lodged with the relevant authorities. A comprehensive Road Diversion Application Report, complete with Civil Engineering Designs, wil be commissioned for this purpose.
- The farm gravel road dissecting the mining area from north to south will be re-routed along the existing farm road along the western boundary of the mine.

2.5.2 Current Traffic Volumes

The proposed coal transport traffic volumes have been calculated as 4 trucks per hour past any given point for the one way sections, and 8 trucks per hour past any given point for the two way sections. In view of this low density of additional traffic volumes, it was deemed unnecessary to conduct formal traffic counts along the proposed transport routes.

Furthermore the gravel road up to the tar road is currently exclusively used for agricultural and general public travel purposes. It is safe to assume that the land owners next to the road are not exposed to excessive noise and dust from the gravel road, especially during the night.

2.5.3 Current Status of Buildings on Lusthof

During a physical site inspection it was verified that the only infrastructure present on either portion 4 or 6 of the farm Lusthof, comprises two houses (H01 and H02), some out buildings (OB01 and OB02) and some cattle pens (CP01) as shown in Figure 2.5.3(a).

Whereas House 1 is in a very bad state of repair the other infrastructure is still in a functional state. However, all the infrastructure will be demolished during the operational phase of the mine as it falls within the bounds of the planned open pit. The property will be purchased by BGCE prior to commencement of mining.

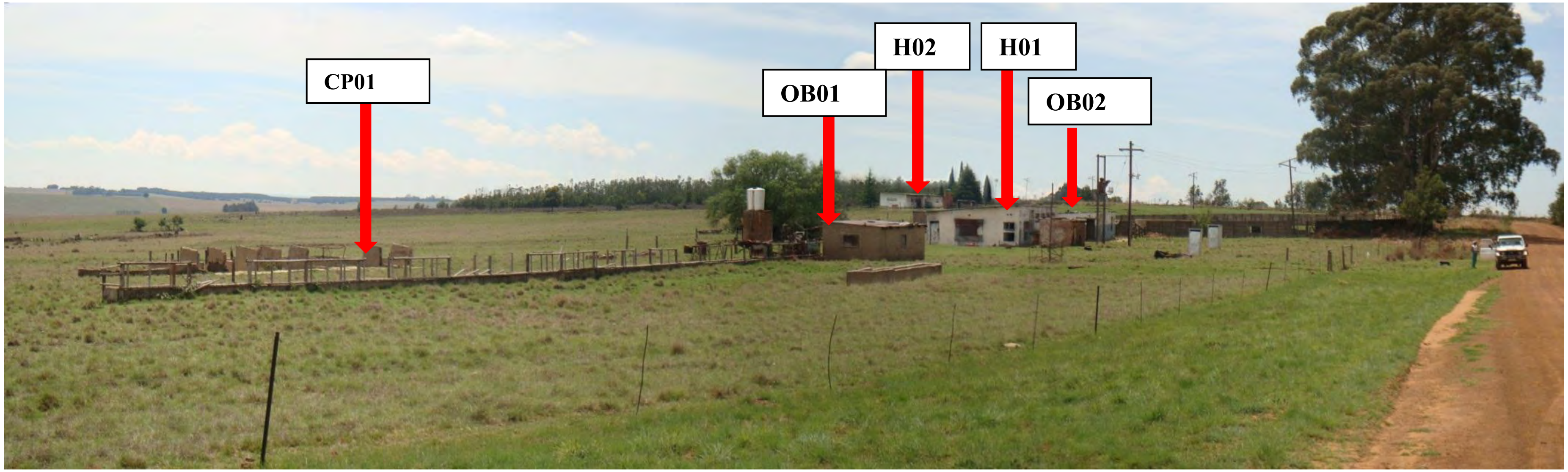


Figure 2.5.3(a): Panorama showing the only Infrastructure present on portions 4 and 6 of the farm Lusthof.

The current condition of the two houses on Lusthof is shown in the Figures below. Both structures will be demolished during mining.

Figure 2.5.3(b): House 01

Figure 2.5.3(c): House 02

2.5.4 Current Status of Buildings and Infrastructure around the Mining Site

In order to establish a current baseline from which to assess possible future mining related impacts on surrounding infrastructure, primarily caused by blasting vibrations, an assessment was made of all neighbouring infrastructure existing within a 1 km radius from the mine. This buffer zone is twice the considered safe distance from blasting of 500 m applied by *inter alia* SASOL in respect of their gas pipe line running some 2 400 m to the north north-west of the proposed Lusthof Colliery. The surveyed infrastructure is shown on Figure 2.5.4(a)

The following infrastructure, and which is currently in use, exists within a 1 km radius from the perimeter of the proposed open pit where blasting will occur:

- Farm workers houses on the property of De Jager located 200 m east of the open pit.
- The homestead and outbuildings of Du Hain located 500 m east of the open pit.
- The homestead and outbuildings of De Jager located 800 m east of the open pit.
- Borehole LC-GW8 belonging to Du Hain located 550 m east of the open pit.
- Borehole LC-GW4 belonging to De Jager located 900 m east of the open pit.

In order to record the current base line situation with respect to the condition of the infrastructure listed, a site inspection will be conducted by JMA Consulting prior to the commencement of mining in order to assess the condition of the infrastructure. A photographic record will be compiled to record any existing damage to infrastructure and the relevant owners will be asked to sign off on the assessment.

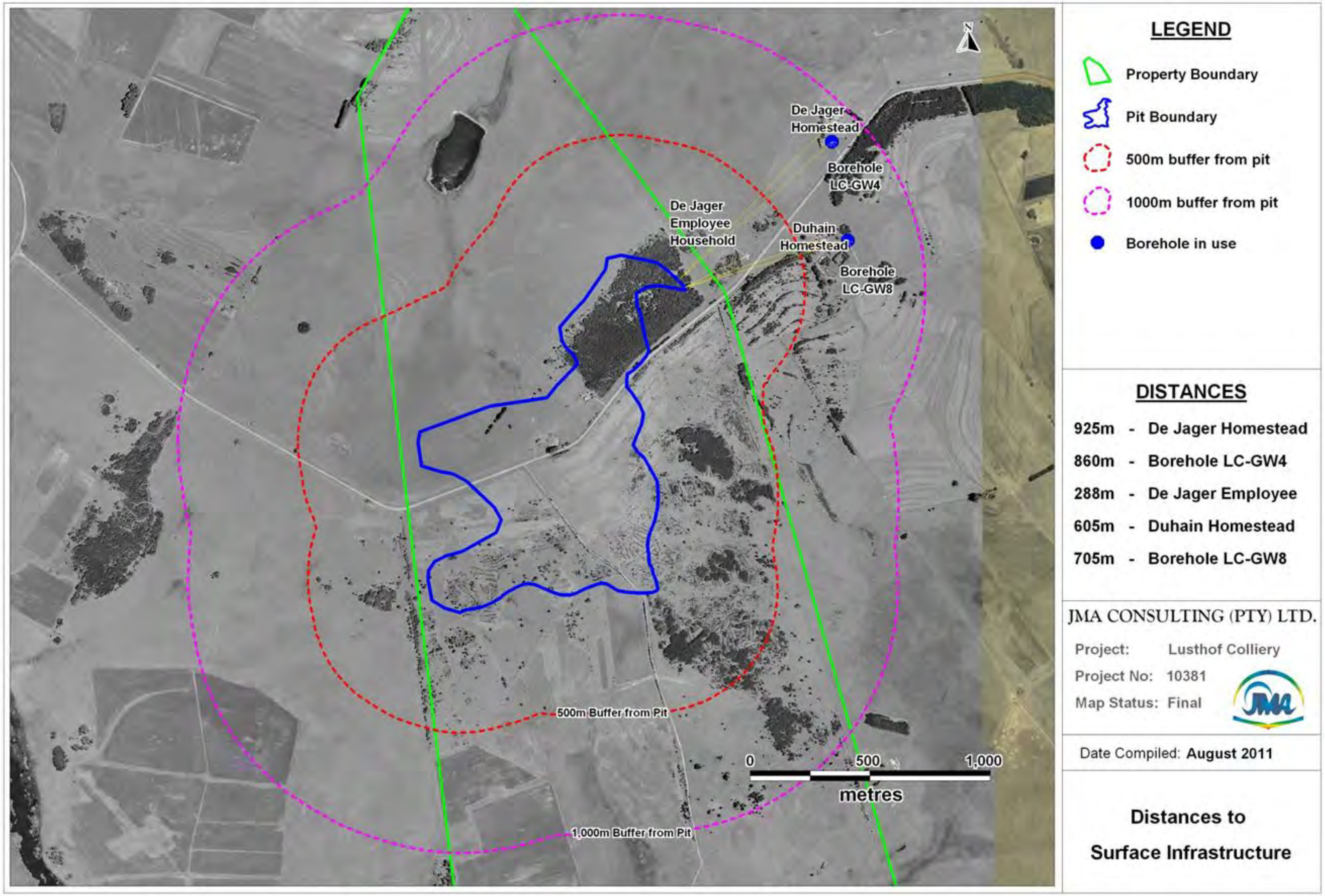


Figure 2.5.4(a): Infrastructure located within 1500 m around the proposed Lusthof Colliery Mining Site

2.6 SOCIO-ECONOMIC BASE LINE

Socio-Economic Aspects (including Land Use) relevant to the Project were investigated and is discussed with reference to the information generated by Socio-Economic Specialist An Kritzinger. A Comprehensive Specialist Report is attached as APPENDIX S 2.6 (A) to this report. However, for this Scoping Report, a synoptic summary was compiled from the Specialist Report. Please refer to the Specialist Report for a more detailed and comprehensive discussion of the Socio-Economic Base Line.

The economic baseline discusses the local development priorities of the economic impact zone as expressed by the relevant policy documents as well as the current status of the zone in terms of the broader economic outcomes/objectives of local economic systems. These economic objectives include outcomes in terms of the traditional focus area of economic efficiency (economic growth and employment), economic equity (income distribution and poverty alleviation) as well as long term economic stability (including long term environmental sustainability and potential macro-economic risks).

2.6.1 Overview of Local Economic Development Priorities

More than 70% of the total coal generated energy capacity in South Africa is located in Mpumalanga Province. There is currently 5000 pending mining applications in Mpumalanga Province also for the purposes of coal exports. With potentially high consequences for agriculture and food security, the effectiveness of land use management tools is very important. There are currently a number of vocal lobbyists in the Province against mining applications in the province due to perceived ineffectiveness of land use management tools. It is argued that land-management tools such as EIAs over–emphasise the potential advantages of single mines relative to long term cumulative impacts from a number of mines.

The processes and number of pending mining licences within specific areas are also not always readily available. It is also argued that ”less than one percent of EIAs are rejected by government permit-issuing departments, and there have been allegations that industry wields considerable power in the assessment process, with little consideration for communities who may already be vulnerable due to food insecurity and poverty” (Kardas-Nelson, 2010: Christie, 2010). There is also a perception that licensing by the Department of Mineral Resources is largely uncoordinated and does not take into account the long term cumulative impacts on the environment.

The urgent need to balance the interests of coal relative to other sectors are highlighted in all the relevant community documents, i.e. the provincial growth and development strategy as well as the Local Economic Development Plans of the relevant district and local municipalities. Local authorities mainly rely on national tools such as nationally imposed EIAs and mining licensing processes (with their perceived shortcomings as mentioned above) as well environmental management tools that enables local authorities to react only after the damage has been done.

The PGDS argues for an Integrated Coal Minerals Resource Development Plan for the Eastern Highveld of the Mpumalanga province to ensure the sustainable development of the Eastern Highveld's coal minerals and the protection of the environment and water resources. While this plan was proposed four years ago (2008) such a strategy has not yet been developed.

GertSibande District Municipality and Albert Luthuli Local Municipality mainly use guidelines provided by the spatial development framework and, in terms of mining license applications, use their discretion in each individual case based on planning guidelines. The question is whether 'discretionary' processes on a local level make sufficient provision for long term cumulative impacts on livelihoods in the area.

2.6.2 Economic Eficiency

Economic output levels grew at a below national average annual rate of 2% per annum (Albert Luthuli) and 2.4% per annum (Msukaligwa) between 2000 and 2010. This is mainly due to a declining and low growth rates in the traditional mainstay sectors of the economy namely agriculture, forestry and wood production and the slow emergence of alternative sectors to take the place of the former leading sectors. The agricultural productivity and income levels from agriculture are low in the economic impact zone. The links of the agricultural sector with downstream manufacturing (e.g. food processing) and upstream manufacturing inputs (e.g. machinery) are furthermore extremely weak. While the forestry sector has limitations in terms its high level of water intensity, it is still regarded as a potential growth sector especially in the areas further away to the east and north of the economic influence zone.

Sectors with higher growth potential include the service sectors (education, trade and finance), transport and construction. The local economy has a very small manufacturing base.The tourism sector is currently not a dominant sector in the area. Tourism is mainly concentrated in the Badplaas area as well as in Chrissiesmeer area.

The unemployment rate of 49% for the Albert Luthuli area in 2011 is much higher than the provincial as well as national averages and the unemployment rates in Msukaligwa (27%). The low proportion of economically active males in the region could be attributed to out-migration in search of jobs in neighbouring areas. The local labour force has very low skill levels even compared to the province as a whole.

While both areas are regional exporters of agricultural products, the foreign export base of both economies are very low to non-existent (in the case of Albert Luthuli). In Albert Luthuli foreign exports made a zero contribution towards output compared to the 0.1% contribution for Msukaligwa.

2.6.3 Economic Equity

The Gross value added/production income (GVA) per capita is below the national average in both municipal areas. In Albert Luthuli, the GVA/capita was a mere R 17 500 per current prices in 2011 compared to the much higher averages for Msukuligwa of R 49 000 albeit it still lower than the national and provincial averages of R 59 000 and R 57 000 respectively.

Although poverty has declined from 61% to 48% between 2000 and 2011 in Albert Luthuli, poverty levels are still significantly higher than in the province (42%) and South Africa (38%) as a whole.

While the poverty rate has decreased for most areas in South Africa mainly due to higher growth rates between 2000 and 2006/7, the percentage of people living in poverty in Msukaligwa has increased slightly between 2000 and 2011 from 47.1% to 47.3%. Despite relatively lower unemployment rates, the poverty rates were high in Msukaligwa signifying relatively smaller household sizes and less dependents being 'lifted'out of poverty due to employment from a household member. This could indicate a larger number of single households within the area, perhaps due to inter- area migration within Msukaligwa. Whether this is also the case in Chrissiesmeer needs to be verified.

The economies of the Albert Luthuli and Msukaligwa municipal areas are in keep with the high level of inequality associated with the South Africa economy. In 2011, the Albert Luthuli economy recorded a relatively lower Gini coefficient of 0.57 (0= perfect equality and 1= perfect inequality) compared to a national Gini coefficient of 0.63 and provincial Gini coefficient of 0.65. Msukaligwa equalled the national Gini coefficient of 0.63.

Albert Luthuli showed signs of improving income inequality with a drop in the Gini coefficient from 0.62 in 2000. Msukaligwa's income inequality remained unchanged from 0.63 in 2000(IHS Global Insight. 2012).

2.6.4 Economic Stability

The local economies are mainly resourced-based (agriculture and to some extent mining) and hence subject to external variables such as climatic conditions. The level of economic concentration in Albert Luthuli and Msukaligwa is slightly higher than the national and provincial levels. It also showed signs of increasing since 2000. The tress index measures the extent of economic concentration in a small number of sectors. The higher the index value, the higher is the rate of economic concentration within an economy and the more its long term stability could be at risk. The tress indices below illustrate the relatively higher levels of economic concentration in Albert Luthuli and Msukaligwa compared to the national as well as provincial economies. The tress index of both these municipal areas furthermore shows signs of increasing since 2000. This could mainly be ascribed to the decline of the contribution of the traditional sectors of agriculture, forestry and wood processing relative to coal and other mining in both municipalities.

Based on a non–renewable resource, the mine has a limited lifespan of around 8 years. As is the case with other commodities, the international commodity price of coal is furthermore subject to large fluctuations.

Currently South Africa is still highly dependent on coal-fired energy and the regular supply of coal is required for stable national energy supply.

The resource sectors are furthermore highly water intensive**.** According to the Albert Luthuli Water Services plan (2012) the available water resources in the municipal area are adequate to meet current and future water demands. There is however a need to upgrade the outdated water resources infrastructure in the area amidst the requirement to service huge water and sanitation backlogs in the area.

The impact of acid mine seepage from mines in the area on the water quality of Carolina and parts of Ermelo made headlines in January 2012. The Boesmanspruit Dam was contaminated by acid mine water seepage, affecting tap water in the town of Carolina, north of Ermelo, and the surrounding areas. While the outdated water treatment plant was also blamed for the catastrophe and water quality has since then been restored to a large extent, the incident focused public attention on the negative impacts of coal mining in the area, especially of mines operating without water licenses.

2.7 CLIMATE/METEOROLOGY BASE LINE

The current meteorology of the study area is described based upon extracts from reports compiled by the air quality (Airshed Planning Professionals) and surface water (Inprocon) specialists. The meteorological information provided by them is reproduced in its entirety in this section.

2.7.1 Regional Climate

The larger study area has a typical Highveld-Type climate, typical to that of the Eastern Escarpment characterized by hot, humid summer and cold, dry winter months. Temperatures within this climatic zone vary between a maximum of 32.5°C and minimum of 1.7°C in the summer and between 21.9°C (maximum) and -6.0°C (minimum) in the winter.

The mean annual precipitation (MAP) within this area ranges between 700 mm/annum and 850 mm/annum. Lusthof falls within the summer rainfall region of South Africa, in which more than 80% of the annual rainfall occurs between October and March.

The average monthly temperatures recorded at the Carolina Monitoring Station range between 9.0°C and 18.9°C with an average temperature of 15.0°C. The mean minimum monthly temperatures range between 1.8°C and 13.4°C with an average of 8.5°C whilst the mean maximum temperatures range between 16.2°C and 24.5°C with an average of 21.4°C.

The mean annual A-Pan Evaporation (MAE) recorded at the Carolina Monitoring Station is 1828 mm, with a monthly average of 152 mm. It is observed that the maximum evaporation occurs during the spring and summer months.

2.7.2 Temperature

The site specific temperatures are discussed with reference to the minimum, maximum and annual temperatures as well as the diurnal temperature trend obtained from the SAWS UM data for the period January 2008 to December 2009 are presented Figure 2.7.2 (a) and Figure 2.7.2 (b) respectively.

Figures 2.7.2 (a) and 2.7.2 (b) indicate that the highest temperatures recorded are in excess of 30°C and occur during the months of December (31.4°C) and January (31.1°C) and peak at around 12:00 in the afternoon.

Temperatures reach a minimum just before sunrise at around 5:00 during winter months of June (-5.4°C) and July (-5.2°C), as indicated on Figure 2.7.2 (a) and Figure 2.7.2 (b).

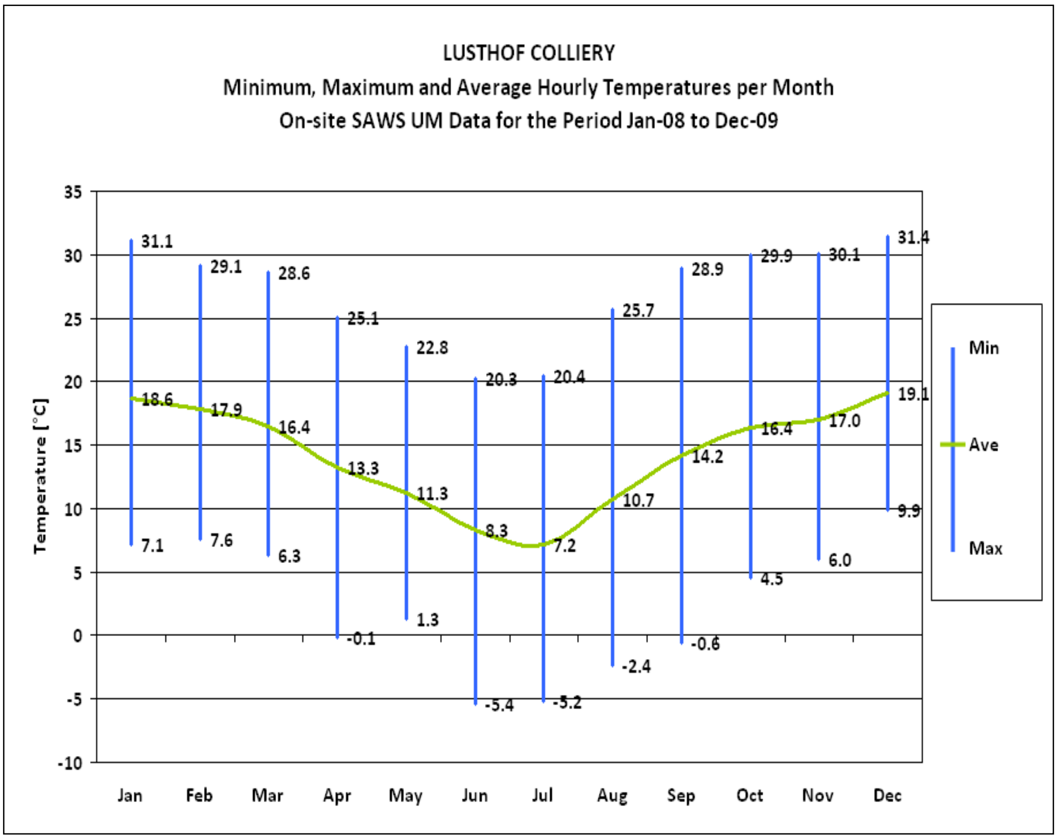


Figure 2.7.2 (a): Minimum, Maximum and Average Hourly Temperatures per Month

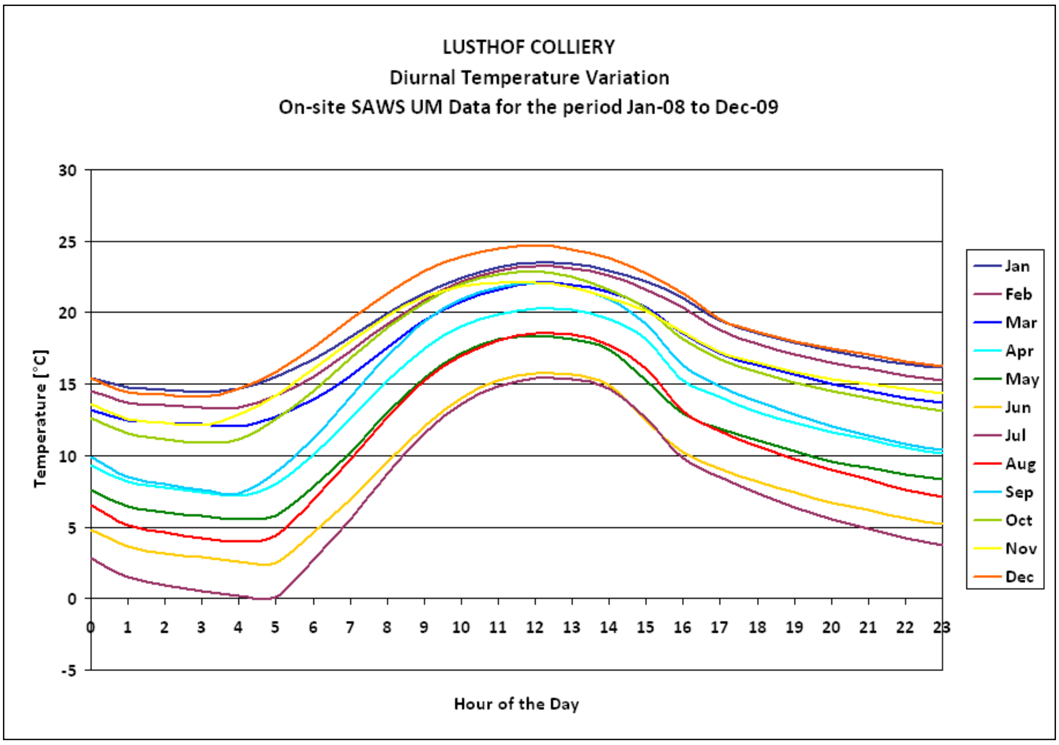


Figure 2.7.2 (b): Average Monthly Diurnal Temperatures

A summary of long term daily temperature statistics for Carolina (1907 to 1982) as well as the daily temperatures obtained from the on-site UM data set 2008 to 2009) is summarized in Table 2.7.2 (a).

Table 2.7.2 (a): Daily Minimum, Maximum and Average Temperatures

Month	SAWS Temperature Statistics for Carolina from 1907 to 1982 (°C)			On-site UM Temperature Data for the period 2008 to 2009 (°C)		
	Daily Minimum	Daily Maximum	Daily Average	Daily Minimum	Daily Maximum	Daily Average
January	13.2	24.4	18.9	13.7	22.0	17.9
February	12.9	24.2	18.6	13.9	20.5	17.2
March	11.7	23.5	17.6	11.5	19.4	15.4
April	9.1	20.9	15.0	7.0	16.5	11.8
May	5.3	18.8	12.1	8.3	15.1	11.7
June	2.0	16.2	9.0	4.1	11.6	7.8
July	2.2	16.7	9.5	3.5	11.8	7.7
August	4.2	19.3	11.8	6.2	15.7	10.9
September	7.4	22.1	14.7	8.5	19.1	13.8
October	10.0	23.3	16.8	10.9	20.5	15.7
November	11.5	23.1	17.3	9.8	21.8	15.8
December	12.6	24.0	18.3	12.5	22.4	17.4

2.7.3 Rainfall

There is a considerable variation in mean annual precipitation (MAP) recorded from various weather monitoring stations within the broader study area. The stations with reasonable record lengths of data are listed in Table 2.7.3 (a) and will be discussed. The localities of the different rainfall stations are shown on Figure 2.7.3 (a).

Table 2.7.3 (a): Rainfall Stations within the Study Area

Station No	Station Name	Lat	Long	Start	End	Yrs	MAP
0480184	CAROLINA (MUN)	26 04	30 07	1905	1948	44	**754.9**
0480194	GOEDEVERWACHTING	26 14	30 07	1920	1953	25	**696.5**
0480347	BOTHWELL	26 18	30 12	1950	2003	52	**775.9**
0480377	CHRISSIESMEER (POL)	26 17	30 13	1967	2005	38	**712.3**
0480435	FLORENCE	26 14	30 14	1903	1938	23	**781.9**
0480520	FAIRVIEW	26 09	30 16	1909	1952	44	**769.5**
0480585	BELLEVUE	26 14	30 19	1908	1956	26	**773.0**
0480618	GRASSDALE	26 18	30 21	1906	1942	23	**806.5**

The variation may be partially due to different record lengths. The two longest records, Bothwell Monitoring Station (52 years) and Carolina Monitoring Station (44 years), have a difference of 21 mm or 3%. It should be noted that these stations cover vastly different periods which don't even overlap.

The site lies across an internal watershed of the quaternary catchment W55A. In the recently published Water Resources 2005 Report (an update of WR90) the MAP for the quaternary is given as 767 mm (Table 2.7.3 (b)). This corresponds closely with the MAP recorded at the Bothwell Monitoring Station which is also one of the few currently open rainfall stations. The rainfall data recorded at the Bothwell Monitoring station is thus used to represent the MAP at Lusthof.

Table 2.7.3 (b): Mean Monthly Rainfall recorded at the Bothwell Monitoring Station (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Mean	126.7	95.6	75.7	48.4	14.5	8.4	6.2	12.4	34.2	92.5	131.4	129.9	**775.9**
%	16.33	12.32	9.76	6.24	1.87	1.08	0.80	1.60	4.41	11.92	16.94	16.74	**100**

2.7.4 Maximum Rainfall Intensities

Storm rainfall intensities are dependent on the duration of the storm and the storm frequency or return period. There are few autographic rain gauges in use and statistical analyses may as a result be limited. Prof WA Alexander recommends the use of the following storm precipitation values (Table 2.7.4 (a)) for the Upper Usutu River which was extracted from TR102 published by the Department of Water Affairs and Forestry (DWAF).

Table 2.7.4 (a): Rainfall Intensities for given Duration and Return Periods

Duration (days)	Return Period (years)				
	5	10	20	50	100
1	76 mm	89 mm	102 mm	122 mm	138 mm
2	90 mm	106 mm	123 mm	146 mm	165 mm
3	99 mm	115 mm	132 mm	156 mm	175 mm
7	131 mm	154 mm	178 mm	211 mm	238 mm

As the catchment areas in this project are relatively small, critical storm durations will be considerably less than the one day reflected in the above. Alternate methods of obtaining storm precipitation values for shorter durations are the Design Rainfall method referred to above as well as the formulation developed by Op ten Oord which is an analytical version of the well- known monograph C2 from the HRU 1/72 report.

Both methods have been employed, the results of which are listed in Table 2.7.4(b) and Table 2.7.4 (c).

Table 2.7.4 (b): Storm Rainfall as per Design Rainfall Method

Duration (days)	Return Period (years)				
	5	10	20	50	100
0.25	21.5 mm	25.3 mm	29.1 mm	34.3 mm	38.4 mm
1	35.4 mm	41.5 mm	47.7 mm	56.3 mm	63.1 mm
2	45.5 mm	53.5 mm	61.5 mm	72.5 mm	81.2 mm
24	76.3 mm	89.6 mm	103.1 mm	121.5 mm	136.1 mm

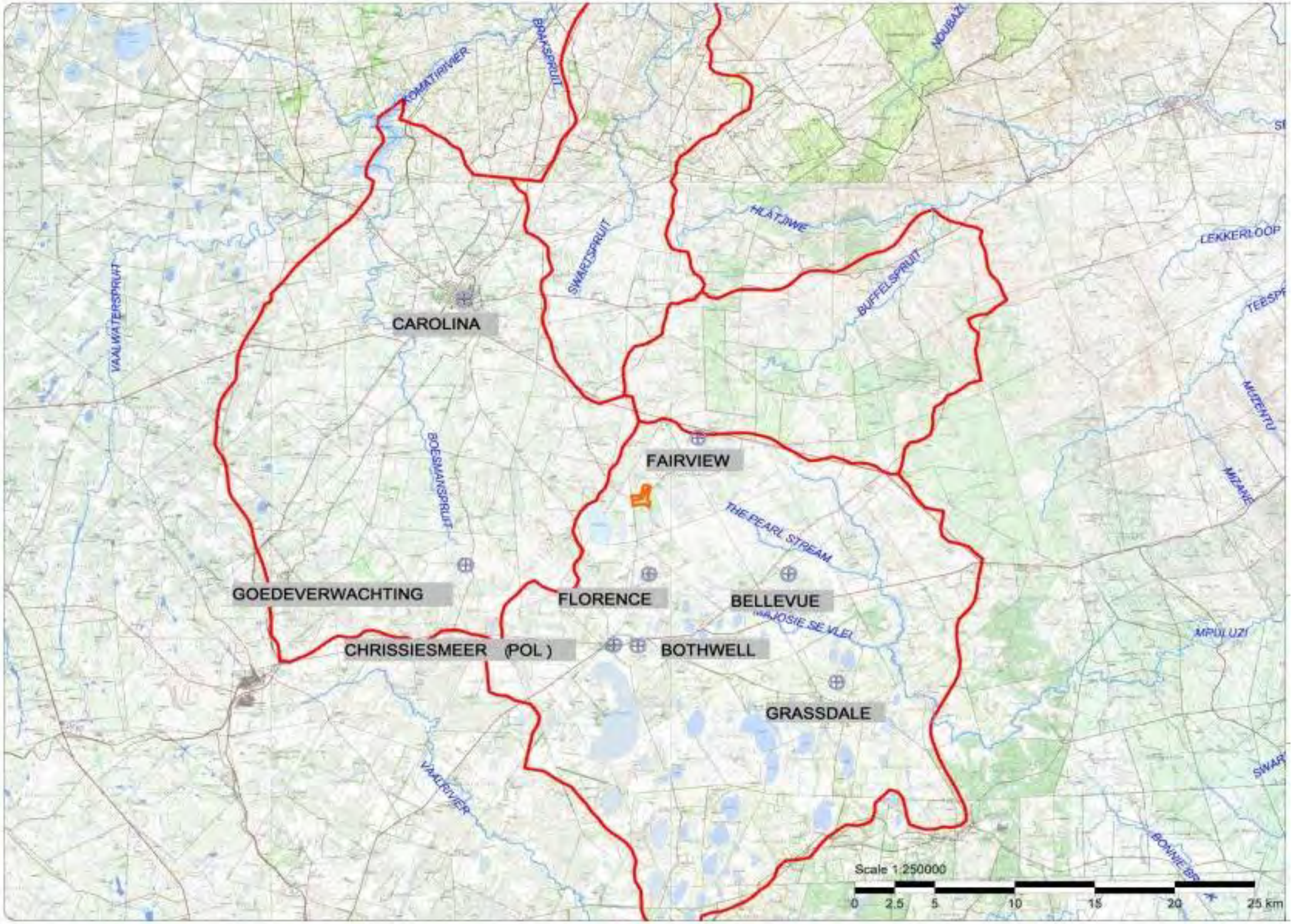


Figure 2.7.3 (a): Rainfall Station Localities

Table 2.7.4 (c): Storm Rainfall as per Op ten Oord Formulation

Duration (days)	Return Period (years)				
	5	10	20	50	100
1	45.1 mm	55.5 mm	68.3 mm	89.9 mm	110.7 mm
2	53.2 mm	65.6 mm	80.8 mm	106.2 mm	130.8 mm
6	65.2 mm	79.2 mm	97.2 mm	130.8 mm	157.8 mm
12	70.8 mm	86.4 mm	106.8 mm	140.4 mm	172.8 mm

It is clear from Table 2.7.4 (b) and Table 2.7.4 (c) that, for the same storm duration of 1 day (24 hrs), the TR102 values and the Design Rainfall method give almost identical results while the Design Rainfall method gives considerably higher results for higher return periods. The Design Rainfall Method however, gives lower values for shorter (1 hour) storm durations. The Op ten Oord formulation will be used in calculating storm rainfall for the various points of interest on the site based on critical storm duration for the given point.

2.7.5 Evaporation

The Mean Annual Evaporation (MAE) for the area is given in WR2005 as 1400 mm/annum. In terms of spatial variation, the mean annual evaporation is fairly constant across the study area. Limited long term evaporation records are available and the one at the Morgenstond Dam has the longest record of data as well as a long term average slightly higher than that referred to above.

The monthly evaporation averages recorded at the Morgenstond Dam is listed on Table 2.7.5 (a).

Table 2.7.5 (a): Average Monthly Evaporation (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Mean	171	145	141	113	102	83	92	116	138	146	155	176	**1583**
%	10.8	9.16	8.91	7.13	6.44	5.24	5.81	7.32	8.72	9.22	9.79	11.18	**100**

Table 2.7.5 (a) indicates that the MAE recorded at the Morgenstond Dam is 1583 mm/annum. This is substantially higher than the MAP (776 mm/annum) recorded for the study area.

2.7.6 Relative Humidity

On-site minimum, maximum and annual relative humidity as well as the diurnal trend obtained from the SAWS UM data for the period January 2008 to December 2009 are indicated on Figure 2.7.6 (a) and Figure 2.7.6 (b) respectively.

Figure 2.7.6 (a) and Figure 2.7.6 (b) indicate that the on-site relative humidity ranges from about 30% during mid-day in winter months to 100% in the early morning hours of summer months. Long term relative humidity statistics for Carolina indicate a range of 28% to 86%.

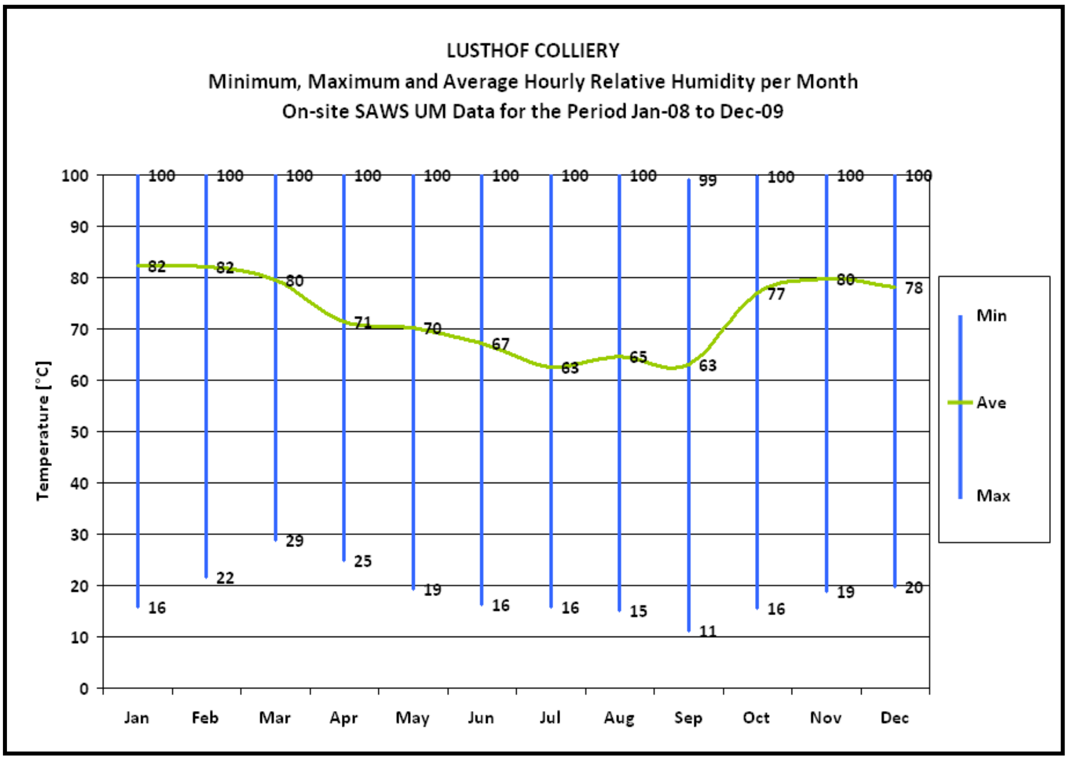


Figure 2.7.6 (a): Minimum, Maximum and Average Hourly Relative Humidity per Month

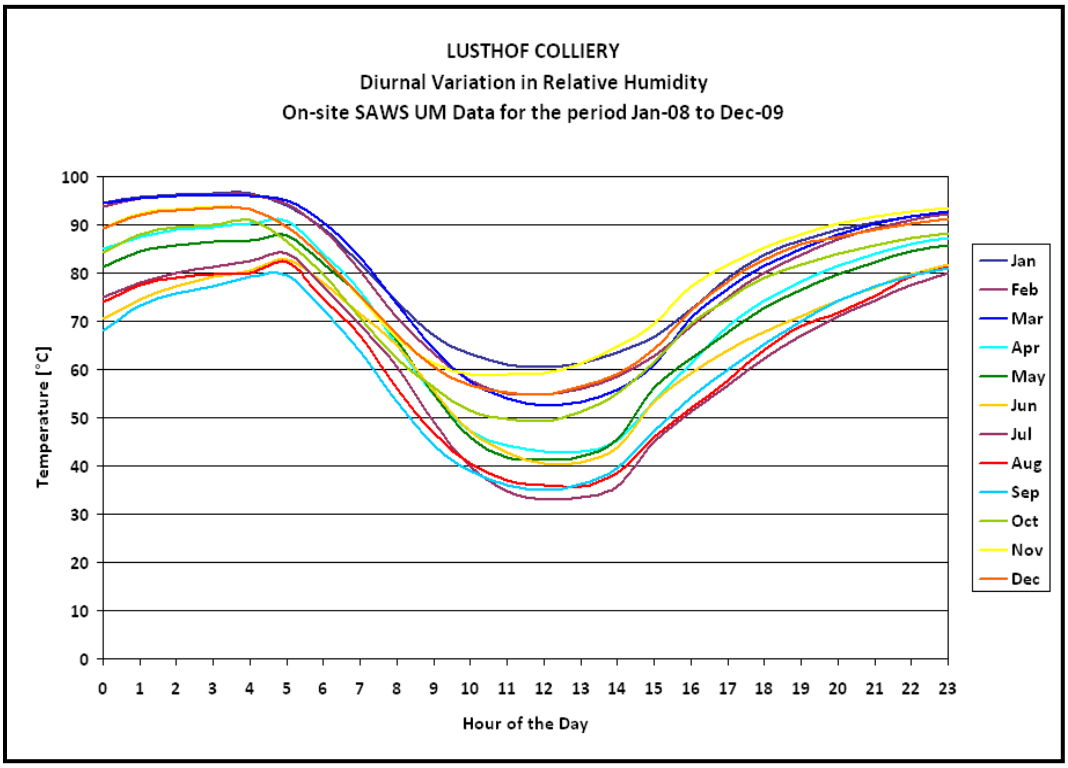


Figure 2.7.6 (b): Diurnal trend in relative humidity per month

A summary of the long term diurnal relative humidity statistics for Carolina are listed in Table 2.7.6 (a).

Table 2.7.6 (a): Monthly Relative Humidity Statistics for Carolina

Month	Monthly Relative Humidity Statistics for Carolina (1951 to 1982)		
	08:00	14:00	20:00
January	82	54	78
February	84	52	80
March	86	48	79
April	86	45	74
May	82	35	64
June	79	32	57
July	77	30	53
August	74	28	54
September	71	32	58
October	74	43	71
November	78	53	79
December	80	53	79
Average	**79**	**42**	**69**

2.7.7 Surface Wind Field

The wind field at Lusthof is dominated by winds from the west, east and east-northeast. The strong winds (5 m/s to 10 m/s) occur most frequently from the west-southwest, west and west-northwest. Wind roses represent wind frequencies for the 16 cardinal wind directions. Frequencies are indicated by the length of the shaft of a petal when compared to the circles drawn to represent a 4% frequency of occurrence.

During the daytime, prevailing winds occur from the west and east with strong winds occurring more frequently than during the night. A decrease in winds from the west and an increase in winds from the east-northeast are observed during night-time hours.

The period, day and night-time wind roses for the study area are indicated on Figure 2.7.7 (a). The seasonal variation in the wind field is indicated on Figure 2.7.7 (b). Wind speed classes are assigned to illustrate the frequencies with high and low winds occurring for each wind vector. The frequencies of calms, defined as periods for which wind speeds are below 1 m/s, are also indicated.

The frequency at which various wind speed categories occur is indicated on Figure 2.7.7 (c). Wind speed below 5 m/s occur 97% of the time. Weak winds of 2 m/s and less, generally regarded as periods of limited dilution, especially at midnight, occurred ~38% of the time.

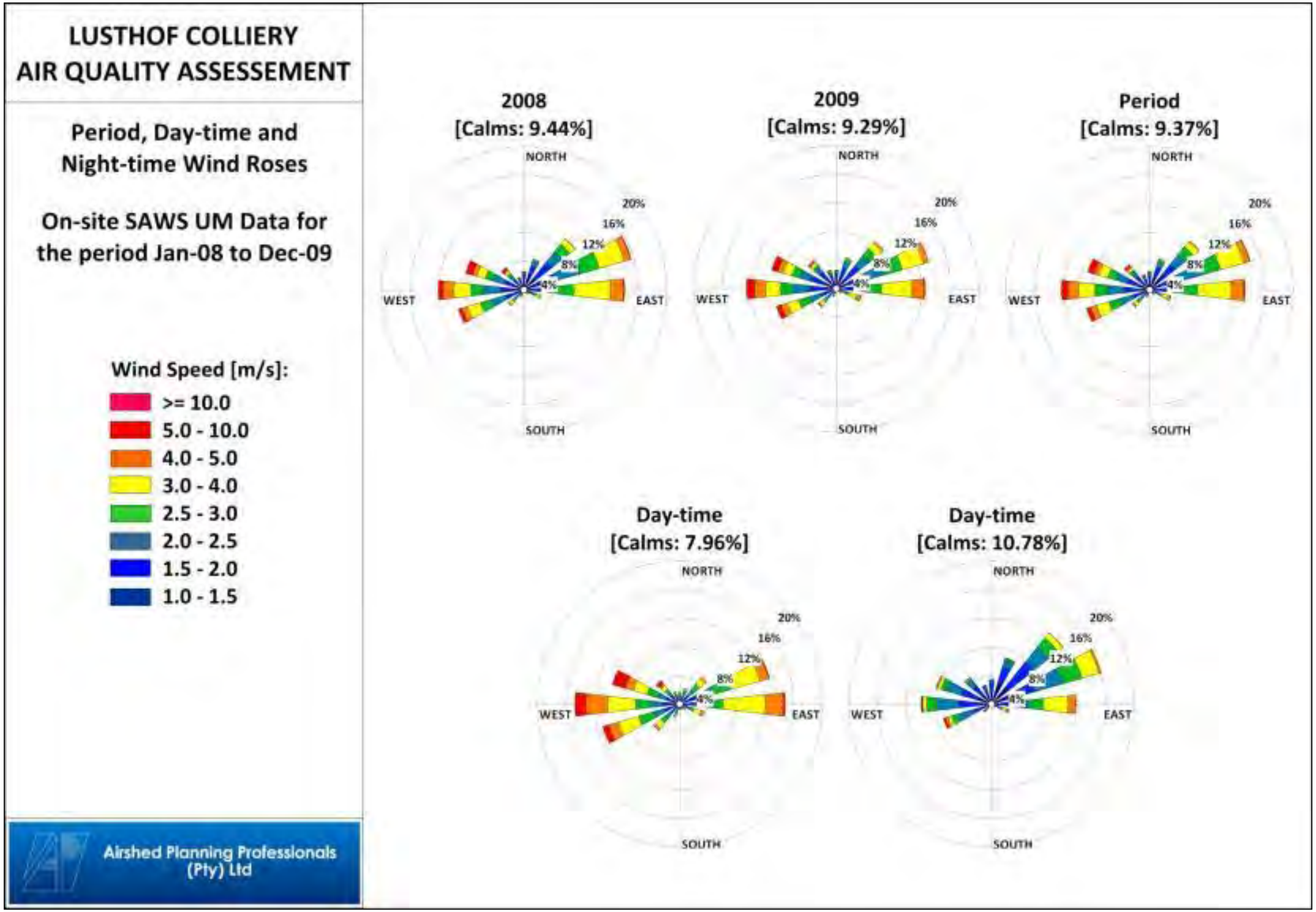


Figure 2.7.7 (a): Period, Day-Time and Night-Time Wind Roses

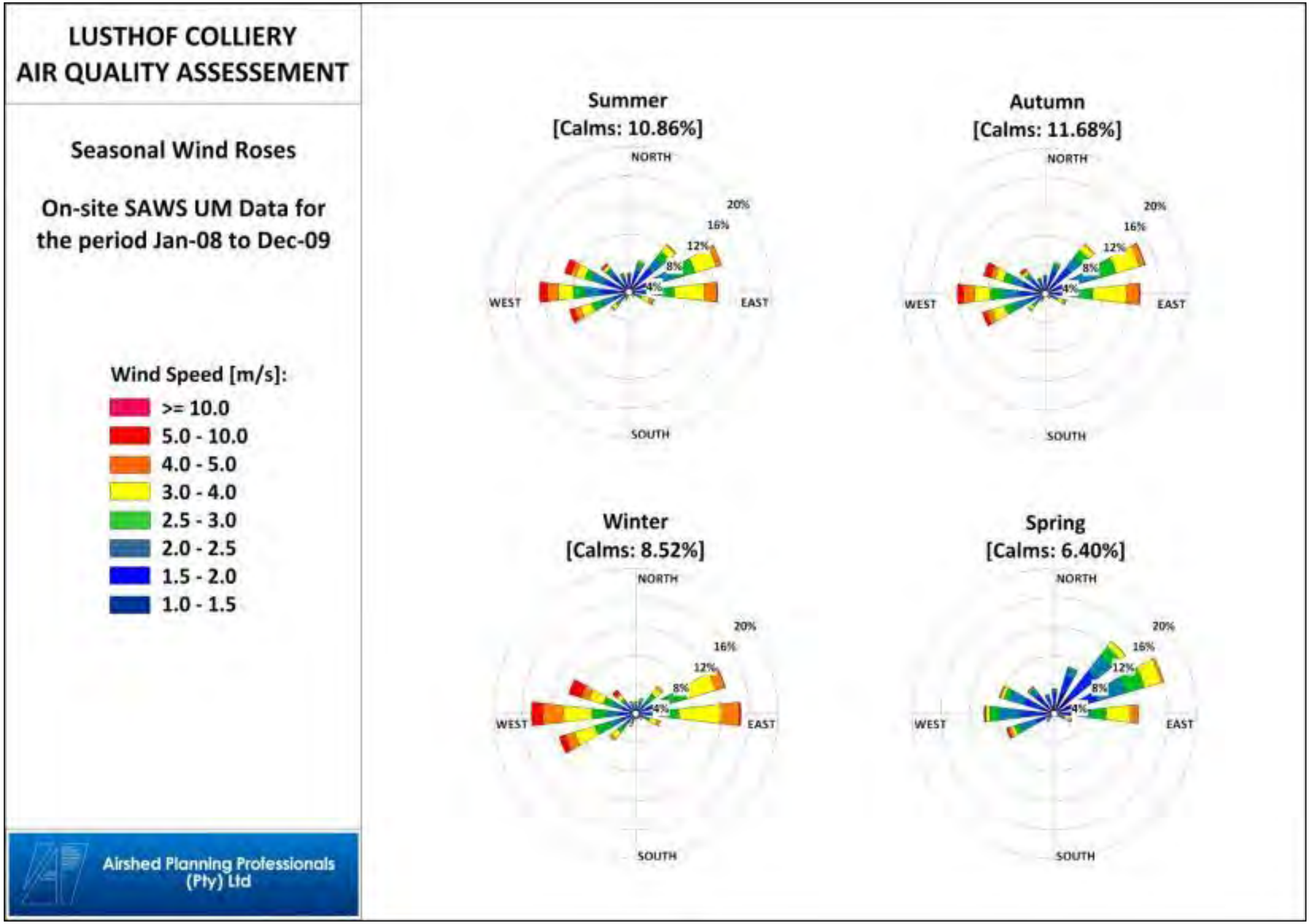


Figure 2.7.7 (b): Seasonal Wind Roses

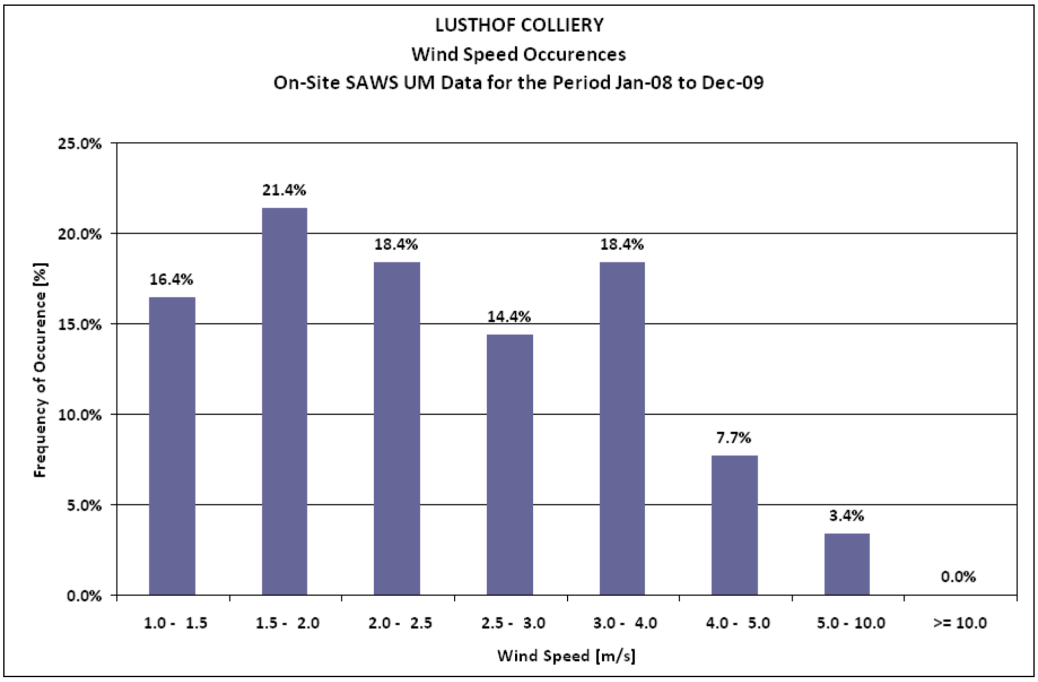


Figure 2.7.7 (c): Frequency of Wind Speeds

2.7.8 Extreme Weather Conditions

The area is prone to a host of extreme events on a regular basis. These events include the following:

- The area is prone to drought conditions.
- Frost occurs during the winter months.
- Rainfall occurs as scattered thunderstorms.
- Strong gusty winds prior to and during thunderstorms.

Temperature	:	Max 32.5 °C Min -06 °C
Hail	:	Occurs 4 to 7 days per year
Drought	:	624 mm – 1965
Frost	:	Occurs between April and September for an average of 120 to 150 days.
Wind	:	Wind velocity varies between 8.28 km/h and 16.2 km/h.

2.8 TOPOGRAPHY BASE LINE

JMA Consulting (Pty) Ltd compiled a detailed topographical base line description for the study area.

2.8.1 Regional and Local Topography

The larger study area is located on the Highveld Region of the Mpumalanga Province at an elevation of between 1700 and 1800 meters above mean sea level (mamsl). The area surrounding the Farm Lusthof 60 IT is characterized by an undulating topography consisting of hills and valleys.

The proposed extent of the Lusthof mining area is situated on a topographical high, and ranges in elevation between 1770 and 1796 mamsl. The immediate mining right area is flat with gentle to moderate slopes in a western and southern direction towards three non-perennial pans and slightly steep slopes in a northerly and easterly direction towards the headwaters of the Mpuluzi River and The Pearl Stream.

Topographical maps of the study area, including the catchment area of the project, were generated in support of the various specialist studies to be conducted for the project. These topographical maps and associated surface information will be used to discuss the topographical setting of the study area.

The topography of the larger study area is discussed with reference to the information obtained from the 1:50 000 Topographical Maps of South Africa (Sheets 2630AA and 2630AB), depicted as Figure 2.8.1 (a).

Figure 2.8.1 (a) indicates that the Farm Lusthof 60 IT is located some 17 km to the South-East of the town Carolina. The town Carolina, the Lusthof 60 IT farm boundary, arterial roads as well as the secondary roads are indicated on Figure 2.8.1 (a) as well.

The proposed pit extent falls on a topographical high as indicated on Figures 2.8.1 (b) and 2.8.1 (c). The secondary gravel road that dissects the proposed pit boundary generally follows this topographical high and forms the boundary between Portions 4 and 6 of Lusthof 60 IT as well.

Figure 2.8.1 (c) indicates the 5 m surface elevation contours of the study area. The 5 m surface elevation contour data was then used to create a 3-D image of the surface topography as well and is indicated as Figure 2.8.1 (d).

Figures 2.8.1 (b), 2.8.1 (c) and 2.8.1 (d) clearly indicate that the surface topography on Portion 6 of Lusthof 60 IT becomes lower towards the north and north-west, away from the proposed pit boundary. The surface topography on Portion 4 of Lusthof 60 IT however becomes lower towards the south and south-east, away from the proposed pit boundary. The surface drainage as a result flows away from the proposed pit boundary as well.

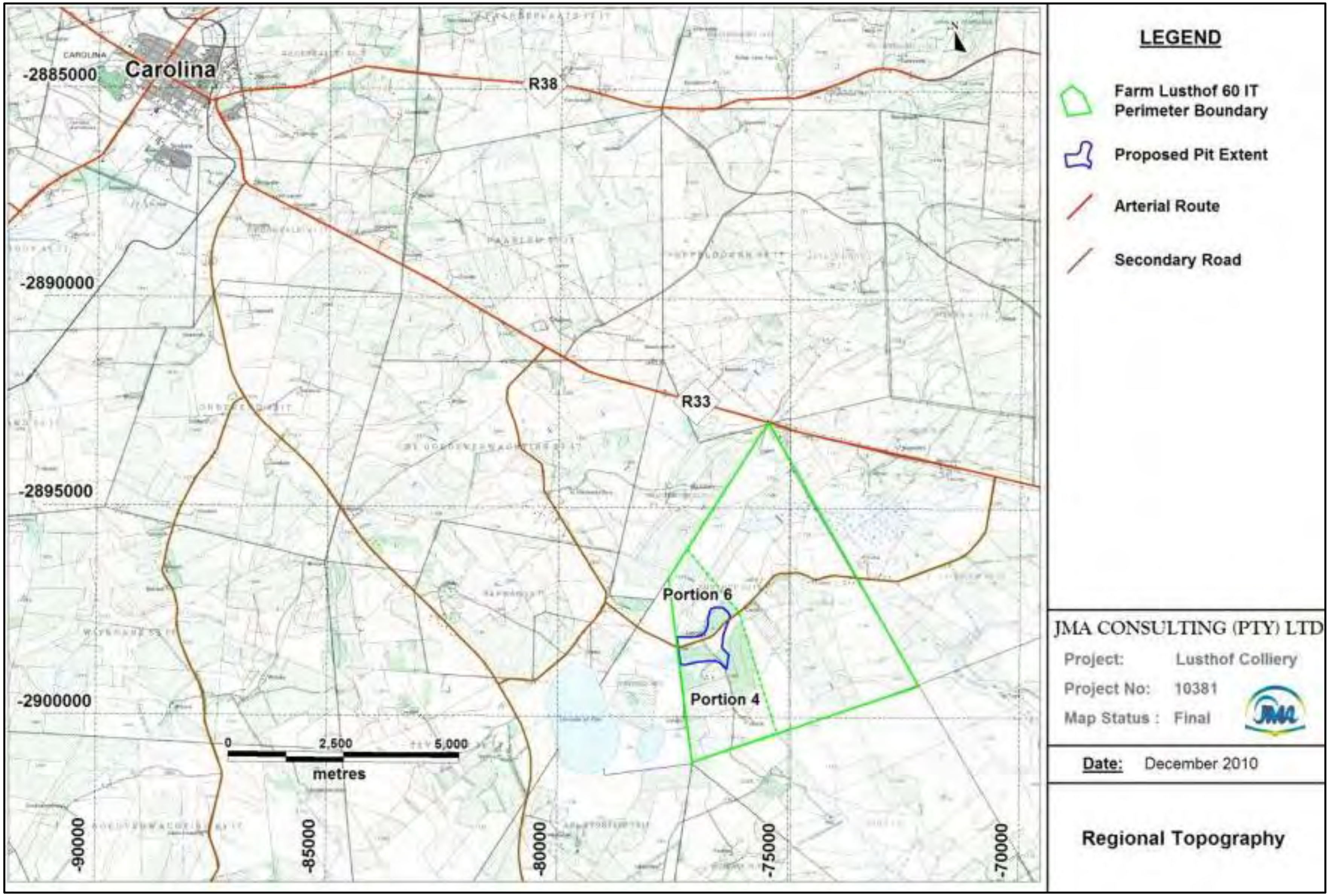


Figure 2.8.1 (a): Regional Topography of the larger Study Area

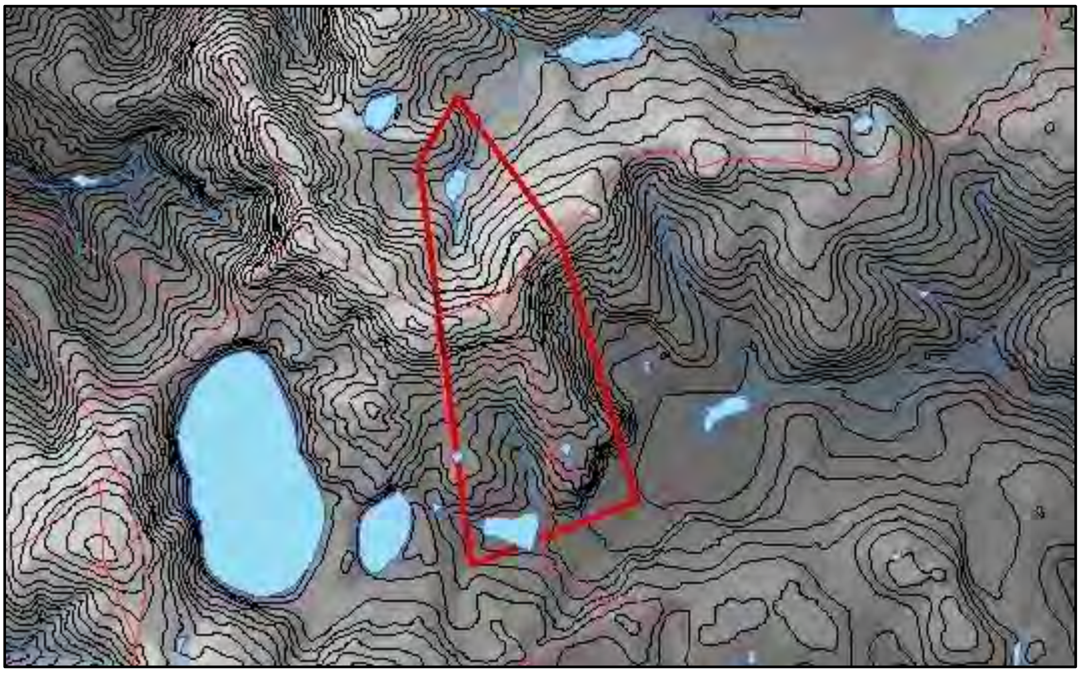


Figure 2.8.1 (b): Shaded Relief Map of the Surface Topography

Portions 4 and 6 of Lusthof 60 IT fall within the north-western region of the W55A quaternary catchment area, which ultimately drains in an easterly direction, as indicated on Figure 2.8.1 (e). The watersheds to the west and north of the Portions 4 and 6 of Lusthof 60 IT separate two primary catchments, namely the Mfolozi/Pongola River Catchment (W) and the Komati/Crocodile River Catchment (X) from one another.

Lusthof Colliery falls within the upper parts of the Mpuluzi River Catchment. The upper Mpuluzi River catchment encloses an area of approximately 163 km^2 with a mean annual runoff (under natural conditions) of 37 million m^3/annum.

In support of the National Water Resource Strategy as per the National Water Act (Act 36 of 1998), the Department of Water Affairs and Forestry delineated the entire country into representative water management areas, primary drainage regions, secondary drainage regions, tertiary drainage regions and quaternary drainage regions. Lusthof falls within the No.6 water management area, of the W55A quaternary catchment area.

Surface water within Portion 6 of Lusthof 60 IT will flow in a northerly to north-westerly direction away from the proposed pit, whilst the surface water within Portion 4 of Lusthof 60 IT will flow in a southerly to south-easterly direction away from the proposed pit. Due to the shallow gradient of the surface, the surface water often ponds at the surface forming marsh areas adjacent to the natural perennial and non-perennial streams.

The Pearl Stream originates to the east of Lusthof, drains in an easterly direction and eventually flows into the Mpuluzi River some 12.8 km to the south-east of the proposed mine extent. The Mpuluzi River initially drains in an easterly direction to the north-east of Lusthof and then further drains in a southerly to south-westerly direction away from the study area.

Figure 2.8.1 (c): Surface Topography of the Study Area (5 m surface elevation contours)

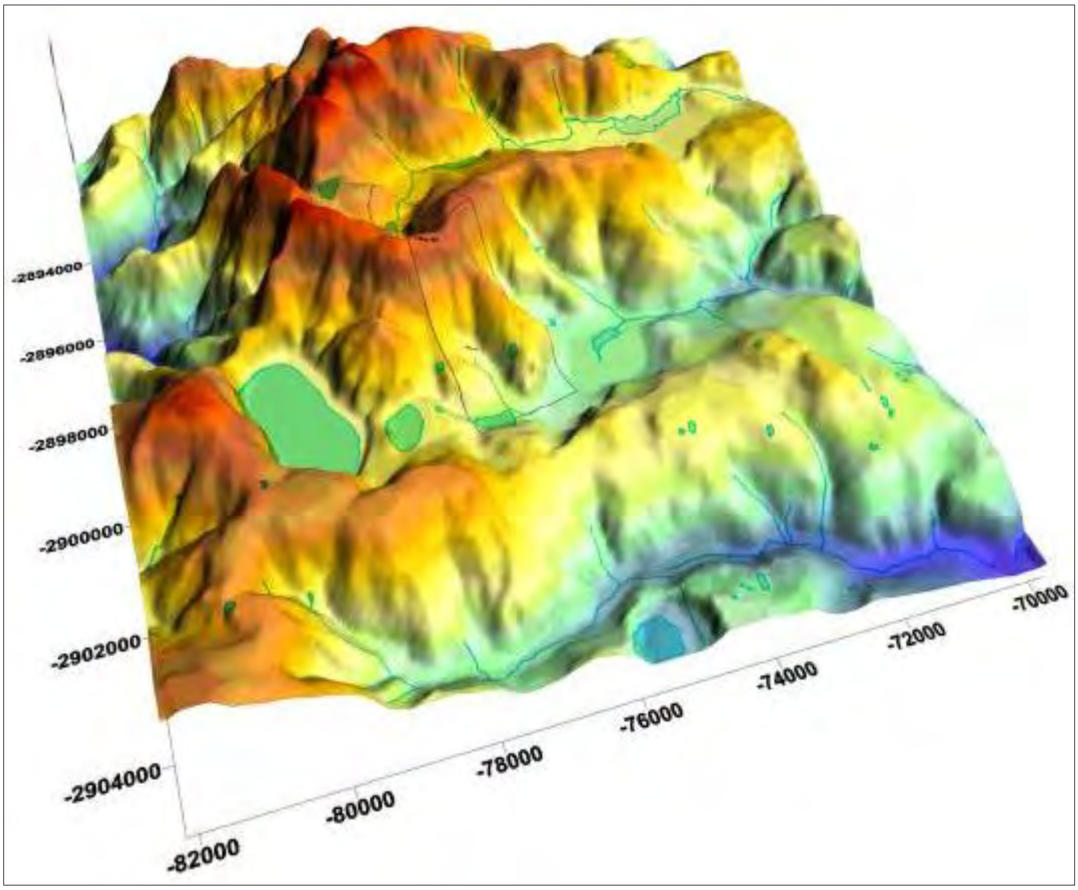


Figure 2.8.1 (d): 3-D Image of the Surface Topography

Several other smaller tributaries contribute to the two main streams of the affected catchment, which ultimately drain into the unnamed dam (receiving water body) at the confluence of the Mpuluzi River and eventually drains into Usutu River. The extent of the abovementioned surface water bodies are delineated on Figure 2.8.1 (e).

The 5 m surface elevation contour data was further used to create a viewshed analysis of the surface topography within the proposed pit boundary. The generated viewshed analysis is indicated on Figure 2.8.1 (f).

The viewshed analysis represented as Figure 2.8.1 (f) indicates the surface areas adjacent to the proposed pit boundary that are visible (green) from within the pit boundary and those areas that are not visible (red) from within the pit boundary.

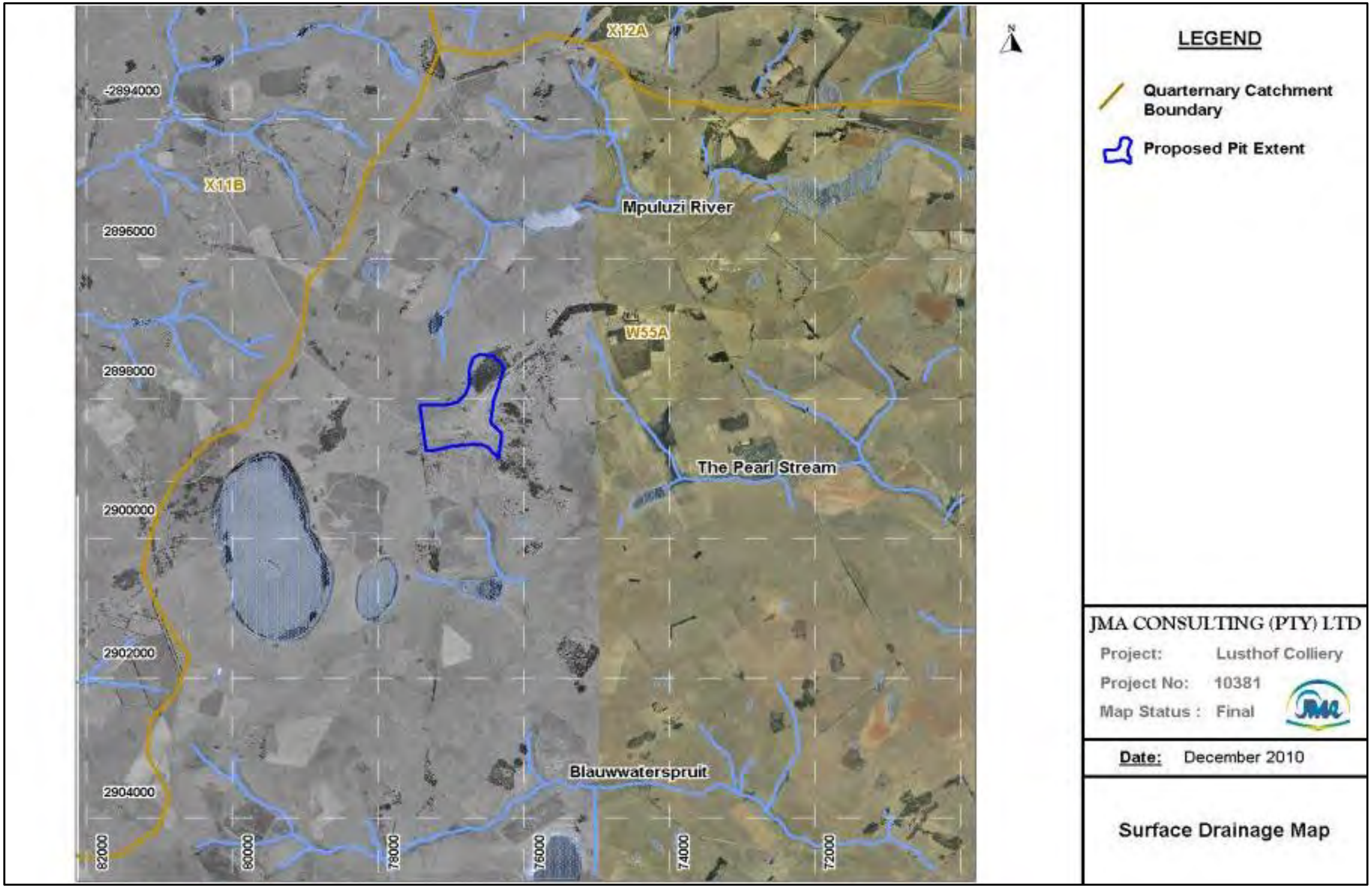


Figure 2.8.1 (e): Quaternary Catchment Delineations

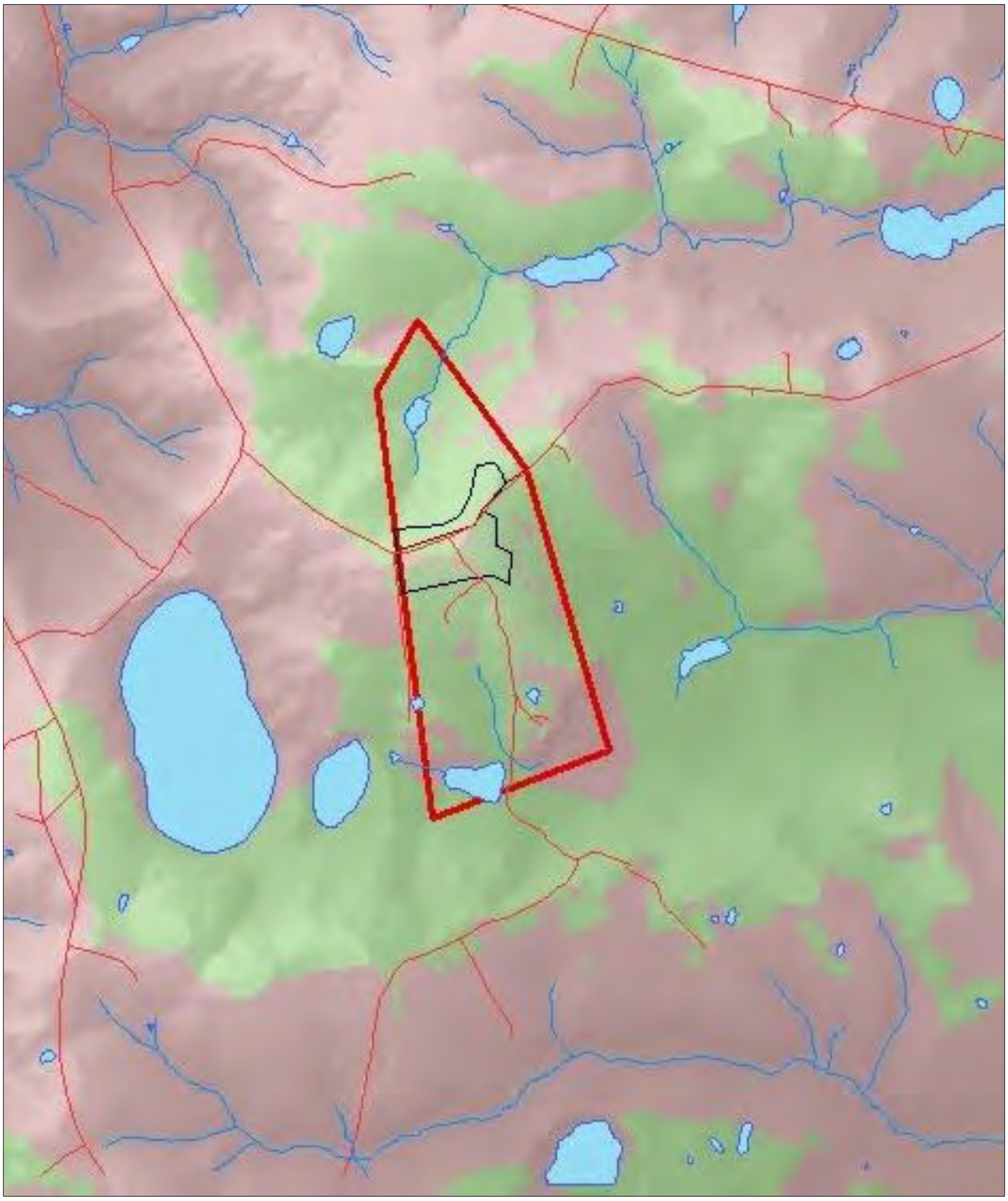


Figure 2.8.1 (f): Viewshed analysis of the surface topography within the proposed pit boundary

** **Note: The viewshed analysis is based entirely on the surface elevation data obtained from the 5 m contours and does not take vegetation or surface infrastructure into consideration***

It is however important to note here that the viewshed analysis is based entirely on the surface elevation data obtained from the 5 m contours and does not take vegetation or surface infrastructure into consideration.

To aid the optimization of the final mine design from an environmental perspective, especially with regards to the surface water infrastructure, an aerial photograph was taken across the proposed mine extent. Surface elevation contours at 1 m resolution were also generated. The 5 m contours are indicated on Figure 2.8.1 (g).

Figure 2.6.2.1 (g): Surface Topography (5 m elevation resolution) for the Proposed Mine Extent

2.9 SOILS BASE LINE

Wetland Consulting Services conducted a detailed soils assessement for the proposed study area. The soils base line description compiled by them is reproduced in its entirety in this section.

A transect sampling approach was adopted for the soil survey within the site. Samples were taken at appropriate intervals along transects running perpendicular to contour so that the catena pattern of soil formation could be established and recorded utilizing a mapping grade Global Positioning System (GPS).

The soil from at each sample point was classified in accordance with *Soil Classification: A Taxonomic System for South Africa* (Soil Classification Working Group, 1991). It should be noted that the soils were classified based on sampling to a depth of 1.2 m. It is quite possible that the underlying material at a greater depth would change the classification. For example a Clovelly might overlie a soft plinthic horizon at 2 m, changing the soil form to an Avalon when the depth of classification is increased. This is essentially an agricultural, and academic, distinction, and not necessarily a functional one.

2.9.1 Study Methodology

Topsoil depth and soil depth up to a maximum of 1.2 m were recorded at each sample point across the entire site, as well as parent material where possible. Information received subsequently to the initial fieldwork indicated that:

- The footprint of the mine is confined to the central, top-slope portion of the farm and is approximately 82 ha in extent; and
- The client wishes to control contaminated runoff from the mine by constructing an easthern berm around the footprint indicated on Figure 2.9.1(a).

The sampling density within the proposed mine footprint was hence increased, as was the depth of sampling to 2.2 m. The subsequent information was assimilated to produce Geographical Information System (GIS) coverage of the soil forms and depths within the boundary of the development site.

Additional sampling was undertaken within the site to identify the potential soil nutrient content distribution within the development site. The objective was to establish baseline data to inform the objectives of the rehabilitation programme. Representative topsoil (0-25 cm) and subsoil samples (60-80 cm) were collected at appropriate intervals and analysed using laboratory techniques to determine:

- density;
- macro- and micro-nutrients;
- pH;
- near-infrared carbon;
- near infrared clay;
- exchangeable acidity; and
- soil texture.

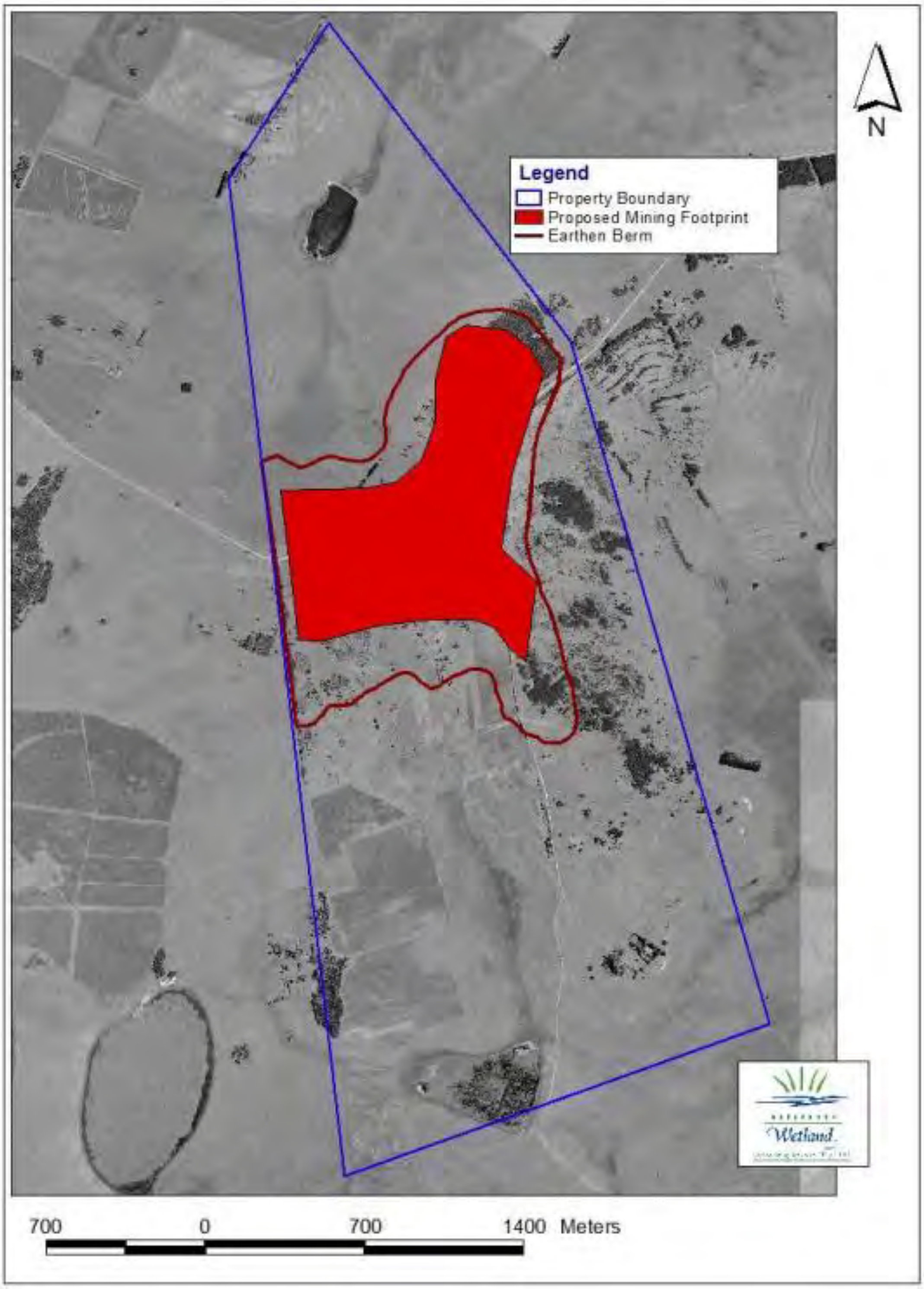


Figure 2.9.1 (a): Location of Proposed Mining Activities

2.9.2 Soil Forms

The geology of the parent material is dominated by sandstone of the Vryheid formation, while a dolerite intrusion has been identified in the southern part of the project area as indicated on Figure 2.9.2 (a). The high iron content of the soils coupled with their free-draining physical properties, has led to the formation of an indurated layer of hard plinthite over much of the higher-lying areas of the farm. This has led to the formation of numerous hillslope-seepage wetlands.

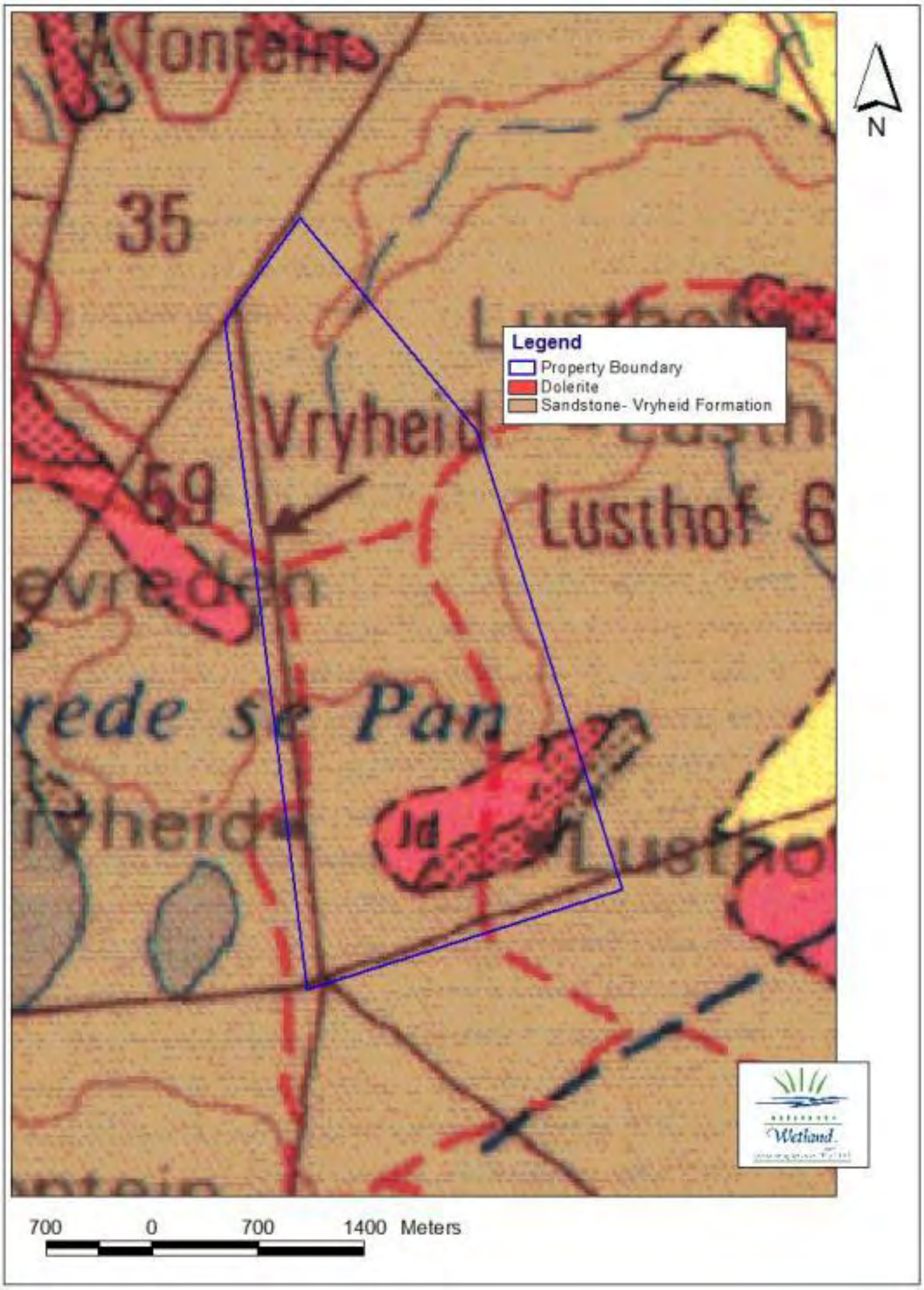


Figure 2.9.2 (a): Geology of the Lusthof study area

The soils within the study area are indicted on Figure 2.9.2 (b) and it is evident that ten soil forms, mostly closely related, were identified.

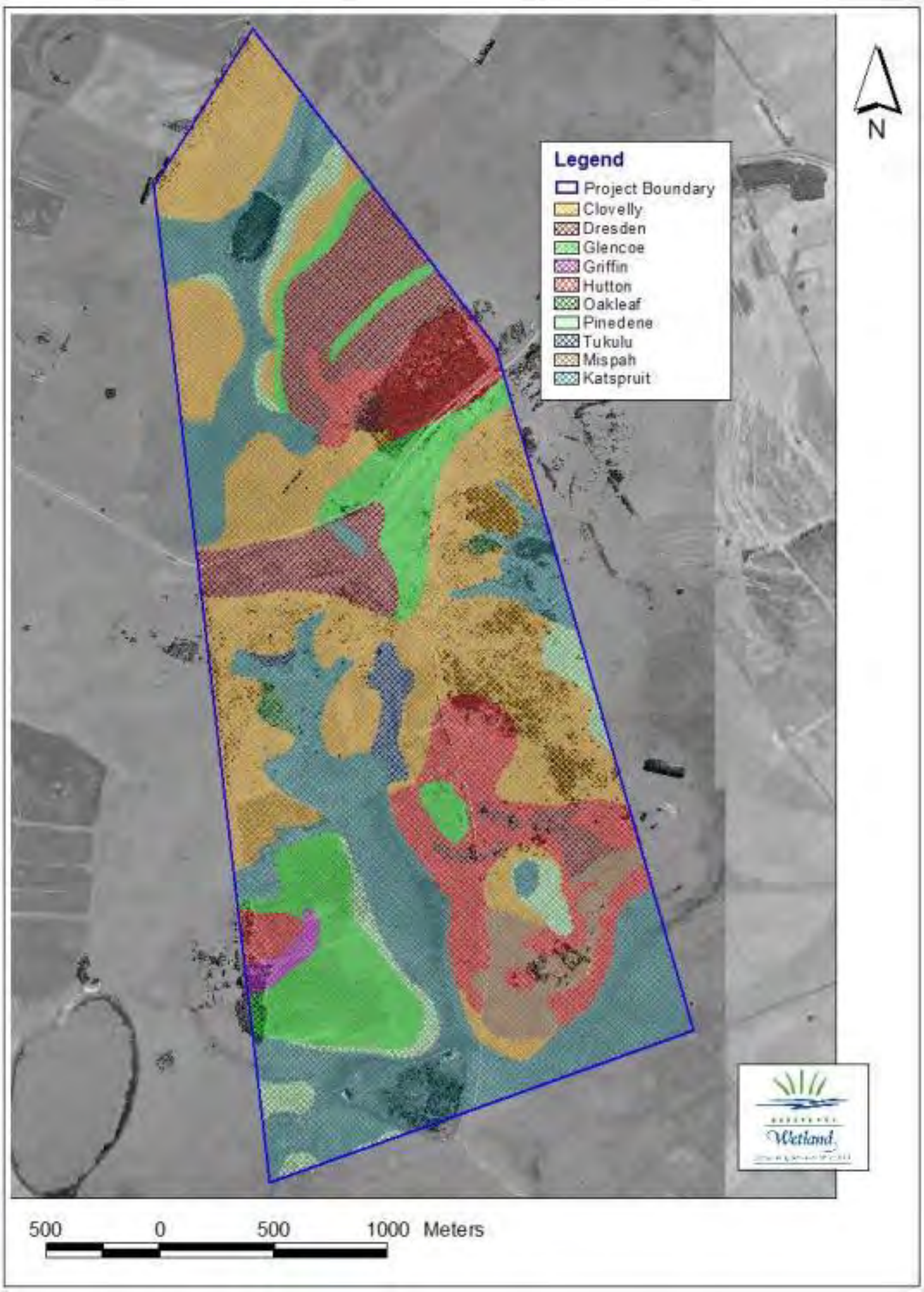


Figure 2.9.2 (b): Soil Forms within the Lusthof Study Area

The farm contains extensive areas of wetland habitat, mostly consisting of un-channelled valley bottom, pan and hill slope seepage systems. The waterlogged conditions within the subsoil have given rise to the **Katspruit** form **(Orthic A/ G),** which covers approximately 181.5ha, or 26% of the project area.

The farm is characterised by the dominance of five closely related soil forms, namely;

- Clovelly (Orthic A/ Yellow-Brown Apedal B/ Unspecified), which covers approximately 207ha (30%) of the farm and is generally confined to the topographically higher areas in the centre and northern parts of the project area.
- Glencoe (Orthic A/ Yellow-Brown Apedal B/ Hard Plinthite), which are essentially the same as Clovelly soils, but have a layer of hard plinthite below the B-horizon instead of parent material;
- Pinedene (Orthic A/ Yellow-Brown Apedal B/ Unspecified with signs of wetness), also very similar to Clovelly soils, but exhibit clear signs of hydromorphy below the B-horizon. They therefore tend to be located on footslopes adjacent to wetlands;
- Luvic Hutton (Orthic A/ Red Apedal B) soils, which dominated the areas characterised by the dolerite extrusion in the southern part of the property; and
- Griffin (Orthic A/ Yellow-Brown Apedal B/ Red Apedal B), a small area of which was identified between the Hutton and Glencoe forms in the south-western corner of the property.

The presence of a red apedal B horizon in the Hutton and Griffin soil forms indicates that weathering takes place in a well-drained, oxidising environment to produce coatings of iron-oxides (haematite) on individual soil particles, giving the diagnostic red colours (Soil Classification Working Group, 1991). The parent material of these red apedal soils is generally dolerite, which would further indicate an advanced degree of weathering. The yellow-brown apedal horizon shares similar properties to the red apedal horizon, being differentiated only on the basis of colour. The individual soil particles are likewise coated with free iron-oxides, in this case, goethite, and the yellow-brown colours are attributed to:

- The composition of the parent material (possibly with a lower ferrous iron reserve); or A higher average moisture status within the B horizon (Soil Classification Working Group, 1991).

Because these soils are sandy and well-drained, it is unlikely that the yellow-brown apedal horizon has been formed mainly through periodic saturation with water alone. The saturation probably occurs on a micro-scale, with water collecting around and between the peds, producing localised reducing conditions which can lead to an overall yellowing of the horizon at that depth. From a practical agricultural point of view the Hutton, Glencoe and Clovelly soil forms are essentially the same. The soils are generally well-drained and aerated and suitable for crop production where the effective rooting depth is appropriate. Both the yellow-brown and red apedal horizons remain unsaturated with water for sufficiently long periods not to adversely affect root growth (Van Huysteen and Ellis, 1997).

Isolated areas of Oakleaf (Orthic A/ Neocutanic B/ Unspecified) and Tukulu (Orthic A/ Neocutanic B/ Unspecified with signs of wetness) soil forms were identified on the south-facing slope in the central portion of the study site. These forms are closely related and are characterised by the neocutanic B-horizon, formed from the pedogenesis of colluvial material and the coating of subsoil macro-peds with cutans of clay and organic matter.

The Tukulu form contained soil with signs of hydromorphy below the neocutanic horizon, and was indicated by the distribution of dense, robust *Hyparrhenia dregeana*.

The Mispah (Orthic A/ Hard Rock) and Dresden (Orthic A/ Hard Plinthite) soil forms are also essentially the same, with the definitive horizon being the hard-plinthic, or hardpan ferricrete, layer that underlies the orthic A-horizon of the Dresden in place of hard rock. Both soils are generally shallow, rarely reaching a depth greater than 35cm. The Mispah form is associated mainly with dolerite and sandstone parent material that lies at or close to the soil surface. The hard plinthite layer is associated with a historic perched water table and is formed by the accumulation of iron and manganese oxides under a regime of severe wetting and drying. As the wet periods recede, the layer desiccates and forms concretions that eventually coalesce to form a continuous indurated sheet, the extent of which is indicated by the distribution of the Dresden and Glencoe soil forms on Figure 2.9.2 (b).

2.9.3 Topsoil Depth

The depth of the topsoil over the study area is illustrated on Figure 2.9.3 (a). A central aim of any post-mining rehabilitation programme would be the return of landuse of a similar type to that prior to mining and the depth of the topsoil is critical in achieving this. Topsoil depth is distributed according to several discernable patterns, namely:

- Deeper topsoils are generally found in areas lower down in the topography, such as in valley bottoms.
- Landuse has an impact on topsoil formation, with most areas under cultivation, hay production and plantations having shallower topsoils than grassland areas due to changes in nutrient cycling patterns.
- The topsoils of the Mispah and Dresden soil forms are often limited by the presence of parent material or hard plinthite.
- Moisture content is associated with more robust vegetation growth and increased volumes of organic matter, the accumulation of which leads to a deeper A-horizon. The climate is also temperate leading to a slower rate of breakdown and hence allowing organic matter to accumulate in the soil.

Figure 2.9.3 (a): Topsoil depth within the Lusthof Study Area

The deepest topsoil recorded was 40 cm, with most sample points having an A-horizon of between 15 and 35 cm. The critical depth chosen was 20 cm due to the practical implications involved in replacing the topsoil during rehabilitation.

2.9.4 Overall Soil Depth

Approximately 52% of the farm consisted of soils that were greater than 110 cm in depth as indicated on Figure 2.9.4 (a), with most of these found on the south-facing southern half of the site. Generally soil depth was determined by the depth to parent material or hard plinthite with the Dresden, Mispah and Glencoe soil forms the shallowest encountered.

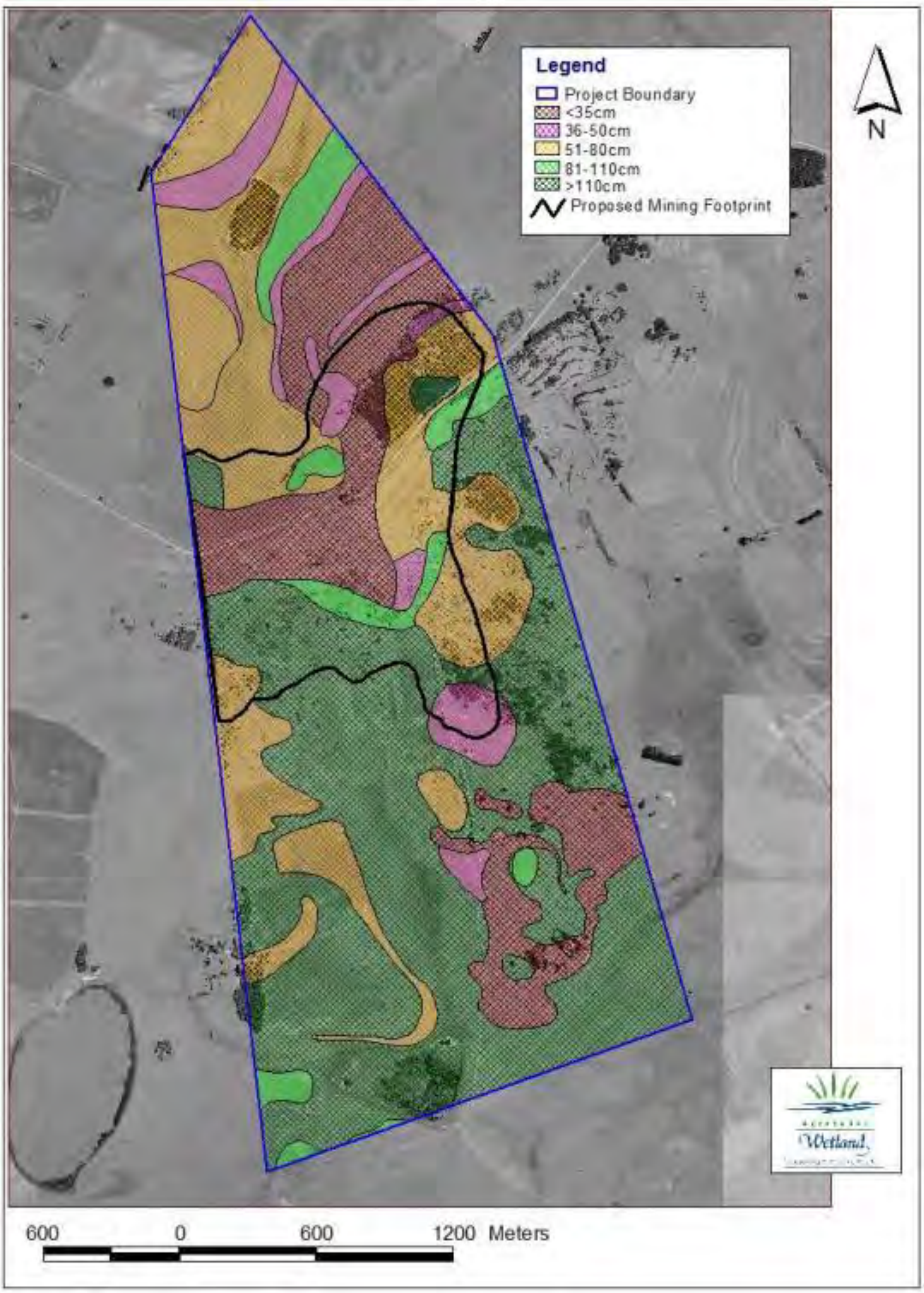


Figure 2.9.4 (a): Overall Soil Depth within the Lusthof Study Area

The soil depth within the proposed pit area is of great importance because soil volume may be a limiting factor in constructing the berm. The two shallowest depth-classes, <35cm and 36-50cm, coincide with the distribution of the hard-plinthic layer in the central high-lying areas of the study site. As indicated on Figure 2.9.4 (b), the plinthite occurs in a band along the western and northern axes of the proposed mining areas.

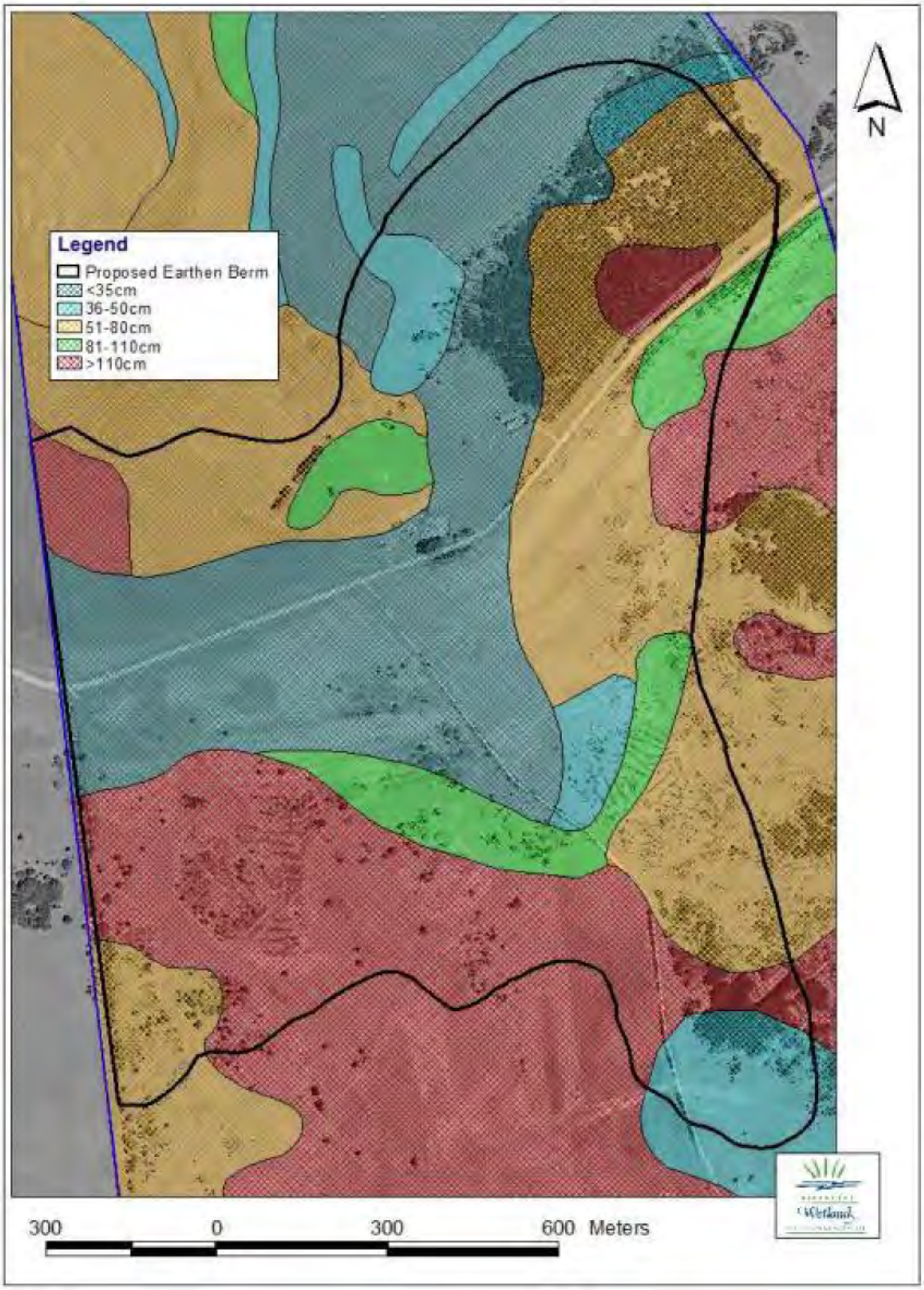


Figure 2.9.4 (b): Soil depth within the Proposed Mining Areas

The deeper soils on the southern side of the proposed mining area overlie soft plinthic material and soft, highly weathered sandstone. This material is soft enough to construct the berm rather than using topsoil, the conservation of which will be central to effective post-mining rehabilitation.

Table 2.9.4 (a) provides an indication of the relative area occupied by each of the soil depth classes, both throughout Lusthof farm and within the proposed mining footprint.

Table 2.9.4 (a): Area of depth classes both within the Lusthof farm boundary and within the area enclosed by the berm

Soil Depth Class	Area of Lusthof Farm (ha)	Area of Lusthof Farm (%)	Area Within Berm (ha)	Area Within Berm (%)
<35cm	44.6	6.5	12.7	7.8
36-50cm	180.2	26.3	47.1	28.8
51-80cm	34.4	5.0	13.5	8.3
81-110cm	122.6	17.9	49.6	30.3
>110cm	302.9	44.2	40.6	24.8
Total	684.7	100.0	163.5	100.0

Using the area values, in conjunction with the soil depth data obtained, it is possible to broadly estimate the maximum and minimum volume of soil contained within each depth class (Table 2.9.4 (b)). This will have a bearing on the feasibility of constructing the earthen berm around the mining footprint. To facilitate the effective rehabilitation of the post-mining landscape it would be preferable for the topsoil horizon to be excluded from incorporation into the berm.

Table 2.9.4 (b): Potential soil volume contained within the Lusthof farm boundary and within the area enclosed by the berm

Soil Depth Class	Minimum Volume of Soil within Lusthof Farm (m^3)	Maximum Volume of Soil within Lusthof Farm (m^3)	Minimum Volume of Soil within Berm (m^3)	Maximum Volume of Soil within Berm (m^3)
<35cm	0	156 100	0	44 450
36-50cm	648 720	901 000	169 560	235 500
51-80cm	175 440	275 200	68 850	108 000
81-110cm	993 060	1 348 600	401 760	545 600
>110cm	3 362 190	6 663 800	450 660	893 200
Total	5 179 410	9 344 700	1 090 830	1 826 750

2.9.5 Soil Analyses

Laboratory texture analysis identified that the clay percentage of the topsoils varied from 17% to 67% (Table 2.9.5 (a)). Subsoil clay content was similar. Most of the samples had a sand fraction of approximately double the clay fraction, indicating the well-drained properties.

Table 2.9.5 (a): Topsoil and Subsoil Textures from Sample

Sample Number	Topsoil			Subsoil			Texture Class
	Clay(%)	Silt(%)	Sand(%)	Clay(%)	Silt(%)	Sand(%)	
375 (topsoil)	34	8	58				Sandy Clay Loam
376 (subsoil)				21	5	75	Sandy Clay Loam
377 (topsoil)	30	7	63				Sandy Clay Loam
378 (subsoil)				32	7	61	Sandy Clay Loam
379 (topsoil)	29	6	65				Sandy Clay Loam
380 (topsoil)	32	8	60				Sandy Clay Loam
381 (subsoil)				27	7	65	Sandy Clay Loam
382 (subsoil)				28	7	65	Sandy Clay Loam
461 (topsoil)	34	7	59				Sandy Clay Loam
463 (topsoil)	17	8	75				Sandy Loam
464 (subsoil)				33	6	62	Sandy Clay Loam
466 (topsoil)	31	5	63				Sandy Clay Loam
467 (subsoil)				24	8	68	Sandy Clay Loam
468 (topsoil)	38	8	54				Sandy Clay
469 (subsoil)				17	4	79	Sandy Loam
471 (topsoil)	36	11	53				Sandy Clay
472 (subsoil)				35	5	60	Sandy Clay
473 (topsoil)	18	9	73				Sandy Loam
479 (topsoil)	67	11	22				Clay
480 (subsoil)				69	10	20	Clay
495 (topsoil)	21	6	74				Sandy Clay Loam
499 (topsoil	23	8	68				Sandy Clay Loam
501 (topsoil)	30	8	62				Sandy Clay Loam
503 (subsoil)				44	11	46	Sandy Clay
507 (topsoil)	26	6	68				Sandy Clay Loam
508 (subsoil)				30	7	64	Sandy Clay Loam
514 (topsoil)	38	9	53				Sandy Clay Loam
515 (topsoil)	30	8	62				Sandy Clay
516 (topsoil)	67	11	23				Clay
517 (topsoil)	43	12	45				Clay
60 (topsoil)	27.4	11.8	59.2				Sandy Clay Loam
60 (subsoil)				17.5	12.2	69.2	Sandy Loam
56 (topsoil)	44.1	11.9	46.6				Sandy Clay
56 (subsoil)				49.0	12.5	38.2	Sandy Clay
68 (topsoil)	30.1	12.4	56.7				Sandy Clay Loam
68 (subsoil)				15.1	14.7	68.5	Sandy Loam

The results of the chemical soil analysis are provided in Table 2.9.5 (b). The pH of the topsoils fell within the range of 3.9 to 4.3, indicating acid soils. The subsoil samples were of a similar pH to those of the topsoil. The topsoil samples had organic carbon contents ranging from 0.5% to 5.3%. Multiplying these figures by the factor 1.724 will provide a rough organic matter percentage. Hence the organic matter content of the topsoil samples ranges from 0.9% to 9.1%. The organic carbon content of the soils decreased down the profile. Samples 56, 60 and 68 were taken from cultivated lands, and the topsoils are distinctive in that they:

- Are higher in P, K and Ca than samples taken from non-cultivated lands;
- Have a lower exchangeable acidity and slightly higher in pH; and
- Have higher concentrations of micro-nutrients such as Zn and Cu. These differences may be attributed to the inorganic fertilizer inputs inherent in commercial crop production.

Table 2.9.5 (b) Soil Nutrient Status per Compartment.

Sample No.	Sample Density	P	K	Ca	Mg	Exch. Acidity	Total Cations	Acid Sat.	pH	Zn	Mn	Cu	MIR clay	MIR Org.C	MIR N
	g/ml	mg/l	mg/l	mg/l	mg/l	cmol/L	cmol/L	%	(KCl)	mg/l	mg/l	mg/l	%	%	%
375 (topsoil)	1.07	3	212	363	139	0.37	3.87	10	**4.3**	0.6	5	3.5	**31**	**3.5**	0.22
376 (subsoil)	1.24	2	172	162	83	0.15	2.08	7	**4.38**	2	2	2.8	**45**	**0.5**	0.05
377 (topsoil)	1.09	7	85	105	41	1.69	2.77	61	**3.9**	1.9	6	2.9	**39**	**4.2**	0.25
378 (subsoil)	1.16	1	335	52	26	0.97	2.3	42	**4.11**	0.2	2	2.2	**37**	**1.3**	0.1
379 (topsoil)	1.05	20	115	115	21	1.21	2.25	54	**4.18**	0.7	4	2.3	**28**	**>6**	0.42
380 (topsoil)	1.11	9	70	268	77	1.17	3.32	35	**4.05**	1.5	5	2.9	**25**	**4.8**	0.31
381 (subsoil)	1.23	4	65	84	29	0.73	1.55	47	**4.19**	0.2	1	2.7	**29**	**3.4**	0.22
382 (subsoil)	1.25	3	113	20	5	1.86	2.29	81	**3.82**	0.8	15	2.1	**51**	**3.5**	0.15
461 (topsoil)	1.22	6	121	207	46	0.75	2.47	30	**4.07**	1.4	4	1.5	**25**	**3.1**	0.2
463 (topsoil)	1.1	2	200	202	45	1	2.89	35	**4.03**	0.9	4	1.2	**35**	**3.2**	0.23
464 (subsoil)	1.14	2	127	105	20	1.46	2.47	59	**4**	0.6	3	1.4	**33**	**1.4**	0.14
466 (topsoil)	0.96	6	128	357	71	0.91	3.6	25	**4.09**	1.2	5	1	**37**	**3.7**	0.29
467 (subsoil)	1.11	2	146	50	26	1.45	2.29	63	**4.04**	0.5	1	1	**40**	**0.8**	0.09
468 (topsoil)	1.05	8	160	196	30	1.36	2.99	45	**3.95**	1.4	9	1.3	**32**	**5**	0.39
469 (subsoil)	1.24	2	115	47	15	1.62	2.27	71	**3.92**	0.4	3	1.9	**35**	**2**	0.15
471 (topsoil)	1.17	6	122	251	48	0.8	2.76	29	**4.07**	0.7	5	1.4	**24**	**3**	0.21
472 (subsoil)	1.27	2	80	95	31	0.75	1.68	45	**4.02**	6.2	3	2.1	**28**	**1.5**	0.13
473 (topsoil)	1.09	16	93	333	32	0.89	3.05	29	**4.07**	2.1	18	2.1	**26**	**5.3**	0.41
479 (topsoil)	1.01	2	319	275	133	0.97	4.25	23	**4.13**	0.6	23	9.8	**51**	**3.5**	0.27
480 (subsoil)	1.03	1	97	123	62	1.15	2.52	46	**4.15**	0.6	8	7.6	**53**	**2**	0.19
495 (topsoil)	1.18	10	165	174	31	1.17	2.72	43	**4**	1.6	22	3.4	**28**	**5**	0.34
499 (topsoil)	1.1	5	225	311	86	0.28	3.12	9	**4.28**	2.5	20	3.7	**38**	**4.5**	0.3
501 (topsoil)	1.12	5	147	252	43	1.15	3.14	37	**3.93**	1.4	13	1.9	**37**	**2.8**	0.2
503 (subsoil)	1.13	1	119	68	11	1.5	2.23	67	**3.9**	0.6	24	3.2	**43**	**1.2**	0.14
507 (topsoil)	1.14	4	115	207	37	1.17	2.8	42	**3.97**	0.6	6	1.7	**28**	**28**	0.17
508 (subsoil)	1.27	1	92	79	12	1.08	1.81	60	**3.91**	0.5	1	2	**36**	**0.8**	<0.05

Sample No.	Sample Density	P	K	Ca	Mg	Exch. Acidity	Total Cations	Acid Sat.	pH	Zn	Mn	Cu	MIR clay	MIR Org.C	MIR N
	g/ml	mg/l	mg/l	mg/l	mg/l	cmol/L	cmol/L	%	(KCl)	mg/l	mg/l	mg/l	%	%	%
514 (topsoil)	1.1	5	67	101	16	1.72	2.53	68	**3.87**	0.9	5	1.8	**39**	**3.2**	0.17
515 (subsoil)	1.21	2	38	27	8	1.34	1.64	82	**3.98**	0.3	1	1.9	**36**	**1.5**	0.14
516 (topsoil)	1	7	99	680	144	0.45	5.28	9	**4.25**	1.2	3	2.7	**47**	**4**	0.32
517 (subsoil)	1.06	2	26	107	23	1.88	2.67	70	**3.93**	0.4	1	3.2	**50**	**2.2**	0.16
60 (topsoil)	1.22	7	293	852	183	0.04	6.55	1	**4.8**	5.8	10	7.2	**35**	**2.5**	0.18
60 (subsoil)	1.22	1	155	490	105	0.55	4.26	13	**4.23**	4.23	7	4.7	**37**	**1.0**	0.11
56 (topsoil)	1.24	5	64	1220	221	0.04	8.11	0	**5.57**	5.57	5	3.3	**23**	**1.2**	0.12
56 (subsoil)	1.26	2	53	503	93	0.07	3.47	2	**4.57**	4.57	2	2.7	**23**	**0.7**	0.08
68 (topsoil)	1.11	1	74	876	158	0.03	5.89	1	**4.89**	4.89	11	11.0	**54**	**2.2**	0.14
68 (subsoil)	1.1	1	73	653	106	0.03	4.35	1	**4.94**	4.94	9	9.0	**50**	**1.8**	0.17

2.10 LAND CAPABILITY AND LAND USE BASE LINE

Wetland Consulting Services conducted a detailed land capability and land use assessment for the proposed study area. The land capability and land use description compiled by them is reproduced in its entirety in this section.

2.10.1 Land Capability

The area within the opencast pit comprises of land with arable, grazing and wilderness capabilities.

2.10.2 Land Use

Due to the shallow nature of the soil profile, the area is predominately used as grazing land. The greatest majority of the area is covered by natural vegetation, disused plow ridges occur, indicating a previous crop production use. Limited dry land maize production is also evident on the study area, as a couple of cultivated fields occur. This is however very small in relation to the total area. A Black Wattle plantation and a couple of isolated patches of Black Wattle also occur within the study area.

The current land uses identified within the Lusthof farm boundary are indicated on Figure 2.10.2 (a) and are listed below:

- Cultivated lands; this includes old lands as well as current maize and soya croplands.
- Wetlands
- Hay pastures; these are predominantly *Eragrostis curvula* fields.
- Woodlot; *Acacia mearnsii* has been planted as a source of wood for farm inhabitants. These trees have expanded independently into a large portion of the grazing lands to the south of the road.
- Grazing lands; these are grasslands used as extensive grazing for beef cattle.

Within the area enclosed by the earthen berm the respective area of each landuse is as follows:

- Cultivated: 5.3ha
- Woodlot: 19.1ha
- Grazing: 91.7ha
- Wetland: 14.4ha
- Hay Pasture: 33ha

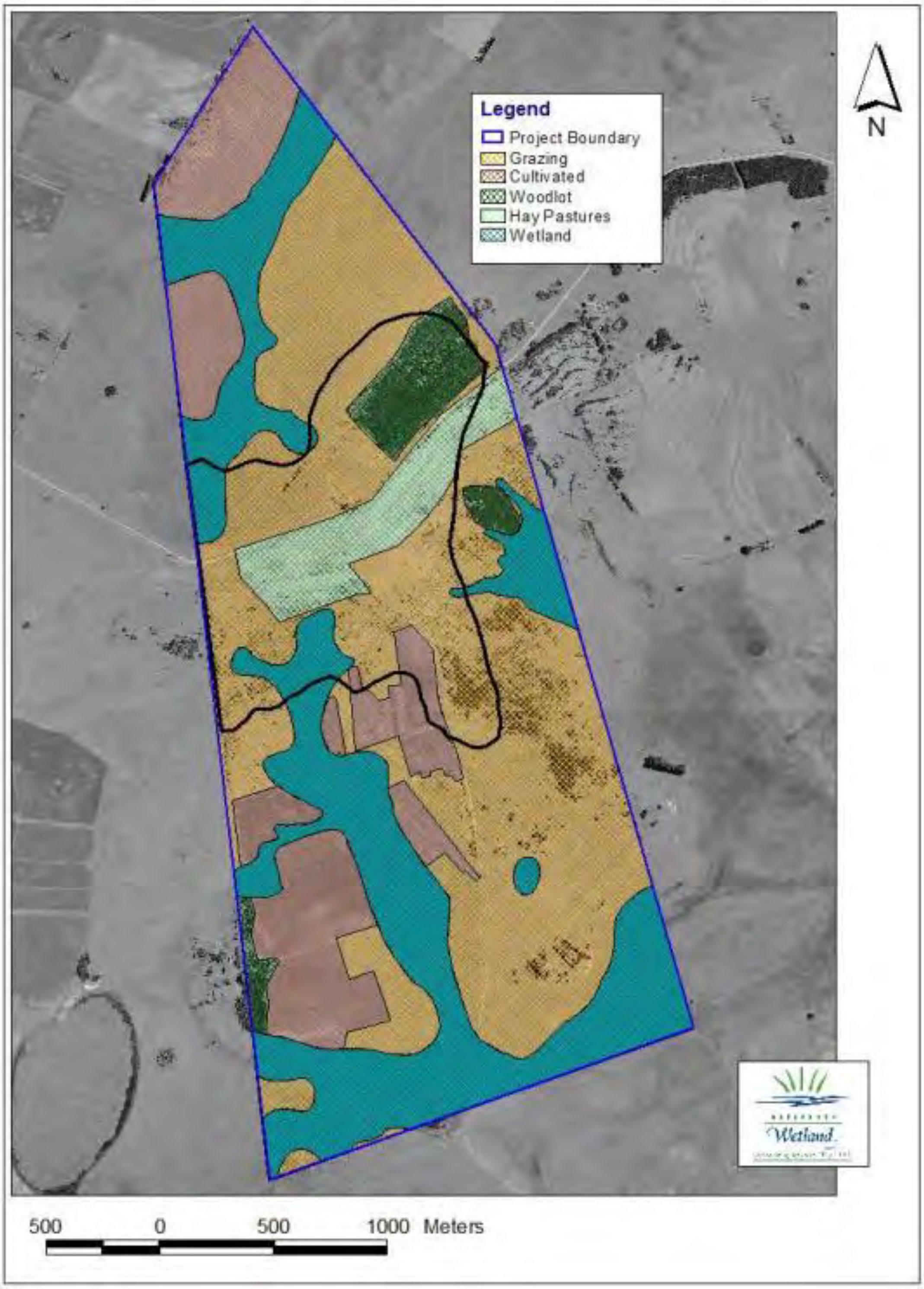


Figure 2.10.2 (a): Current Land Uses within the Lusthof Study Area

A secondary Provincial gravel road runs through the proposed mining area. Two old farmhouses and a couple of out buildings occur on a small portion of the farm, they are still inhabited by farm labourers. No signs of erosion were observed during the survey.

2.11 GEOLOGY BASE LINE

JMA Consulting (Pty) Ltd conducted a detailed geological base line assessment for the Lusthof study area. The geology description compiled by them is reproduced in its entirety in this section.

The geological investigation comprised of a quantitative site specific investigation using data obtained in the field as well as that recorded in previous studies and documents.

The site specific geology at Lusthof will be discussed with reference to the geological information recorded in the field, during the drilling and magnetic survey field work programmes. Additional geological information was obtained from the geology recorded in the 36 cored exploration (LH-) boreholes drilled at Lusthof Colliery.

Geological logs were generated at 1 meter intervals during the drilling of each of the 17 ground water monitoring boreholes in January 2009. The boreholes were drilled to serve as ground water monitoring points of the shallow weathered zone aquifer and are located on Figure 2.11 (a).

The geology intersected, water strike depths, blow yields and borehole construction details were recorded in the field during the drilling programme and are included in the Geological Logs and Borehole Site Reports.

The geological information was further statistically assessed and evaluated with regards to the lithological thicknesses and structural compartmentalization or continuity thereof.

2.11.1 Regional Geology

The aim of the regional geological discussion is not intended to elaborate on the tectonics and formation of the geology and geological structures in the study area, but rather to give a description of the underlying geological formations, identify and delineate the geological features of interest and provide information relating to the hydrogeology of the study area as well. The occurrence and movement of ground water, as well as the ground water quality, are functions of the geological host rock in which the ground water occurs, including the alteration thereof as a result of human activities, such as mining.

The regional geology of the study area is addressed with reference to the clipped region of the 1:250 000 Geological Map Series of South Africa – Sheet 2630 MBABANE, 1984, depicted as Figure 2.11.1 (a). The regional geology map indicates that the surface geology of the study area consists predominantly of sedimentary lithologies of the Vryheid Formation as well as Jurassic Age Dolerite intrusives.

The Vryheid Formation (Pv) forms part of the Ecca Group of the Karroo Supergroup, and outcrops extensively across the study area. The Vryheid Formation generically consists of grit, sandstone and shale layers within the study area. Carbonaceous shale and coal layers are generally associated with the Vryheid Formation as well.

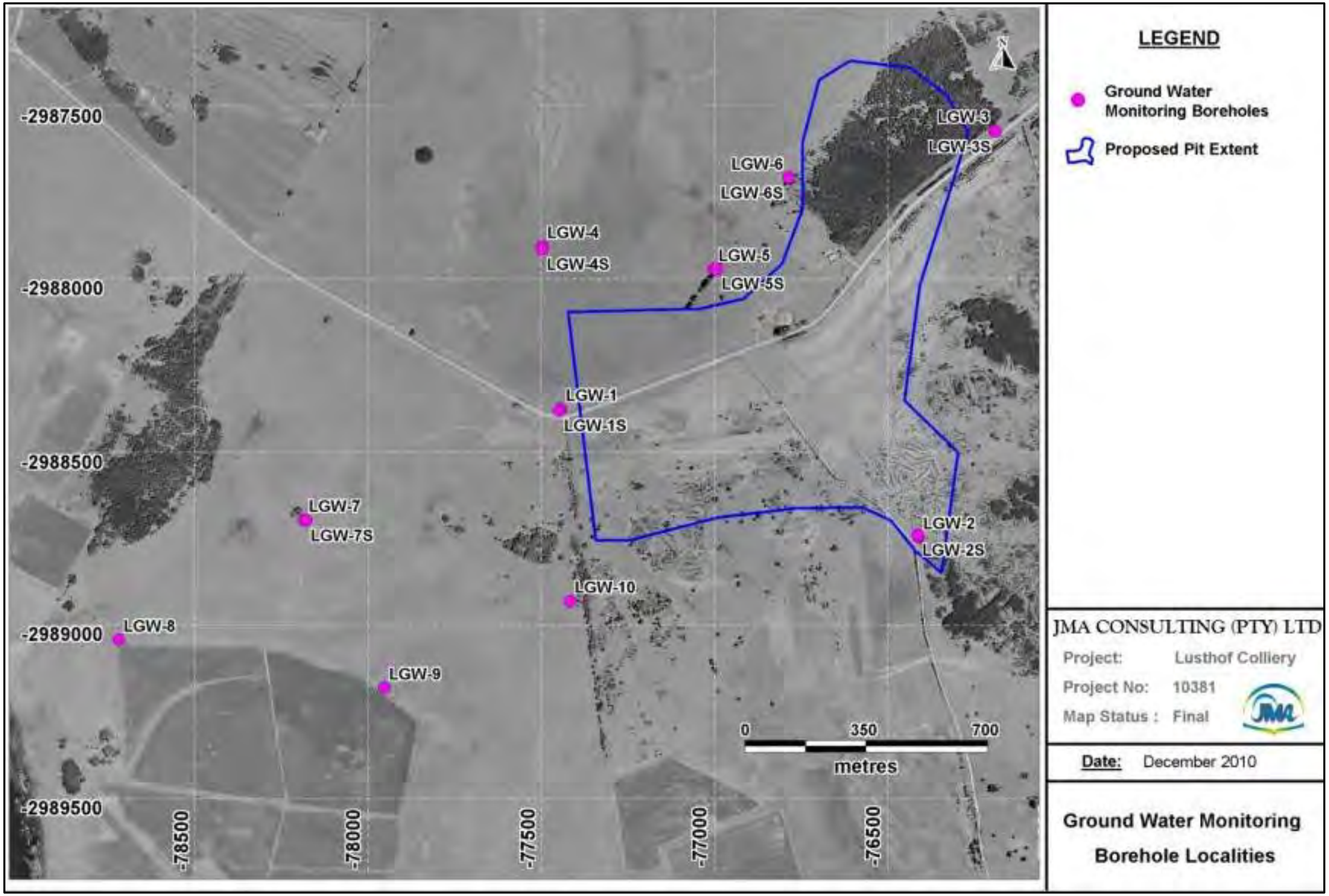


Figure 2.11 (a): Localities of Ground Water Monitoring Boreholes from which Geological Information was obtained

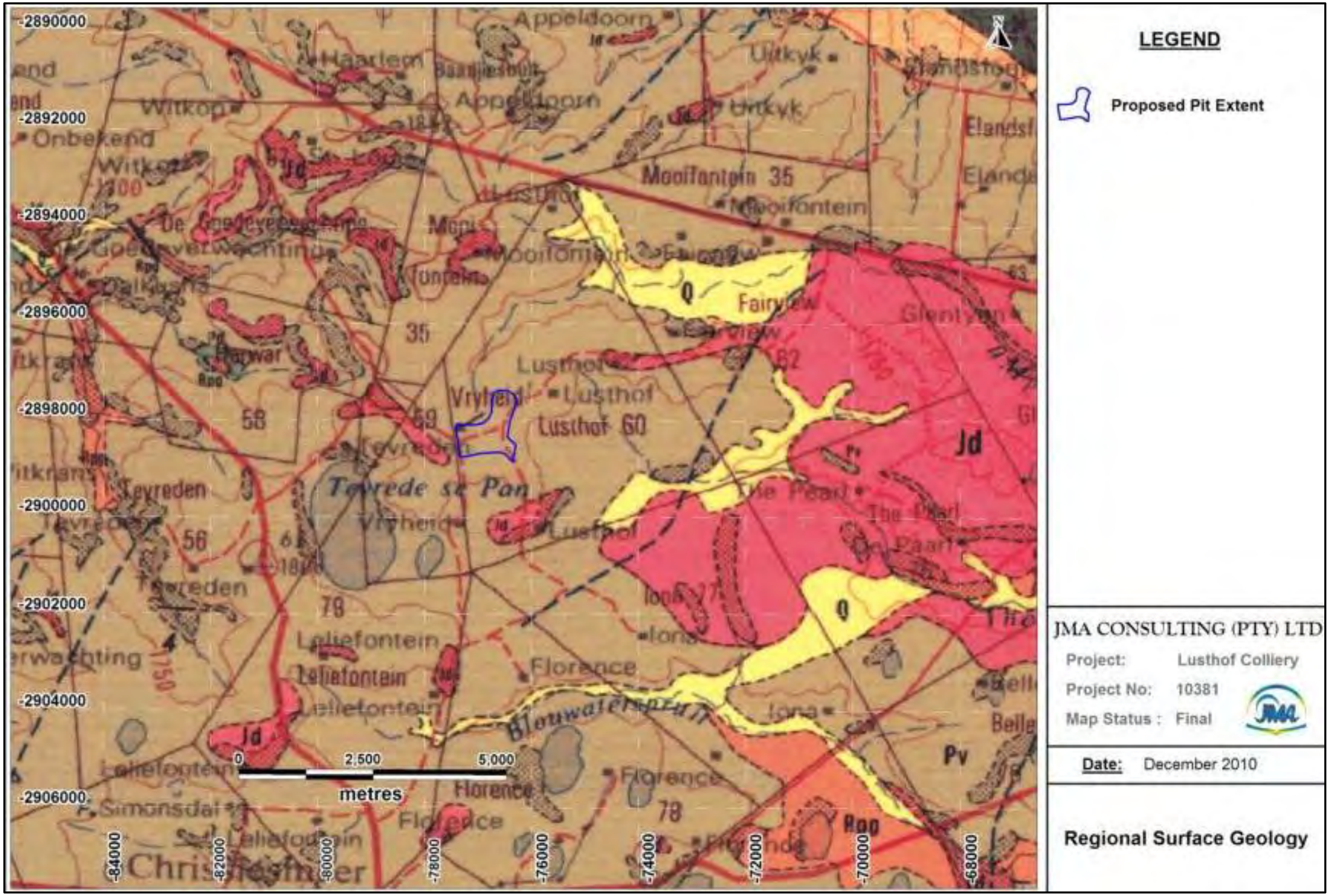


Figure 2.11.1 (a): Lusthof Colliery Regional Geology

The dolerite present within the study area (Jd) is younger than the Vryheid Formation and intruded into and through the sedimentary rocks of the Vryheid Formation. The dolerite outcrops and sub-outcrops extensively across the eastern extent of the Study Area. Localized dolerite sills outcrop across the central and western parts of the study as well. The dolerite intrusions typically occur as sills within the study area and are often responsible for the devolatization of the coal adjacent to the dolerite intrusions.

The low lying areas across the study area are typically associated with the deposition of quaternary sediments (Q). These quaternary sediments typically include alluvial sands and sediments along river and stream beds and typically include ferricrete within the study area as well.

Localized Randian-Age leucocratic pottasic granites (Rpg) have been recorded along the south-eastern and western extents of the study area. These granites are highly sporadic and discontinuous within the study area.

2.11.2 Localized Lithology and Stratigraphy

The geology intersected by the LGW- and LGW-S boreholes consists initially of shallow soils and a discontinuous brown ferricrete layer of up to 3 meters thick. The soils consist predominantly of shallow (<90 mm) Avalon and Mispah type soils. The textures of the yellow-brown apedal soils are generally sandy-loam in the topsoil and sandy-loam to sandy-clay-loam in the subsoil.

The area within the eastern parts of the pit extent is characterised by a shelf of hard plinthite and is generally associated with shallow soils ranging from 10 cm to 35 cm in depth and consists of the Dresden and Glencoe soil forms. The soils across the southern and eastern regions of the proposed mine extent are deeper and are characterised by apedal soils of approximately 80 cm in depth.

The ferricrete layer varies in thickness and forms isolated lenses within the study area. The ferricrete outcrops at various points within the proposed pit extent and is generally very shallow (<35 cm). The ferricrete was predominantly observed across the central and north-eastern regions of the proposed pit extent as well as to the north of the pit extent.

The ferricrete to the north of the pit was slightly deeper (up to 50 cm in places). Based on the information obtained the ferricrete is limited to the mid and upper slopes and laterally discontinuous across the extent of the study area.

The ferricrete is predominantly underlain by grey siltstone, sandstone, shale and associated coal of the Vryheid Formation although, clay was observed in 6 of the boreholes. The clay ranges in thickness between 1.5 and 4.5 meters, with an average thickness of 2.7 meters.

The geological sequence of the Vryheid Formation penetrated at Lusthof consists primarily of argillaceous units of carbonaceous shales and siltstones as well as arenaceous sandstones ranging in grain size from coarse to fine grained.

Reviews of the borehole cores shown in Figure 2.11.2 (a) and Figure 2.11.2 (b) indicate that the coal horizons and successions penetrated at Lusthof correlate with the Carolina-Breyten Sector of the Ermelo Coalfield. The coal seems present within this Sector are alphabetically numbered from the top (surface) to bottom as follows: “A”, “B”, “C”, “D” and “E” coal seams.

The “A” and “D” coal seams within the Carolina-Breyten Sector are generally too thin (< 0.6 meters) to be of economic importance. The “B” coal seam generally attains a thickness of between 2.0 – 3.7 m and consists of alternating layers of poor and good quality coal with generally high ash content. The “C” coal seam splits into a “C” Upper seam and a “C” Lower seam and attain thicknesses of 0.6 and 2.0 meters respectively. The “E” coal seam is generally well developed in the Carolina – Breyten sector of the Coal Province and may attain thicknesses of up to 3 meters.

Three coal seams were penetrated at Lusthof, namely the upper “B”, lower “B” and “C” coal seams. The upper “B” coal seam has been degraded to a black carbonaceous shale which has no economic value. As such, the main exploitable coal reserve at Lusthof comprises primarily of the lower “B” seam. In addition to this reserve the “C” coal seam is preserved over much of the property and does possess economic value if mined in conjunction with the “B” seam.

The “B” coal seam ranges in depth from sub-outcrop depths of 5 meters, covered by soft overburden and soils, to a maximum depth of 31 meters. The hard overburden comprises typically of fine to coarse grained sandstones. The immediate roof lithology of the “B” coal seam consists of a well defined black carbonaceous shale/mudstone, which possess rapid weathering properties coupled with a tendency towards “discing” on exposure.

The “B” coal seam has an average thickness of 1.94 meters with a maximum thickness of 2.31 meters at Lusthof. This coal seam consists predominantly of mixed bright and lustrous coal with a characteristic brighter fraction towards the base of the seam. The immediate floor lithology of the “B” coal seam comprises of a micaceous siltstone.

The “C” coal seam is further subdivided into an upper and a lower seam. The Upper “C” coal seam is separated from the “B” coal seam by a medium-grained horizontally laminated sandstone, with an average thickness of 5.7 meters and forms the immediate roof to the Upper “C” coal seam.

The Upper “C” coal seam therefore ranges in depth between 10 and 36 meters below the surface. The upper “C” coal seam has an average thickness of 0.69 meters across the extent of the proposed mining area and consists mainly of lustrous coal with occasional dull and bright coal present as well.

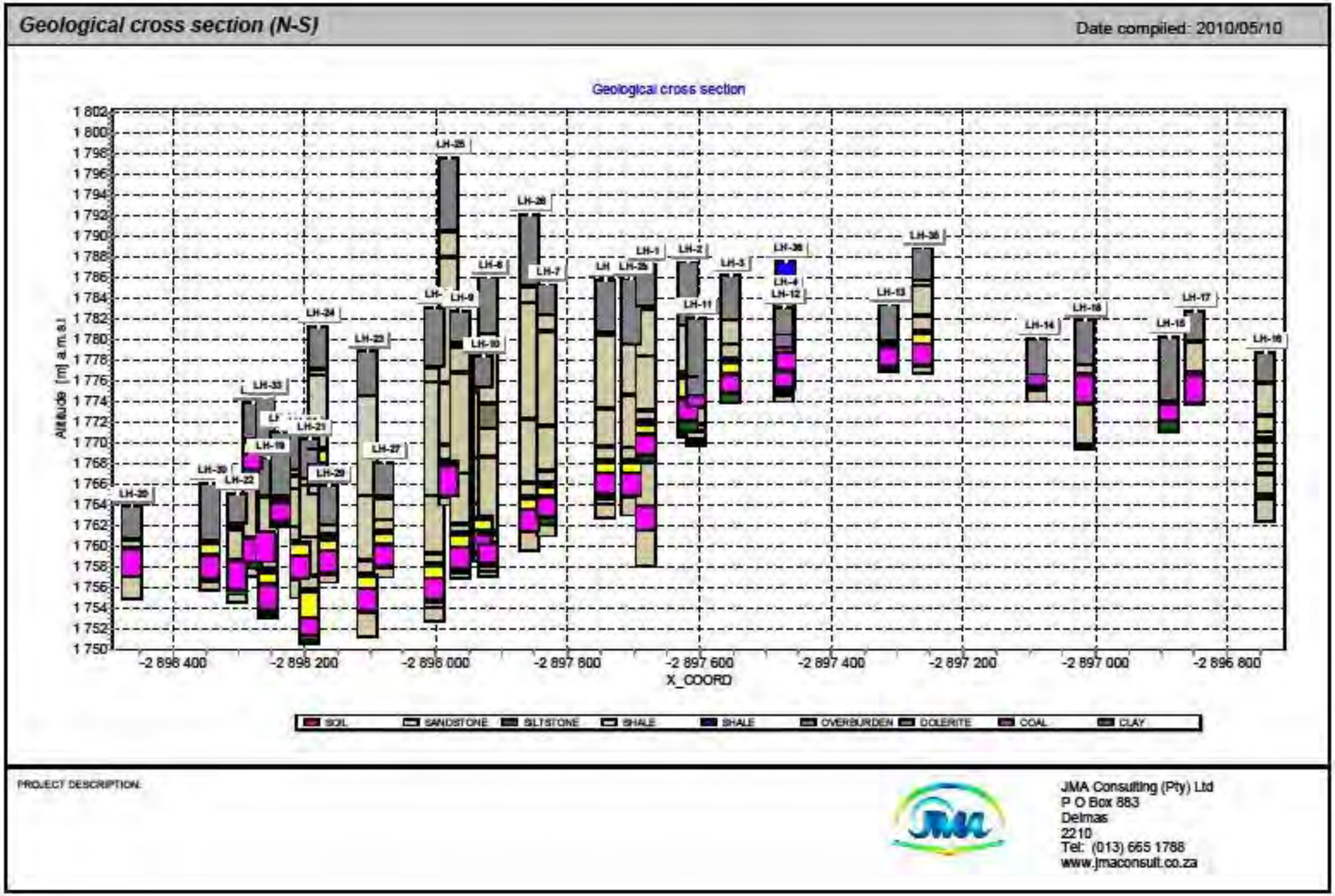


Figure 2.11.2 (a): N-S Geological Cross Section (LH- Exploration Boreholes)

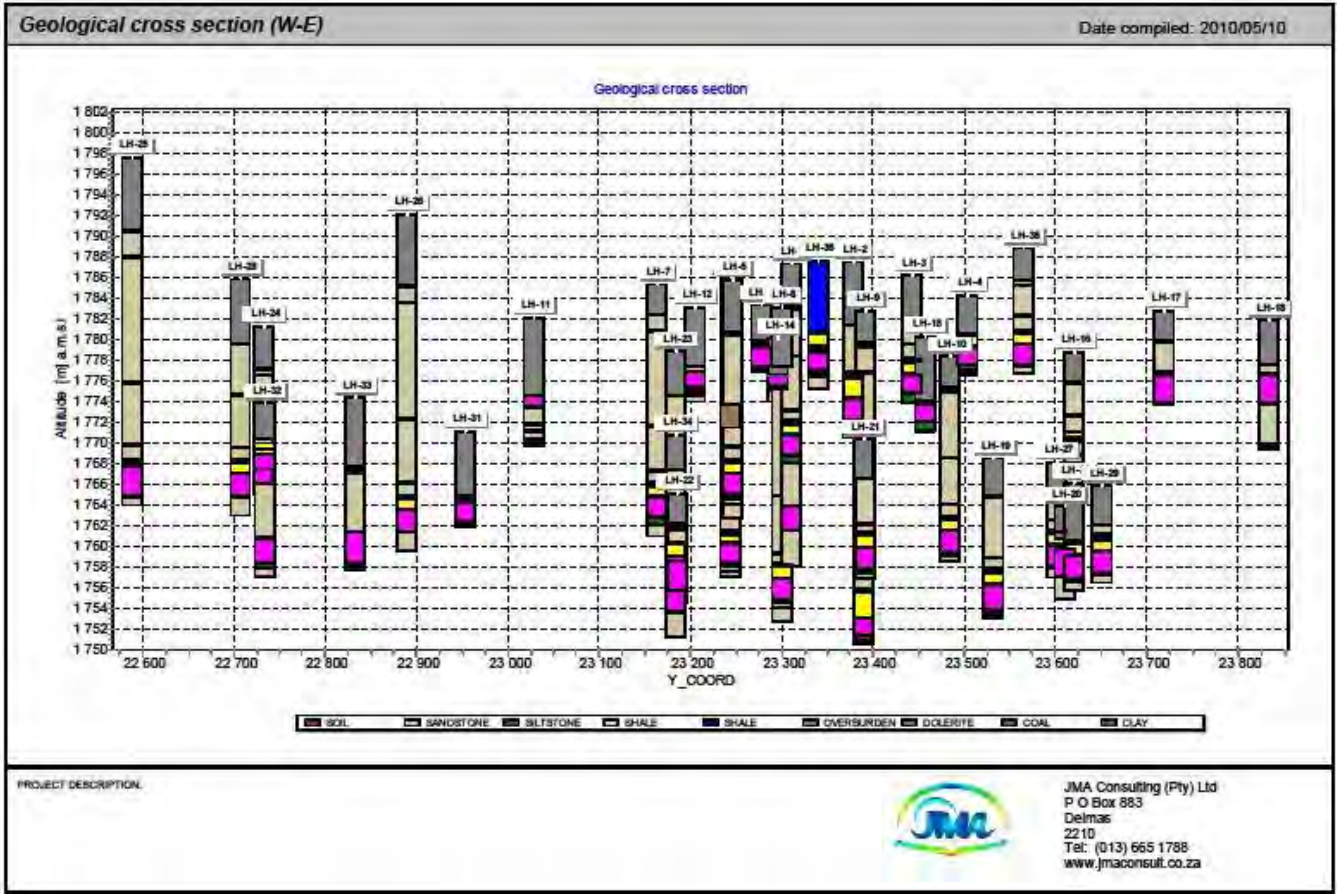


Figure 2.11.2 (b): W-E Geological Cross Section (LH- Exploration Boreholes)

The Lower "C" coal seam is separated from the Upper "C" coal seam by a characteristic "dirty grey" interbedded sandstone. This parting is small and the depth distribution of the Lower "C" coal seam is merely a function of the added thickness of the parting layer. The Lower "C" coal seam ranges in depth between 12 and 38 meters below the surface. The average thickness of the Lower "C" coal seam is approximately 1.79 meters and consists of bright lustrous coal.

The continuity of the coal seams at Lusthof pinches out and have been terminated to the West and South West as a result of surface erosion. Coal was not intersected in boreholes LGW-7, LGW-8 or LGW-9. All three of these boreholes are located to the West and South-West of the proposed mine extent, and are situated between Tevrede se Pan and the proposed mine extent.

Borehole LGW-7 intersected dolerite between the depths of 3 and 13 meters below the surface. The dolerite intersected forms part of the Jurassic-Age dolerite intrusives.

2.11.3 Linear Geological Features

In order to identify and accurately delineate any possible linear geological features (faults / dykes) at Lusthof an extensive magnetic geophysical survey was conducted. The magnetic survey was specifically structured in order to determine whether linear geological features occurred to the South and South-West of the proposed pit extent, towards the two surface water pans.

During the magnetic survey conducted at Lusthof, 15 magnetic traverse lines were walked, the extents of which are indicated on Figure 2.11.3 (a). Magnetic field readings were recorded (nanoTesla) at 5 meter intervals along each traverse walked, whilst each traverse was located 400 meters away from each other. The magnetic readings were used in addition to the surface geology recorded in the field in order to delineate the extent of dolerite within the study area.

Two dolerite sills were identified within the study area and are delineated on Figure 2.11.3 (b). The dolerite sills outcrop and sub-outcrop to the south and west of the proposed mine extent respectively. Borehole LGW-7 penetrated the dolerite sill to the west of the proposed mine extent between the depths of 3 and 13 meters below the surface, verifying the existence thereof.

No magnetic anomalies were observed and no dykes or faults were identified based on the information obtained from the magnetic survey. No dykes and faults were recorded in the field and there was no evidence of dykes or faulting based on the information obtained during the drilling of the LGW- boreholes either.

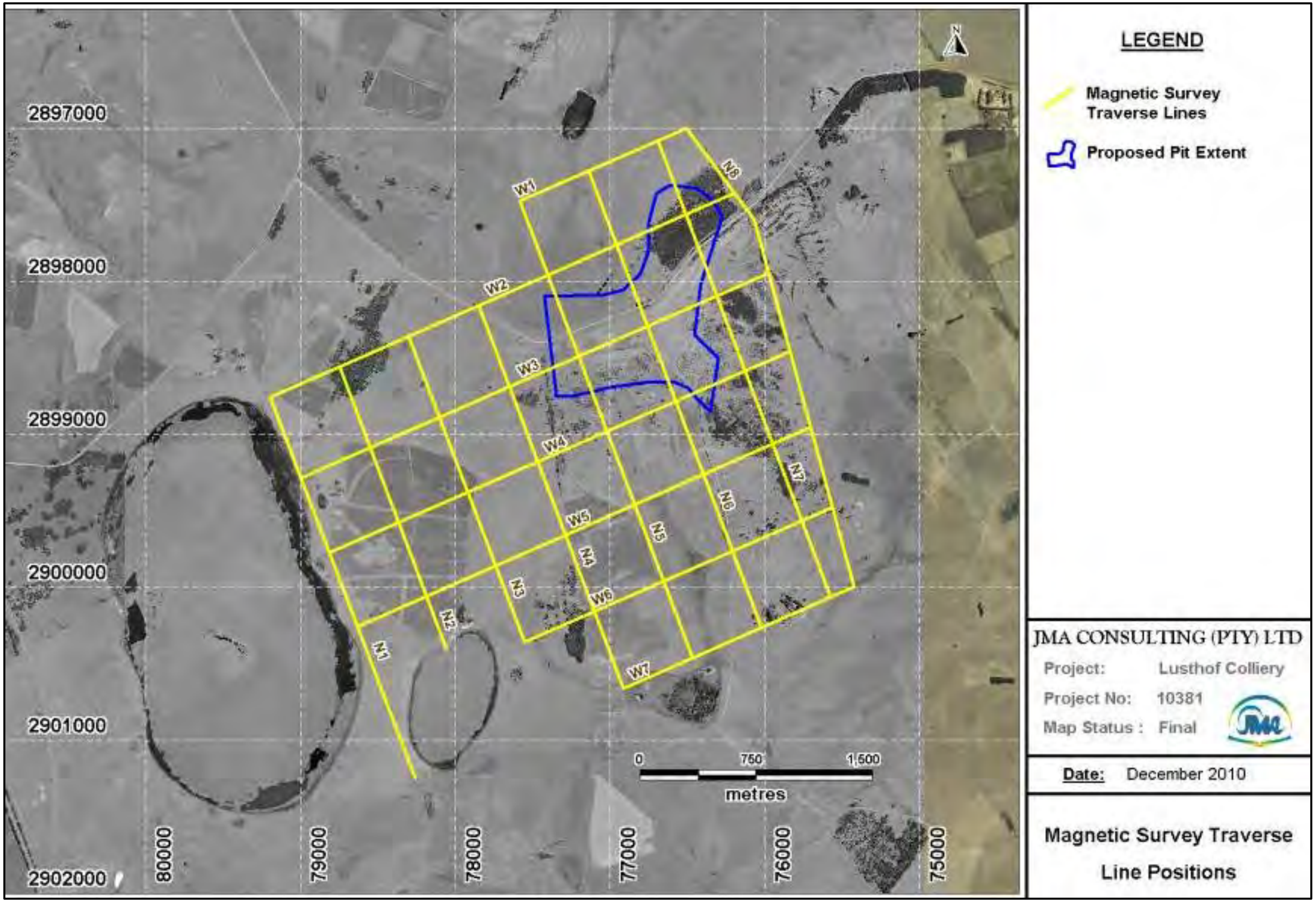


Figure 2.11.3 (a): Magnetic Survey Traverse Line Positions

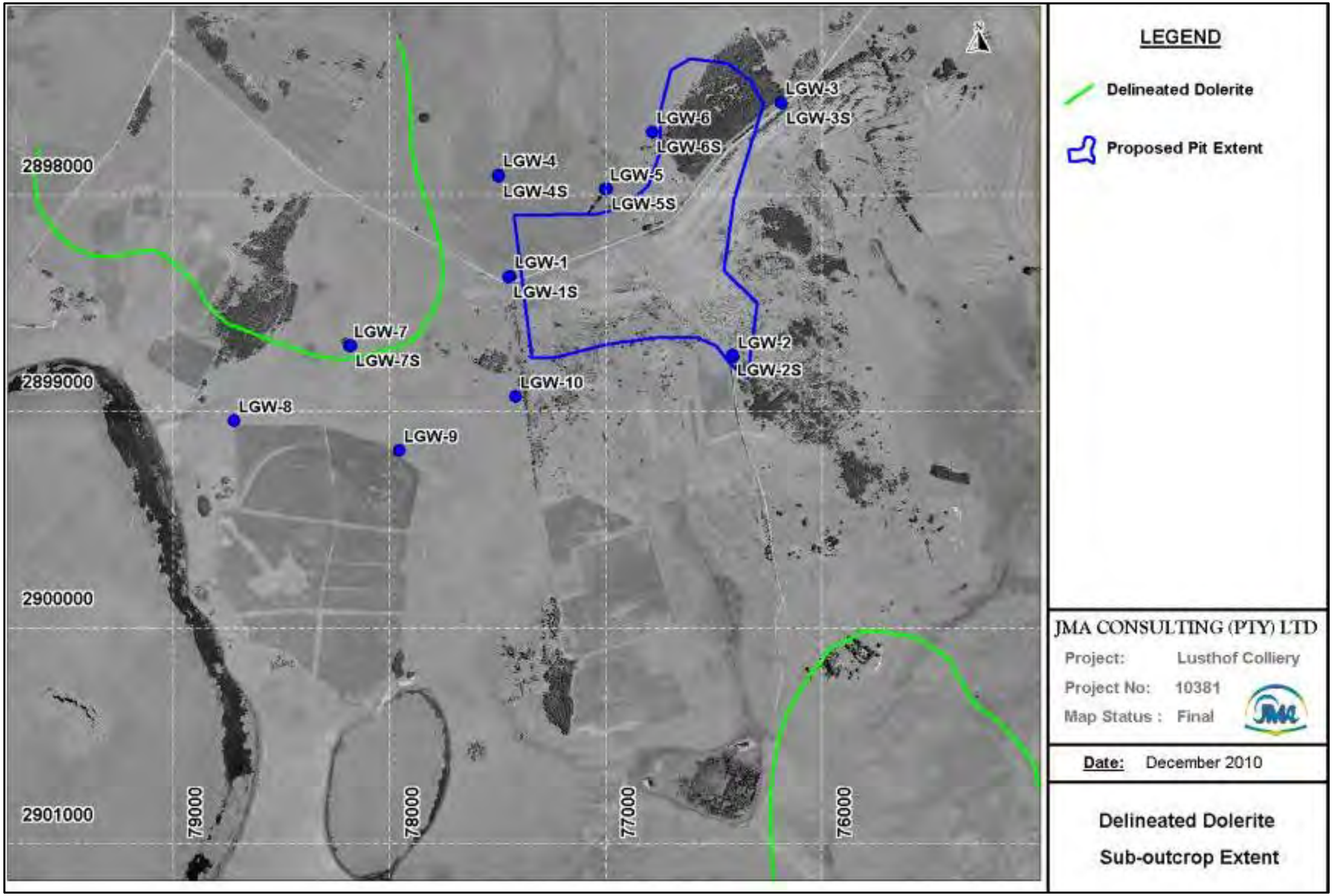


Figure 2.11.3 (b): Delineated Dolerite Sub-Outcrop Extent

2.11.4 Mineralogy

The typical mineralogical composition of the sandstone and shale lithological units of the Vryheid Formation is summarized in Table 2.11.4 (a).

Table 2.11.4 (a): Mineralogical Content of the Lithological Units

Mineral	Sandstone and Shale (%)
Calcite	0.48
Dolomite	1.12
Siderite	3.03
Pyrite	1.12
Anatase	0.46
K-feldspar	4.52
Plagioclase	1.27
Quartz	48.25
Mica	3.94
Kaolinite	35.80
Total	100.00

Table 2.11.4 (a) indicates that the 48.25% of the mineralogical composition of the sandstone and shale units of the Vryheid Formation consists of Quartz. Quartz is a hard and stable mineral that is composed entirely of SiO_2.

The second most abundant mineral (35.80%) is the clay mineral Kaolinite ($Al_2Si_2O_5(OH)_4$) which forms as the result of the weathering of the Feldspar minerals.

4.52% of the mineralogical composition of the sandstone and shale lithological units consist of K-feldspars and 1.27% consist of plagioclase feldspars, indicating that a large quantity has broken down into kaolinite.

Together Quartz and Kaolinite make up 84.05% of the composition of the sandstone and shale lithological units of the Vryheid Formation.

2.12 GROUND WATER BASE LINE

JMA Consulting (Pty) Ltd conducted a detailed ground water base line assessment for the Lusthof study area. The geohydrological description compiled by them is reproduced in its entirety in this section.

The geohydrological investigation at Lusthof entailed a site specific quantitative investigation in accordance with the various guidelines and documents obtained from the regulating authorities.

2.12.1 Regional Geohydrology

The regional geohydrological setting is described with reference to available published information for the study area. The regional geohydrology of the study area will be discussed with reference to the available information relevant to the map extract shown in Figure 2.12.1 (a). This map extract was clipped from the published 1:500 000 Hydrogeological Map Series of the Republic of South Africa – Sheet 2530 Nelspruit, 1999.

The regional geohydrological attributes of the study area are clearly a function of the geological formation distribution. Two distinctly separate stratigraphic sequences (Pe and Jd) occur within the study area, each with their own geohydrological manifestations.

The central and western extent of the study area is predominantly underlain by arenaceous rocks of the Ecca Group – denoted by "Pe" on the map. The eastern extent of the study area is predominantly underlain by mafic intrusive (dolerite) igneous rocks – denoted by "Jd" on the map.

The ground water within the study area primarily occurs within the weathered zone or in joints and fractures of the competent arenaceous rocks, related to tensional or compressional stresses and offloading. Ground water also occurs along sedimentary – sedimentary or sedimentary – igneous rock contacts. Localised large water bearing fractures generally occur along the sedimentary – igneous contact zones related to the heating and cooling of the arenaceous host rock caused by the intrusion of dolerite dykes and sills as well.

The borehole yielding potential within the study area is classified as d3, which implies an expected average yield of between 0.5 l/s and 2.0 l/s. No large scale ground water abstraction is indicated to occur from these inter-granular and fractured aquifers within the bounds of the study area. The ground water potential within the study area is given as greater than 60%, and indicates the probability of drilling a successful borehole (yield > 0.1 l/s) whilst the probability of obtaining a yield in excess of 2 l/s is given as between 10% and 20%.

The mean annual recharge (MAR) to the ground water system in the study area is estimated to be between 50 mm and 75 mm per annum, which relates to between 7% and 10% of the mean annual precipitation (MAP). The ground water contribution to ground stream base flow is relatively high, and is estimated to be between 50 mm and 100 mm per annum.

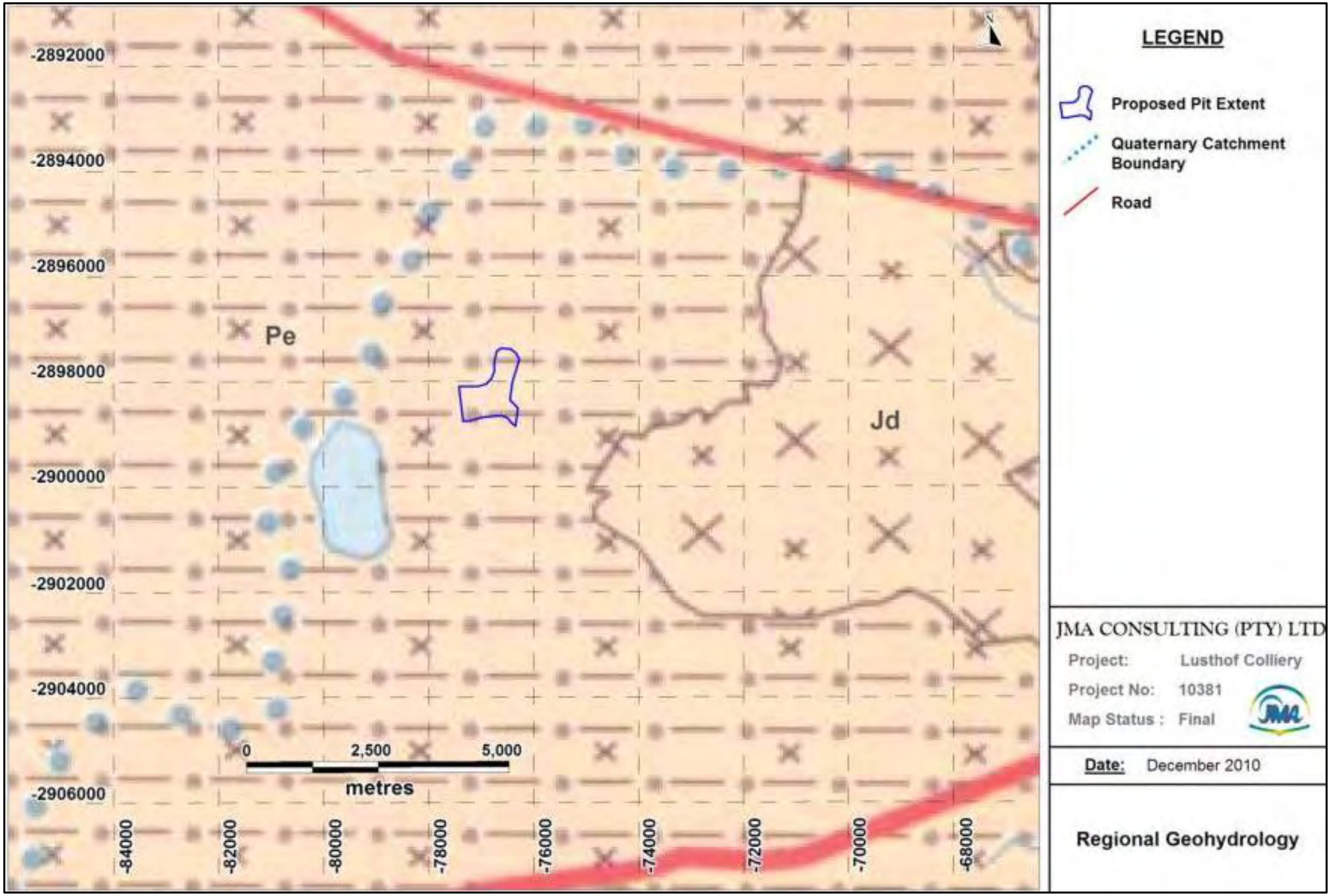


Figure 2.12.1 (a): Regional Geohydrology

The depths to ground water levels are estimated to be between 10 m and 20 m below the ground with a standard deviation (SD) of greater than 15 m from the mean. The aquifer storativity (S) for the inter-granular and fractured aquifers in the study area is estimated to be between 0.01 and 0.001. The saturated interstice types (storage medium) are pores in disintegrated / weathered to partly weathered and fractured rocks, as well as fractures which are restricted principally to the zone directly below the ground water level.

The pristine ground water quality is good with a Total Dissolved Solids (TDS) range of less than 300 mg/l. The ground water is classified to be of the hydrochemical type B, with dominant cations Ca^{2+} and Mg^{2+} and dominant anion being HCO_3^-.

2.12.2 Physical Aquifer Description

The physical aquifer delineation and description for the underlying aquifers at Lusthof will be based on the geological information generated during the investigative field programmes. The lithology that was penetrated, its weathering and fracturing status, as well as its water yielding capacity was recorded for each borehole during drilling.

2.12.2.1 Aquifer Matrix (Soil and Geological Matrix)

The host rock matrix at Lusthof consists initially of shallow soils and a discontinuous brown ferricrete layer of up to 3 meters thick. The soils at Lusthof consist predominantly of shallow (<90 mm) Avalon and Mispah type soils. The textures of the yellow-brown apedal soils are generally sandy-loam in the topsoil and sandy-loam to sandy-clay-loam in the subsoil.

The area within the eastern parts of the pit extent is characterised by a shelf of hard plinthite and is generally associated with shallow soils ranging from 10 cm to 35 cm in depth and consists of the Dresden and Glencoe soil forms. The soils across the southern and eastern regions of the proposed mine extent are deeper and are characterised by apedal soils of approximately 80 cm in depth.

The ferricrete layer varies in thickness and forms isolated lenses within the study area. The ferricrete outcrops at various points within the proposed pit extent and is generally very shallow (<35 cm). The ferricrete was predominantly observed across the central and north-eastern regions of the proposed pit extent as well as to the north of the pit extent.

The ferricrete to the north of the pit was slightly deeper (up to 50 cm in places). Based on the information obtained, the ferricrete is limited to the mid and upper slopes and laterally discontinuous across the extent of the study area.

The ferricrete is predominantly underlain by grey siltstone, sandstone, shale and associated coal of the Vryheid Formation although, clay was observed in 6 of the boreholes. The clay ranges in thickness between 1.5 and 4.5 meters, with an average thickness of 2.7 meters.

The geological sequence of the Vryheid Formation penetrated at Lusthof consists primarily of interbedded argillaceous units of carbonaceous shales and siltstones as well as arenaceous sandstones ranging in grain size from coarse to fine grained and varying in thickness. Coal was intersected at various depths in 7 of the 10 deep ground water monitoring boreholes.

Three coal seams were penetrated at Lusthof, namely the upper “B”, lower “B” and “C” coal seams and correlate with the Carolina-Breyten Sector of the Ermelo Coalfield. The upper “B” coal seam has been degraded to a black carbonaceous shale which has no economic value. As such, the main exploitable coal reserve at Lusthof comprises primarily of the lower “B” seam. In addition to this reserve the “C” coal seam is preserved over much of the property and is economically exploitable if mined in conjunction with the “B” coal seam.

The “B” coal seam ranges in depth from sub-outcrop depths of 5 meters below the surface, covered by soft overburden and soils, to a maximum depth of 31 meters. The hard overburden comprises typically of fine to coarse grained sandstones. The immediate roof lithology of the “B” coal seam consists of a well defined black carbonaceous shale/mudstone, which possess rapid weathering properties coupled with a tendency towards “discing” on exposure. The “B” coal seam has an average thickness of 1.94 meters with a maximum thickness of 2.31 meters at Lusthof. This coal seam consists predominantly of mixed bright and lustrous coal with a characteristic brighter fraction towards the base of the seam. The immediate floor lithology of the “B” coal seam comprises of a micaceous siltstone.

The “C” coal seam is further subdivided into an upper and a lower seam. The Upper “C” coal seam is separated from the “B” coal seam by a medium-grained horizontally laminated sandstone, with an average thickness of 5.7 meters and forms the immediate roof to the Upper “C” coal seam. The Upper “C” coal seam therefore ranges in depth between 10 and 36 meters below the surface. The upper “C” coal seam has an average thickness of 0.69 meters across the extent of the proposed mining area and consists mainly of lustrous coal with occasional dull and bright coal present as well.

The Lower “C” coal seam is separated from the Upper “C” coal seam by a characteristic “dirty grey” interbedded sandstone. This parting is small and the depth distribution of the Lower “C” coal seam is merely a function of the added thickness of the parting layer. The Lower “C” coal seam ranges in depth between 12 and 38 meters below the surface. The average thickness of the Lower “C” coal seam is approximately 1.79 meters and consists of bright lustrous coal.

The continuity of the coal seams at Lusthof pinch out and have been terminated to the West and South West of the proposed mine extent as a result of surface erosion. This was verified during the drilling of ground water monitoring boreholes as coal was not intersected in boreholes LGW-7, LGW-8 or LGW-9. All three of these boreholes are located to the West and South-West of the proposed mine extent, and are situated between Tevrede se Pan and the proposed mine extent.

Borehole LGW-7 intersected dolerite between the depths of 3 and 13 meters below the surface. The dolerite intersected in borehole LGW-7 forms part of the Jurassic-Age dolerite intrusives.

2.12.2.2 Aquifer Types (Primary, Weathered, Fractured, Karst, Perched)

With reference to the local geology of the site, it is regarded that two aquifer types occur within the ground water study area, namely: 1) an extensive shallow weathered zone aquifer and 2) more localized fractured aquifer systems.

The predominant aquifer type present within the study area is a laterally extensive shallow weathered zone aquifer which occurs in the weathered and weathering related fractured zone, within the Vryheid Group host rock matrix. This aquifer extends across the entire proposed pit extent and has an average vertical thickness of 17.5 m. This aquifer zone will store and transport the bulk of the ground water in this area. This aquifer will display unconfined to semi-unconfined piezometric conditions and is, as a result, highly susceptible to surface induced activities and impacts.

The localized fractured aquifers present within the study area are restricted to the contact zones between the intrusive dolerite bodies and the host rock. The bulk of the water supplied by these aquifers will be drained laterally from storage within the shallow weathered zone aquifers neighbouring onto them.

With regards to the two aquifer types present within the study area, and subject to the site specific host matrix physical properties, it is assumed that the bulk of the ground water zone within the study area will display porous ground water flow conditions. The "fractured conditions" encountered, may, due to their scale and interconnectivity, also be regarded as porous ground water flow zones.

The 7 shallow ground water monitoring (LGW-S) boreholes were drilled and constructed to specifically determine whether perched aquifer conditions occurred at Lusthof or not. During the June 2010 ground water sampling field programme all 7 of the shallow boreholes were dry. This indicates that no perched aquifer conditions were observed at the boreholes and further indicates that if perched aquifer conditions are present, they occur as isolated lenses and are laterally discontinuous.

2.12.2.3 Aquifer Zones (Unsaturated, Saturated)

Both the geological and geohydrological information generated at Lusthof do not indicate the presence of an extensive perched aquifer system within the study area. This simplifies the geohydrology and indicates that the conceptual geohydrological model can be comprehensively described in terms of unconfined to semi-unconfined unsaturated and saturated zones.

<u>Unsaturated Zone:</u>

Due to the nature of the shallow weathered zone aquifer at Lusthof, the top of the unsaturated zone is defined by the land surface, whilst the bottom of the unsaturated zone is defined by the ground water table/level.

The thickness of the unsaturated zone is therefore defined as the depth to the ground water level recorded at the LGW- boreholes. The thickness of the unsaturated zone was calculated using the water level data recorded in June 2010 and varies between 0.00 m, in which case the ground water was artesian (LGW-4) and 5.23 m (LGW-6). The unsaturated zone has an average thickness of 2.75 m at Lusthof. The thickness distribution of the unsaturated zone is heterogeneous as indicated in Figure 2.12.2.3 (a).

Saturated Zone:

The saturated aquifer thickness of the shallow weathered zone aquifer at Lusthof is calculated by subtracting the measured ground water level depth from the weathered or weathering related fractured depth as recorded at the LGW- ground water monitoring boreholes. The thickness distribution of the saturated zone at Lusthof is indicated in Figure 2.12.2.3 (b).

The saturated zone of the shallow weathered zone aquifer at Lusthof is defined at the top by the ground water table/level and at the bottom by the weathered/fractured and fresh bedrock interface. The saturated thickness varies between 11.43 m and 27.27 m with an average thickness 17.67 m.

2.12.2.4 Lateral Aquifer Boundaries (Physical, Hydraulic, Arbitrary)

The ground water zone of influence may be defined and delineated by three principle types of aquifer boundaries, namely physical, hydraulic and arbitrary boundaries.

- Physical boundaries are defined by linear geological intrusions (dykes) or geological contacts between rocks with different geohydrological attributes.
- Hydraulic boundaries are defined by dams, rivers and streams, or alternatively by surface water and ground water divides.
- Arbitrary boundaries are selected in terms of ground water flow directions and are usually chosen parallel to the ground water flow direction.

The delineation of the lateral aquifer boundaries at Lusthof will define the extent of the ground water zone that could potentially be affected by surface activities within the proposed mine extent. The ground water influence zone is therefore delineated with reference to the lateral aquifer boundaries as mentioned above. The extent of the potential ground water influence zone at Lusthof is delineated on Figure 2.12.2.4 (a).

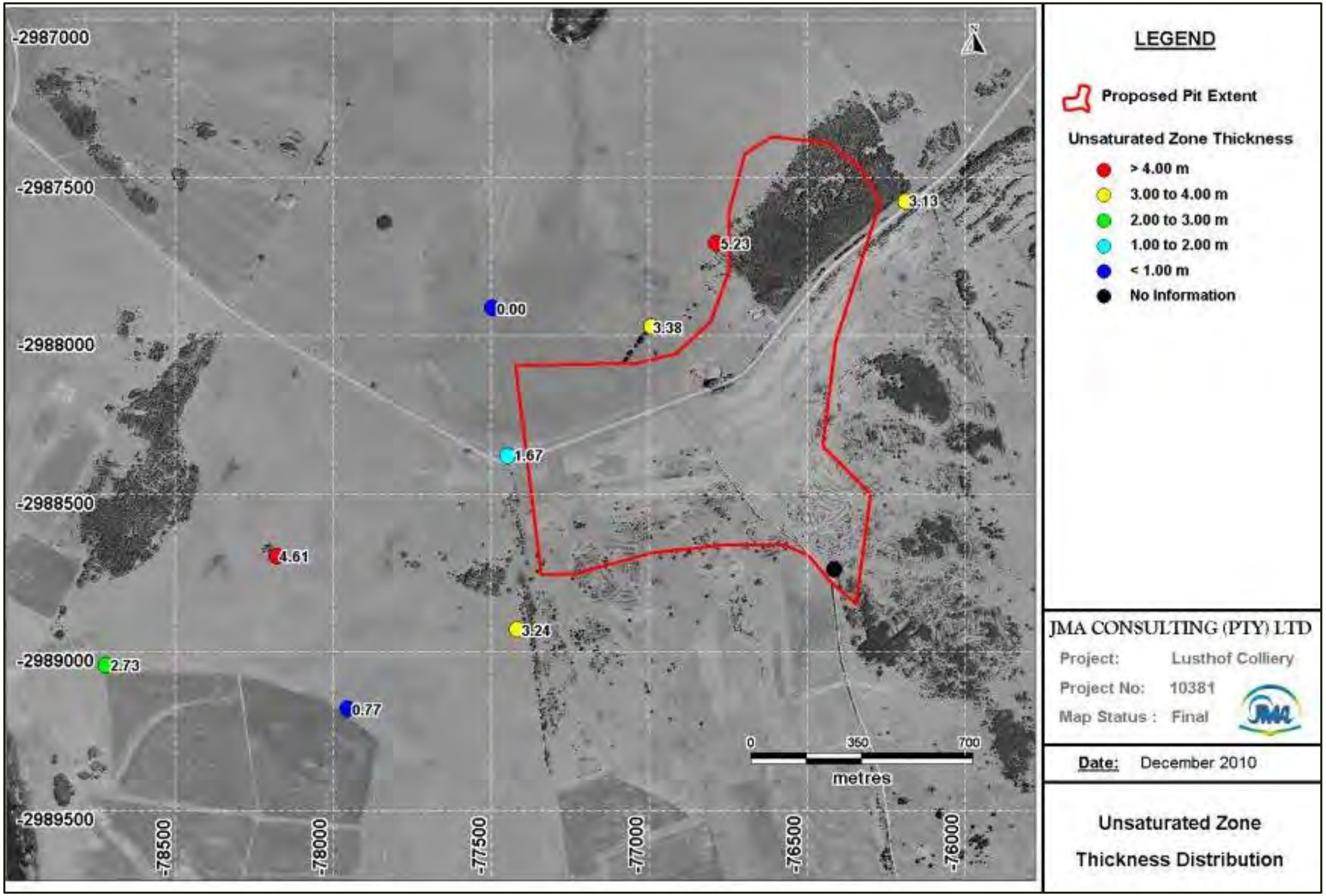


Figure 2.12.2.3 (a): Unsaturated Zone Thickness Distribution

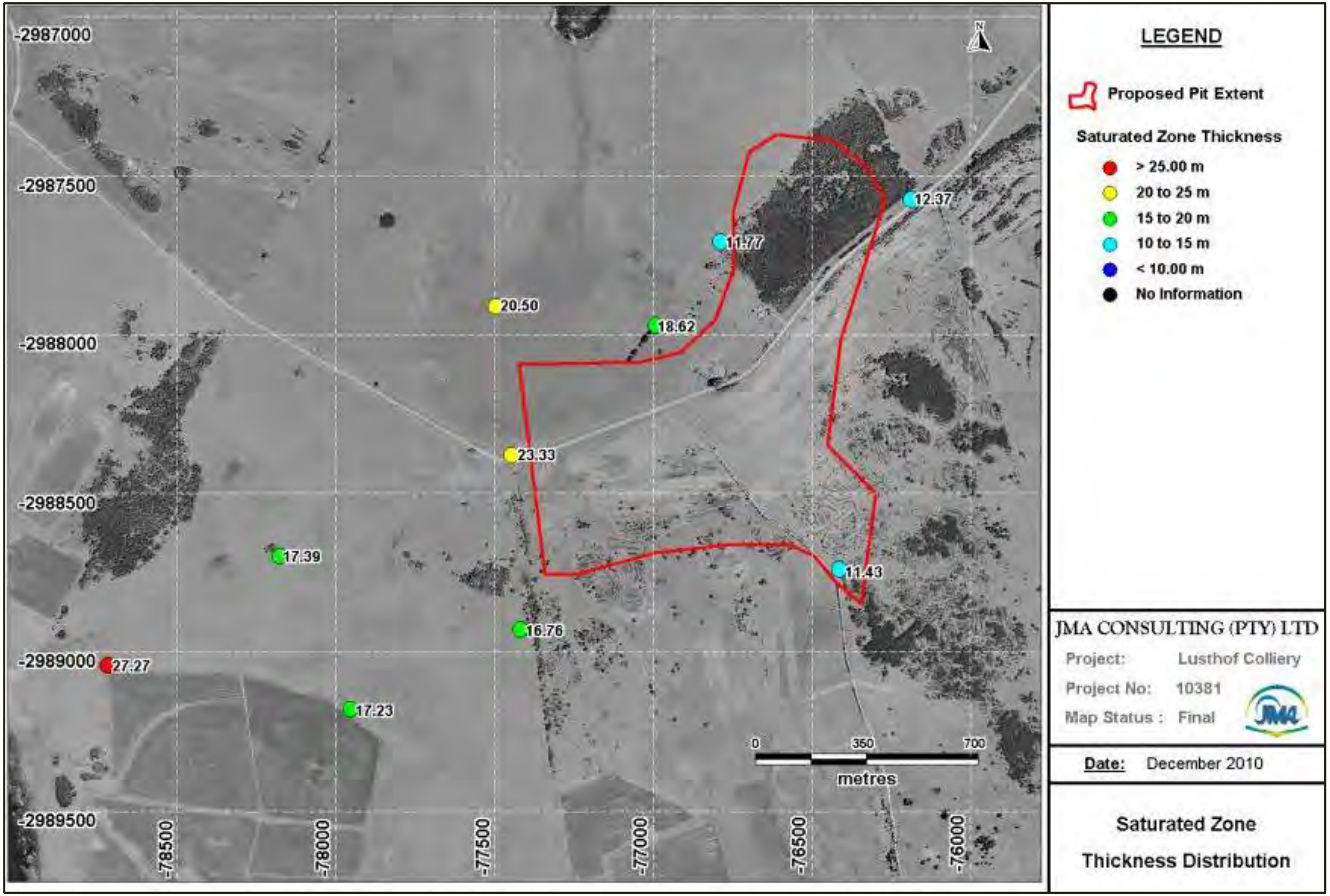


Figure 2.12.2.3 (b): Saturated Zone Thickness Distribution

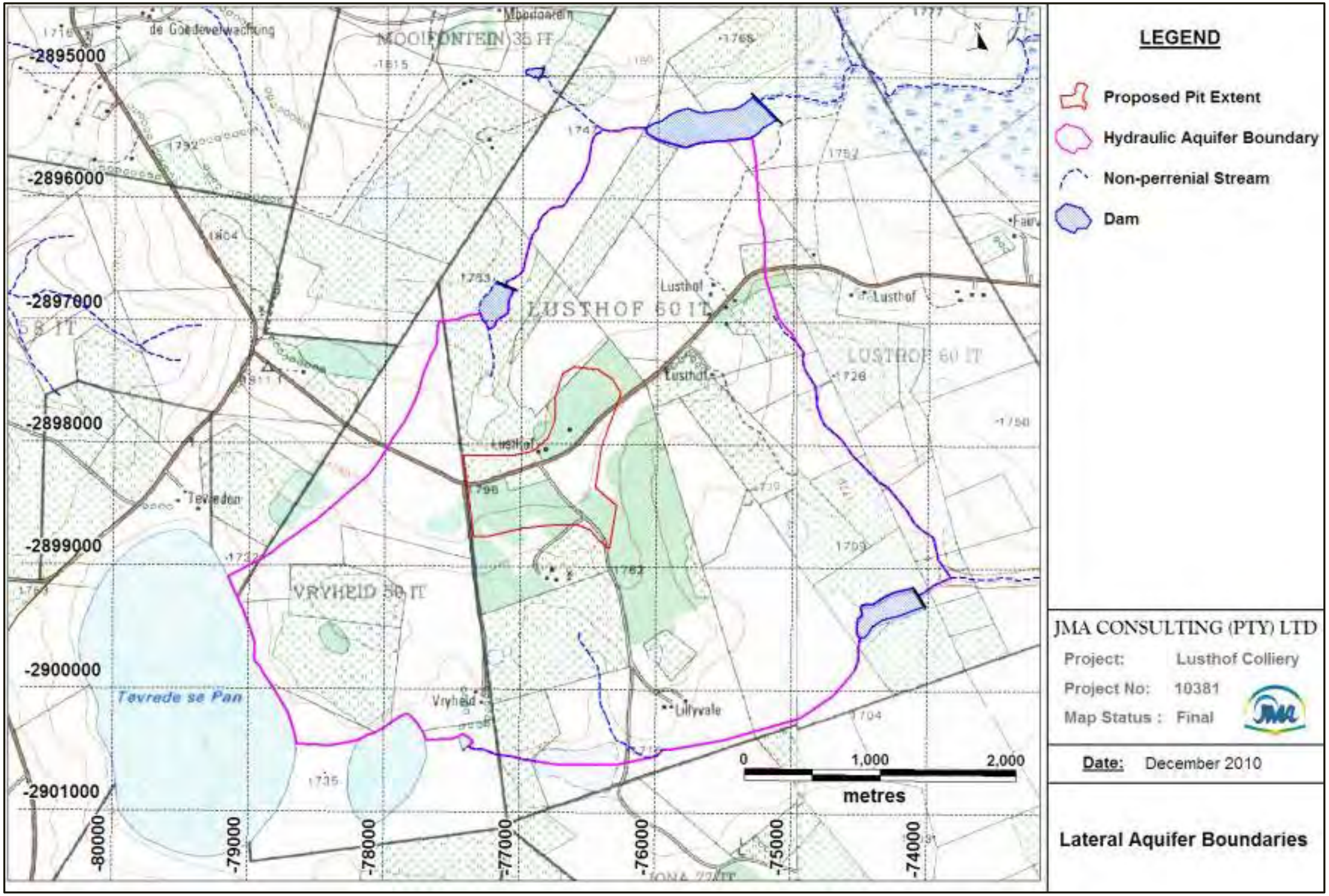


Figure 2.12.2.4 (a): Lateral Aquifer Boundaries

The lateral aquifer boundaries at Lusthof comprise entirely of hydraulic boundaries. The perennial streams, pans and dams form ground water discharge boundaries to the north, east and south of the proposed mine extent. The western, north-eastern and south-western (between the pans) aquifer boundaries are defined by no-flow ground water aquifer boundaries.

2.12.2.5 Preferential Ground Water Flow Zones

Preferential ground water flow zones are associated with the highly fractured zones along faults as well as within contact zones associated with intrusive igneous bodies. The zones adjacent to the dykes and sills are generically highly fractured due to their intrusive nature and are thus often associated with fault zones. As the magmas intrude into the crust, they bake and fracture the host rock. If the dykes cool quickly they form fractures at their edges as well.

These "contact zones" between the dykes and adjacent host rock are thus often highly fractured and result in zones of relatively high porosities and permeability's. These highly fractured contact zones have higher transmissivity values and represent zones through which the ground water can move more freely as opposed to the adjacent host rock and could thus affect the natural ground water flow characteristics of the shallow weathered zone aquifer as well.

No faults and dykes were observed or recorded during the drilling and geophysics field work programmes conducted at Lusthof. Two dolerite sills were however identified in the field and are delineated in Section 2.6.4. The nature and extent of the associated contact zones are defined by the geometry and extent of the two identified dolerite sills.

Based on the field investigations, no extensive preferential ground water flow zones were identified within the study area at Lusthof.

2.12.3 Hydraulic Aquifer Description

The hydraulic aquifer description relates to the parameters which determine the hydraulic ground water properties, such as the occurrence, availability, storage and movement of the ground water within the shallow weathered zone aquifer systems present at Lusthof. The hydraulic attributes for the unsaturated and saturated shallow weathered zones will essentially be the same, with the only difference being the degree of saturation.

2.12.3.1 Borehole Yields

Blow yields were obtained from 8 of the LGW- boreholes during the drilling of the boreholes. Boreholes LGW-8 and LGW-10, along with the LGW-S boreholes did not have blow yields. The blow yields recorded were obtained from the shallow weathered zone aquifers present at Lusthof. The borehole blow yield distribution at Lusthof is indicated on Figure 2.12.3.1 (a).

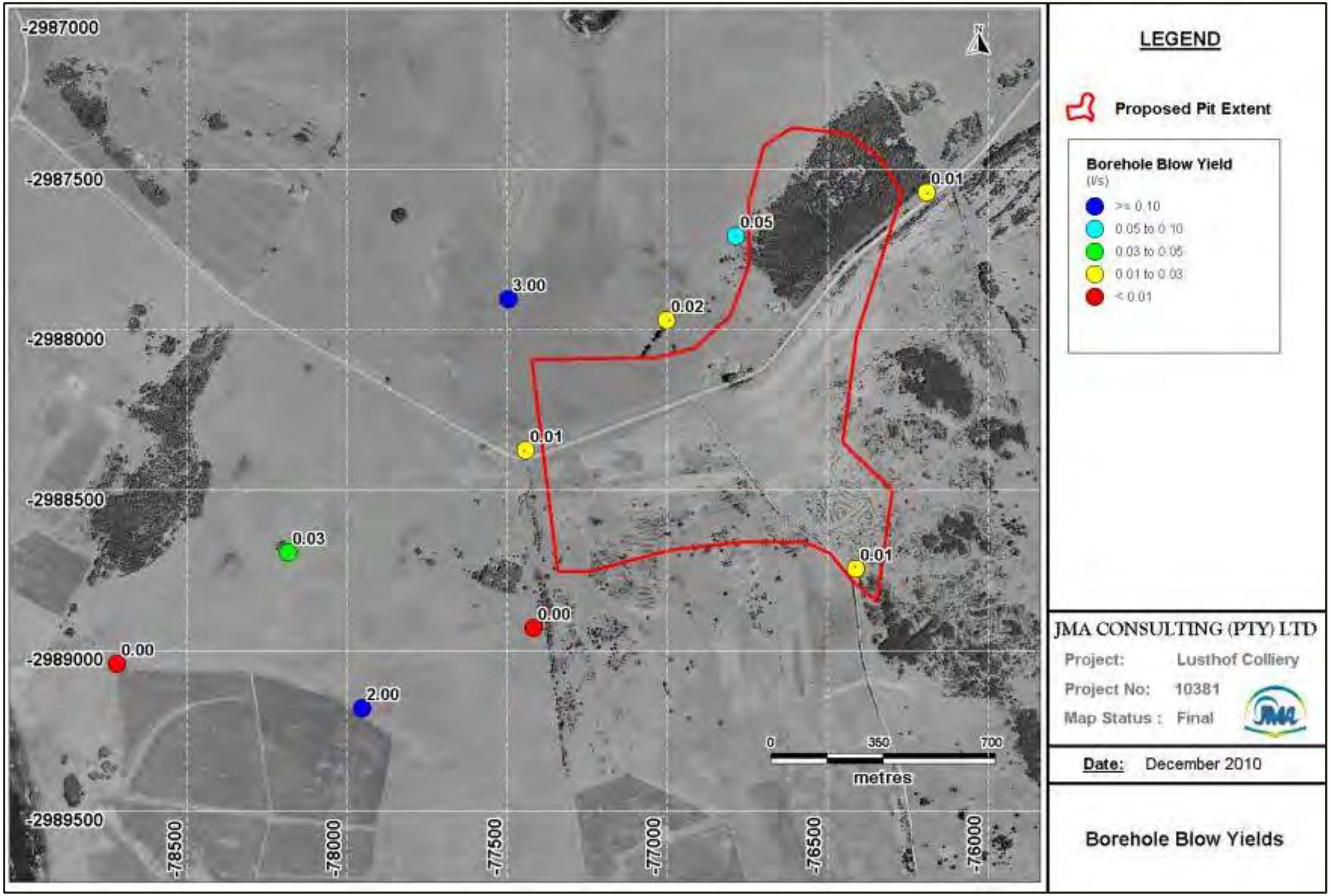


Figure 2.12.3.1 (a): Borehole Blow Yield Distribution

With regards to the borehole blow yield distribution at Lusthof the following is important:

- Borehole blow yields were recorded at 8 of the LGW- ground water monitoring boreholes.
- Boreholes LGW-8 and LGW-10 had no blow yields.
- The recorded borehole blow yields are heterogeneously distributed and vary between 0.01 l/s and 3.00 l/s, with an average yield of 0.6 l/s.
- Boreholes LGW-4 and LGW-9 had blow yields of 3.00 l/s and 2.00 l/s respectively.
- The average yield recorded at Lusthof falls within the stated average yield (0.5 l/s to 2.0 l/s) for the regional geohydrological setting at Lusthof.

2.12.3.2 Aquifer Permeability/Transmissivity

The hydraulic conductivity or permeability (**k**) of an aquifer is a measure of the ease with which ground water can pass through the aquifer system. The permeability is defined as the volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured at perpendicular to the flow direction and is expressed in m/day.

The permeability of the aquifer was determined by analysing the rate of change in the water level of the shallow weathered zone aquifer during the slug tests. Slug tests were carried out at 8 of LGW- boreholes at Lusthof. The data obtained from the slug tests was analysed and the permeabilities of the aquifers adjacent to the boreholes were determined. The calculated aquifer permeabilities are listed in Table 2.12.3.2 (a).

Table 2.12.3.2 (a): Calculated Aquifer Permeability and Transmissivity

Borehole Number	Saturated Thickness (m)	Slug Test k (m/day)	Pump Test k (m/day)	Pump Test T (m^2/day)
LGW-3	11.94	0.018	-	-
LGW-4	20.14	2.080	0.74	14.9
LGW-5	17.02	0.033	0.024	0.41
LGW-6	11.46	0.009	-	-
LGW-7	16.91	0.027	-	-
LGW-8	26.68	0.004	-	-
LGW-9	16.64	3.200	0.86	14.2
LGW-10	16.08	0.007	-	-
Harmonic Mean	**16.05**	**0.01**	**0.07**	**1.16**
Geometric Mean	**16.56**	**0.05**	**0.25**	**4.43**
Arithmetic Mean	**17.11**	**0.67**	**0.54**	**9.84**

Slug tests could not be carried out at boreholes LGW-1 and LGW-2 and the aquifer permeabilities adjacent to these boreholes could thus not be determined. Table 2.6.5.3.2 (a) indicates that 6 of the 8 boreholes tested had permeabilities of below 0.035 m/day, with an average permeability of only 0.016 m/day for these 6 boreholes. Boreholes LGW-4 and LGW-9 however had substantially higher permeability's of 2.08 m/day and 3.20 m/day respectively. The aquifer permeability distribution at Lusthof is indicated on Figure 2.12.3.2 (a).

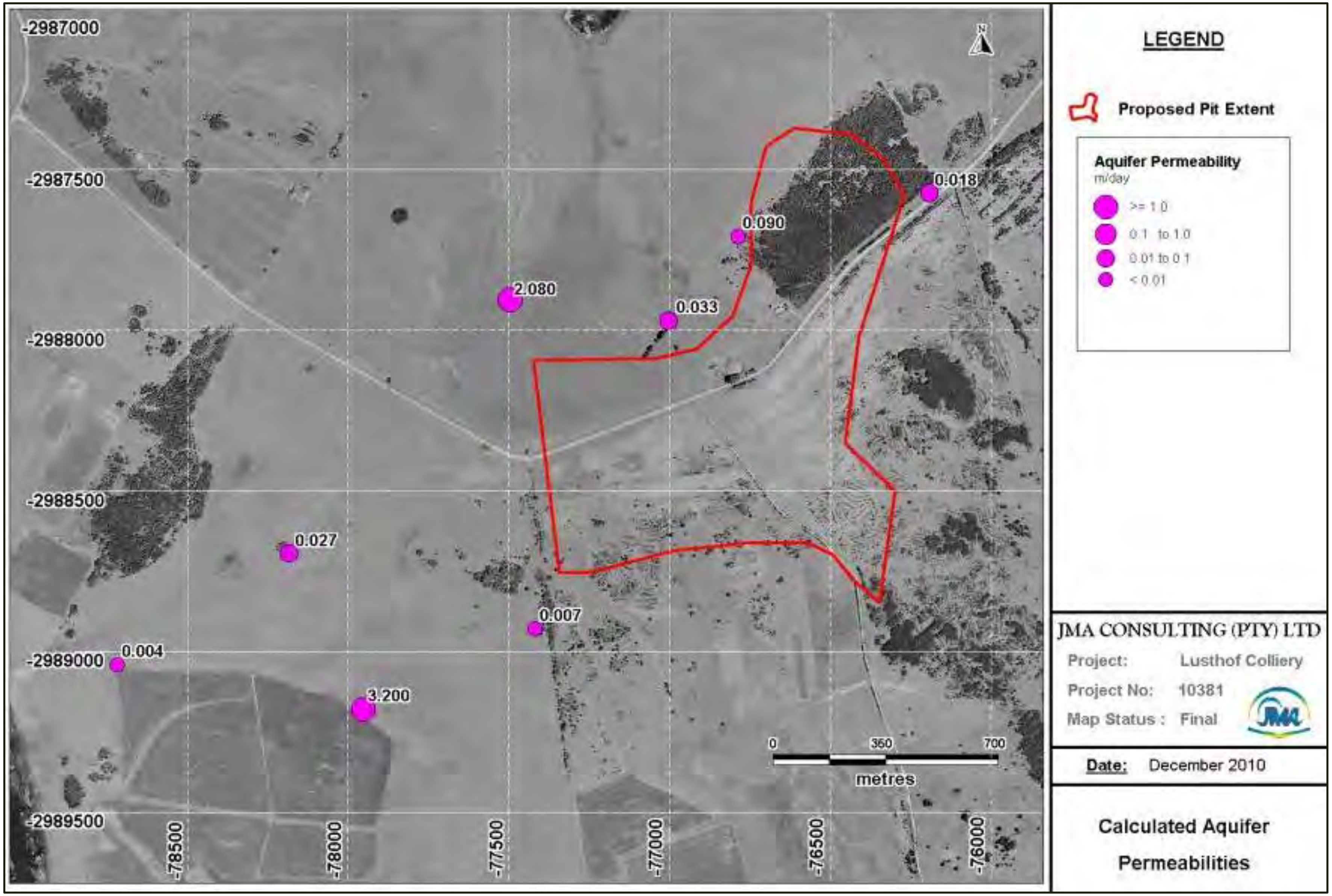


Figure 2.12.3.2 (a): Aquifer Permeability Distribution

The transmissivity (**T**) of an aquifer represents the ground water flow potential through the entire saturated zone. The transmissivity is defined as the rate at which water is passed through a unit width of an aquifer under a unit hydraulic gradient. It is expressed as the product of the average permeability and the thickness of the saturated portion of the aquifer (**D**). The transmissivity is thus calculated as **T=k*D** (m^2/day).

The transmissivity may also be determined by analysing the rate of change in the water level of the shallow weathered zone aquifer during a pump test. The transmissivity values that were calculated from the three constant rate pump tests conducted at Lusthof are listed in Table 2.12.3.2 (a).

Table 2.12.3.2 (a) indicates that the calculated aquifer permeability at borehole LGW-5 is similar for the data used from the slug and pumping tests. The calculated permeability's at boreholes LGW-4 and LGW-9 are however calculated to be an average of three times smaller using the pumping test data as opposed to the slug test data. This may be as a result of the respective size of the aquifer analysed during each of the investigations.

2.12.3.3 Aquifer Storativity

The storativity (S) of an aquifer is defined as the volume of water that an aquifer releases from, or takes into, storage per unit surface area of the aquifer per unit hydraulic gradient.

The storativity of the shallow weathered zone aquifer at Lusthof is taken to be approximately 0.001. The saturated interstice types or storage medium of the aquifer are the interstices and fractures present below the ground water level, as a result of weathering and the weathering related fracturing of the host rock.

2.12.3.4 Aquifer Porosity

The porosity of an aquifer is the ratio of the void space to the total volume of the aquifer. The porosity gives an indication of the amount of water in the subsurface, but does not represent the volume that can be released from, or taken into, storage. The ratio between the volume of water that can be drained from the aquifer and the total volume of the aquifer is referred to as the effective porosity. The effective porosity is the same as the specific yield for the unconfined shallow weathered zone aquifer at Lusthof.

The effective porosity will represent a fraction of the total aquifer porosity, due the influence of the adhesive forces that the particles and host rock exert on the water particles within the aquifer system. The effective porosity is related to the connectivity of the pores and is an important factor in that it governs the specific ground water flow velocities through the aquifer.

In the shallow weathered zone aquifer, the effective porosity will play the most significant role as it will determine the ground water flow velocity. The ground water flow velocity represents the velocity at which advective contaminant transport will take place. Areas of smaller effective porosities will result in greater effective flow velocities through the aquifer.

The effective porosity in the weathered zone aquifers at Lusthof will vary between 0.01 and 0.07, with a bulk probable effective porosity value of 0.05.

2.12.4 Aquifer Dynamics

The term aquifer dynamics refer to all aquifer attributes which are transient in nature and therefore changes with time.

2.12.4.1 Rainfall Recharge

The recharge to the shallow weathered zone aquifer at Lusthof will occur primarily through infiltration of the rain water and surface water bodies. The mean annual recharge (MAR) to the ground water system at Lusthof is estimated to be between 5% and 8% of the MAP and is calculated as between 38 mm and 60 mm per annum.

2.12.4.2 Ground Water Level Depths and Fluctuations

The average depth to the ground water level at Lusthof as recorded at the LGW-boreholes is shallow and varied between 0.00 m (LGW-4) and 5.23 m (LGW-6) below the ground, with an average depth of 2.75 mbs in June 2010. The ground water level depths measured in April 2009 varied between 0.00 m (LGW-4) and 6.96 m (LGW-6) below surface, with an average depth of 3.71 mbs. The recorded ground water level depths recorded in April 2009 and June 2010 are listed in Table 2.12.4.2 (a).

Table 2.12.4.2 (a): Recorded Ground Water Level Depths

BH No.:	Date	Time	Water Level (mbs)	Date	Time	Water Level (mbs)	Change in WL (m)
LGW-1	22/04/2009	17:05	-	08/06/2010	13:35	1.67	**-**
LGW-2	23/04/2009	12:27	5.91	08/06/2010	14:11	-	**-**
LGW-3	23/04/2009	13:30	4.73	07/06/2010	13:10	3.13	**1.60**
LGW-4	23/04/2009	11:27	0.00	08/06/2010	12:45	0.00	**0.00**
LGW-5	22/04/2009	15:38	4.03	07/06/2010	14:00	3.38	**0.65**
LGW-6	22/04/2009	14:05	6.94	07/06/2010	14:50	5.23	**1.71**
LGW-7	23/04/2009	07:58	5.08	09/06/2010	10:40	4.61	**0.47**
LGW-8	23/04/2009	08:52	2.32	09/06/2010	11:20	2.73	**0.41**
LGW-9	23/04/2009	09:37	0.66	09/06/2010	12:00	0.77	**0.11**
LGW-10	23/04/2009	10:30	3.72	08/06/2010	14:40	3.24	**0.48**
Average	**-**	**-**	**3.71**	**-**	**-**	**2.75**	**0.68**

Table 2.12.4.2 (a) indicates that the ground water levels fluctuated by an average of 0.68 meters between April 2009 and June 2010. Borehole LGW-6 had the largest recorded ground water level fluctuation and fluctuated by 1.71 meters. The June 2010 ground water level depth distribution map is indicated in Figure 2.1.4.2(a).

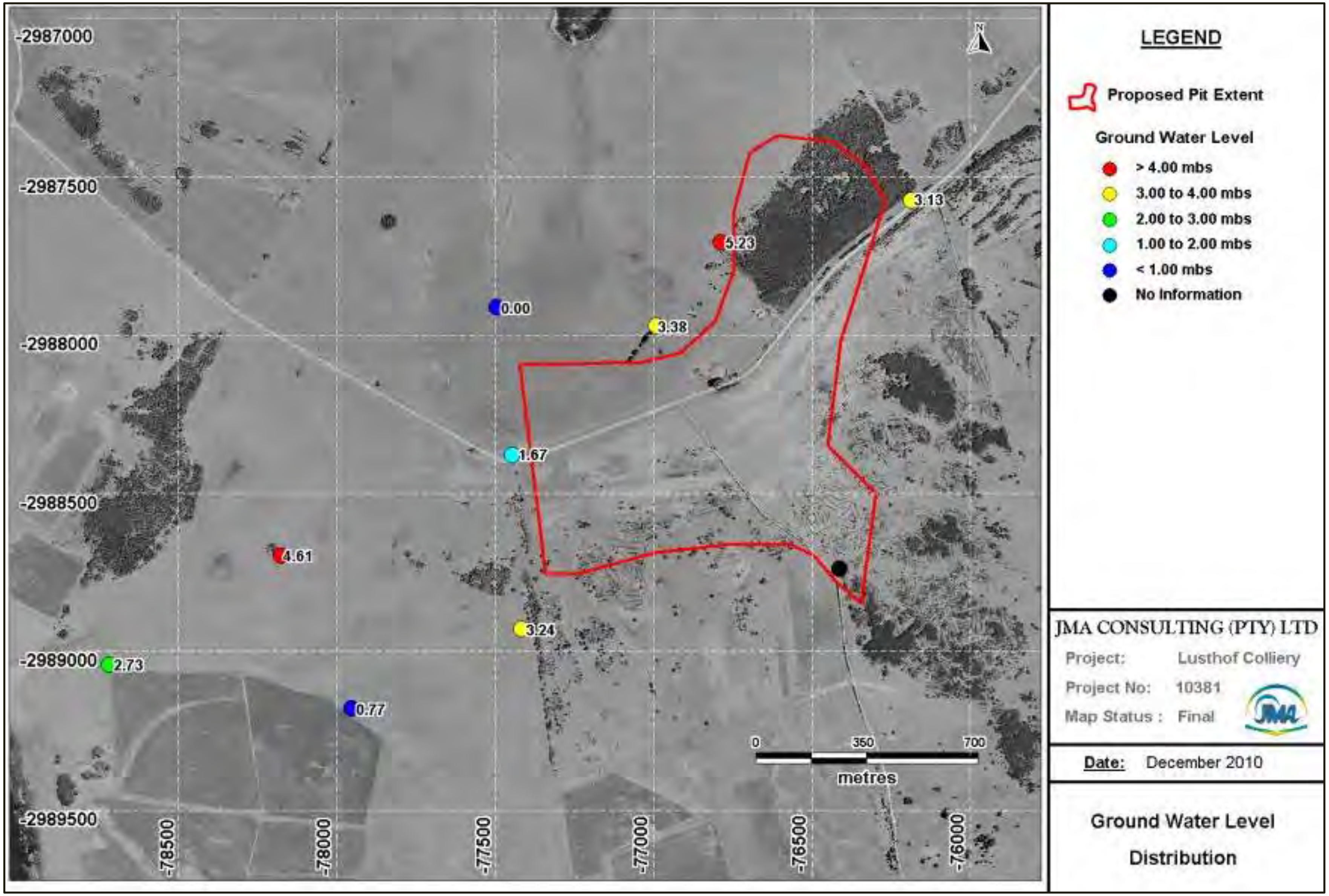


Figure 2.12.4.2 (a): Ground Water Level Depth Distribution

2.12.5 Aquifer Hydrochemistry

The Lusthof site represents a green fields site and any impact at the surface has the potential of affecting the quantity and quality of the underlying ground water resource. It is therefore of vital importance that the current (baseline) ground water quality situation be assessed and comprehensively determined.

2.12.5.1 Background Ground water Quality

A hydrocensus was conducted on Portions 4 and 6 of the Lusthof 60 IT as well as at the adjacent land owners in order to determine the current background ground water quality at Lusthof. During the ground water hydrocensus, 19 boreholes (LC-GW) were identified and are indicated on Figure 2.12.5.1 (a). Photos of each of the boreholes identified during the ground water hydrocensus are included in Table 2.12.5.1 (a).

Table 2.12.5.1 (a): Boreholes Identified during the Hydrocensus

 **LC-GW1**	 **LC-GW2**	 **LC-GW3**	 **LC-GW4**
 **LC-GW5**	 **LC-GW6**	 **LC-GW7**	 **LC-GW8**
 **LC-GW9**	 **LC-GW10**	 **LC-GW11**	 **LC-GW12**
 **LC-GW13**	 **LC-GW14**	 **LC-GW15**	 **LC-GW16**
 **LC-GW17**	 **LC-GW18**	 **LC-GW19**	

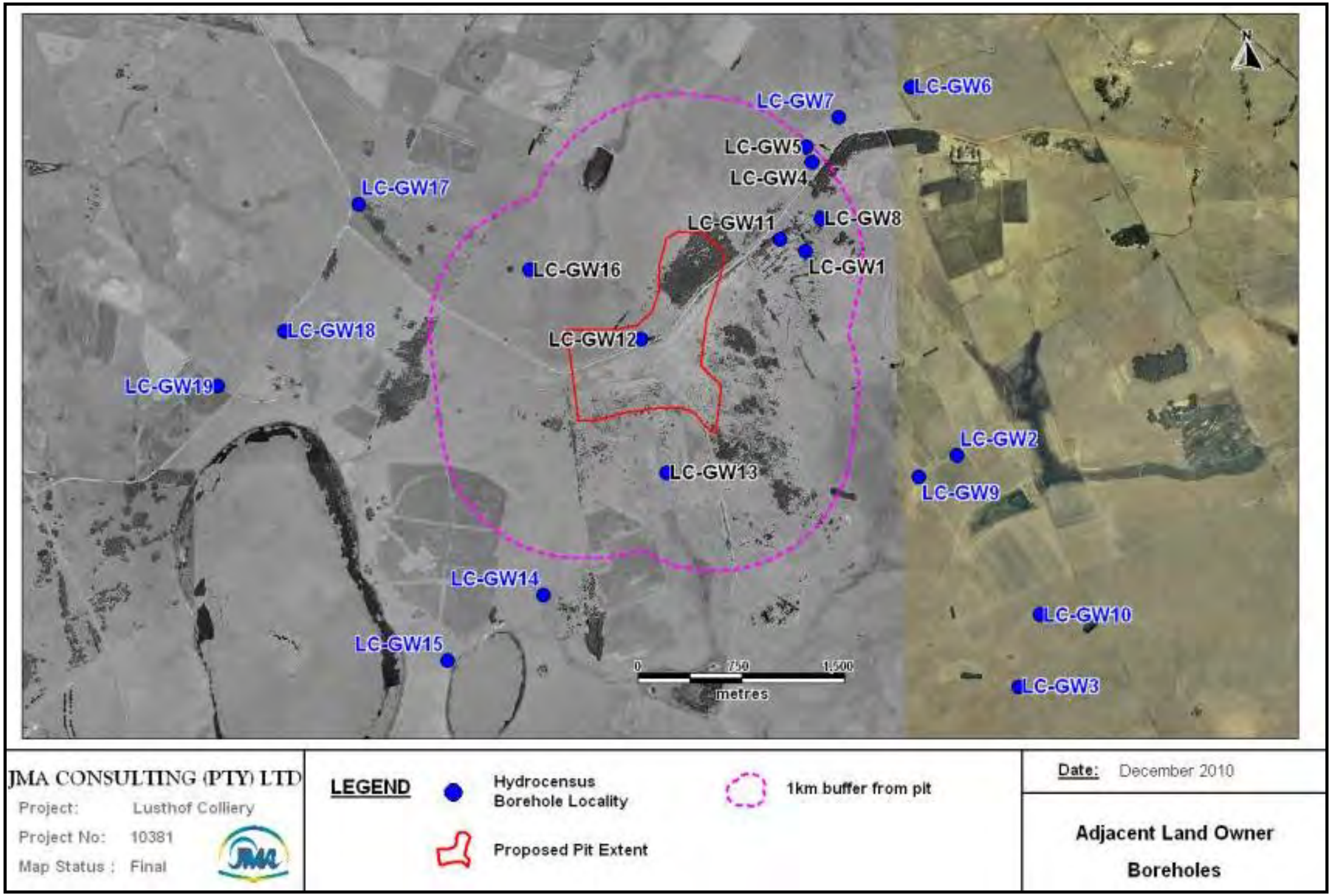


Figure 2.12.5.1 (a): Boreholes Identified during the Hydrocensus

Eight (8) of the boreholes identified during the hydrocensus are situated within a 1 km radius of the proposed pit boundary and are labelled in black on Figure 2.12.5.1 (a). The eleven (11) boreholes labelled in blue on Figure 2.12.5.1(a) are located further than 1 km from the proposed pit boundary.

Information regarding the land owner, borehole depth, collar height, casing type, depth of casing, casing diameter, ground water abstraction volumes, ground water use and type of equipment installed etc. was obtained for each of the boreholes where available. The information obtained in the field during the ground water hydrocensus is recorded on the hydrocensus field forms attached as Appendix 8 (A) to the Specialist Ground Water Baseline report.

Ground water was sampled from 13 of the 19 LC-GW boreholes and were analysed for the following water quality variables: **pH, EC, TDS, T.Alk, NH_4, Ca, Cl, Mg, NO_3, K, Na, Si, SO_4, Al, Sb, As, B, Cd, Cr(T), Cr^{6+}, Co, Cu, F, Fe, Pb, Mn, Hg, Se, V and Zn.**

The 13 boreholes that were sampled during the hydrocensus are located on Figure 2.6.5.5.1 (b). The ground water quality variable concentrations determined for each of the 13 sampled boreholes are listed in Table 2.12.5.1 (b).

A ground water reserve, stipulating the ground water quality and quantity compliance values, has currently not been determined for the quaternary catchment. The background ground water quality recorded was therefore assessed against the SANS 241:2006 Drinking Water Standard. The assessment was made with reference to the SANS 241:2006 Drinking Water Standard as it has a comprehensive list of variables against which an assessment could be made.

The SANS 241:2006 Drinking Water Standard gives an indication of the "fitness of use" of the water if consumed by human beings. If the water is deemed "fit for human consumption" it is expected that the water is fit for livestock and irrigation purposes as well.

Variable concentrations in the ground water that fall within Class I of the SANS 241:2006 Drinking Water Standard are indicated in **Green** in Table 2.12.5.1 (b) and are classified having concentrations that are "**Fully Compliant**" with regards to the SANS 241:2006 Drinking Water Standard.

Variable concentrations that fall within Class II are indicated in **Orange** in Table 2.12.5.1 (b) and are classified as having concentrations that are "**Marginally Compliant**" with regards to the SANS 241:2006 Drinking Water Standard.

Variable concentrations that exceed Class II are indicated in **Red** in Table 2.12.5.1 (b) and are classified as having concentrations that are "**Non-Compliant**" with regards to the SANS 241:2006 Drinking Water Standard.

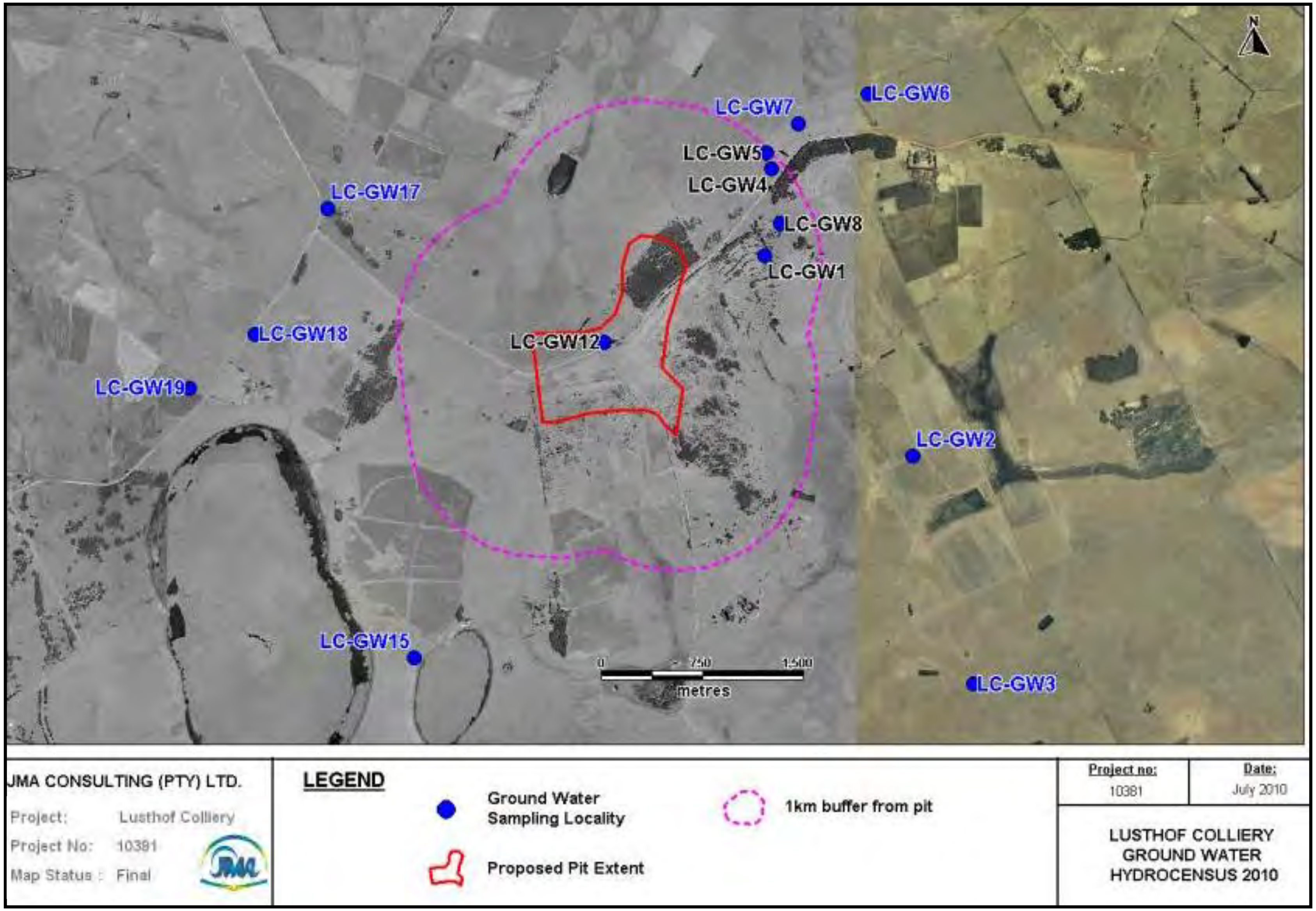


Figure 2.12.5.1 (b): Hydrocensus Ground Water Sampling Localities

Table 2.12.5.1 (b): Background Ground Water Quality Compliance Assessment: SANS 241:2006 Drinking Water Standard

BH No.		LC – GW 1	LC – GW 2	LC – GW 3	LC – GW 4	LC – GW 5	LC – GW 6	LC – GW 7	LC – GW 8	LC - GW 12	LC - GW 15	LC - GW 17	LC - GW 18	LC - GW 19
pH		7.45	4.21	7.47	7.21	6.17	7.23	6.02	6.69	6.39	7.36	6.71	7.12	6.70
EC	mS/m	16.7	11.2	22.1	8.22	3.11	8.22	8.11	19.4	44.2	25.5	5.15	27.4	38.7
TDS	mg/l	82.4	53.9	97.2	39.9	15.6	41.2	42.0	94.3	275	146	28.2	159	197
Ca	mg/l	15.6	2.47	12.4	4.57	1.27	5.71	1.66	14.3	35.9	19.8	2.89	26.2	31.2
Mg	mg/l	4.89	2.11	6.54	2.46	0.860	2.81	0.978	8.97	20.9	13.5	1.93	8.34	10.5
Na	mg/l	5.78	6.56	2.85	5.57	2.45	4.75	11.9	5.53	13.9	16.1	4.44	21.3	23.3
K	mg/l	4.75	3.83	7.94	4.39	2.01	3.55	1.66	5.99	6.93	2.22	2.56	2.07	4.66
Si	mg/l	9.96	12.9	1.73	16.0	9.49	2.54	2.78	8.47	16.6	15.4	11.4	17.9	13.3
T.Alk	mg/l	75.1	Nil	92.2	39.8	15.1	39.4	9.66	70.5	34.8	117	26.3	139	71.7
F	mg/l	0.147	0.116	0.084	0.106	0.017	0.019	0.078	0.049	0.527	0.416	0.399	0.478	0.364
Cl	mg/l	6.88	4.85	7.34	1.40	1.18	3.65	19.8	9.54	3.36	16.2	1.45	4.05	58.2
SO_4	mg/l	1.90	12.4	1.04	1.30	0.360	0.380	1.48	13.5	179	5.53	0.930	15.6	10.7
NO_3	mg/l	0.170	5.56	0.280	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.920	<0.01	0.015	4.45
NH_4	mg/l	0.480	0.060	6.68	<0.01	0.096	<0.01	0.089	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Al	mg/l	<0.01	0.110	0.028	0.025	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.028
As	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
B	mg/l	<0.01	<0.01	<0.01	0.070	0.050	0.060	0.060	0.060	0.060	0.060	0.060	0.070	0.050
Cd	mg/l	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cr(T)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Co	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fe	mg/l	0.150	0.240	0.090	0.018	0.128	0.082	0.013	0.015	0.578	0.012	0.102	<0.01	0.131
Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mn	mg/l	0.440	0.090	1.55	<0.01	0.036	0.121	0.064	<0.01	0.234	0.033	0.057	0.025	<0.01
Pb	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sb	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Se	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
V	mg/l	0.012	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zn	mg/l	<0.01	0.059	0.038	0.452	0.040	<0.01	0.135	0.014	<0.01	<0.01	0.112	<0.01	0.038

Table 2.12.5.1 (b) indicates that 7 of the 13 boreholes sampled during the hydrocensus had ground water qualities that were fully compliant with regards to the SANS 241:2006 Drinking Water Standard. 5 of the ground water samples had one or two parameters that were slightly elevated to a marginally compliant quality with regards to the SANS 241:2006 Drinking Water Standard. Only borehole LC-GW3 had parameters that were classified as having a non-compliant quality with regards to the SANS 241:2006 Drinking Water Standard.

The parameters that were elevated with regards to the SANS 241:2006 Drinking Water Standard included NH_4 and Mn, which had concentrations of 6.68 mg/l and 1.55 mg/l respectively. Mn occurred at marginally compliant concentrations in 3 additional samples as well, whilst the NH_4 concentrations had fully compliant concentrations for all the other ground water samples. The other parameters that had marginally compliant ground water qualities were Fe, and Zn which were only elevated in or two of the ground water sampled collected.

It is known that the conservation of the aquatic ecosystems at Lusthof is of vital importance and an assessment of the background ground water quality was made with regards to the concentrations stipulated in South African Water Quality Guidelines: Aquatic Ecosystems (Volume 7) document. This Aquatic Ecosystems Standard had only 9 stipulated variables against which an assessment could be made. These are namely: **F, NH_4, Al, Cu, Hg, Mn, Pb, Se and Zn.** The ground water quality compliance assessment with regards to the Aquatic Ecosystems Guideline is indicated in Table 2.12.5.1 (c).

Table 2.12.5.1 (c): Background Ground Water Quality Compliance Assessment (South African Water Quality Guidelines: Aquatic Ecosystems)

BH No.	F (mg/l)	NH_4 (mg/l)	Al (mg/l)	Cu (mg/l)	Hg (mg/l)	Mn (mg/l)	Pb (mg/l)	Se (mg/l)	Zn (mg/l)
LC - GW1	0.147	0.48	<0.01	<0.01	<0.001	0.44	<0.01	<0.005	<0.01
LC - GW2	0.116	0.06	0.11	<0.01	<0.001	0.09	<0.01	<0.005	0.059
LC - GW3	0.084	6.68	0.028	<0.01	<0.001	1.55	<0.01	<0.005	0.038
LC - GW 4	0.106	<0.01	0.025	<0.01	<0.001	<0.01	<0.01	<0.005	0.452
LC - GW 5	0.017	0.096	<0.01	<0.01	<0.001	0.036	<0.01	<0.005	0.04
LC - GW 6	0.019	<0.01	<0.01	<0.01	<0.001	0.121	<0.01	<0.005	<0.01
LC - GW 7	0.078	0.089	<0.01	<0.01	<0.001	0.064	<0.01	<0.005	0.135
LC - GW 8	0.049	<0.01	<0.01	<0.01	<0.001	<0.01	<0.01	<0.005	0.014
LC - GW 12	0.527	<0.01	<0.01	<0.01	<0.001	0.234	<0.01	<0.005	<0.01
LC - GW 15	0.416	<0.01	<0.01	<0.01	<0.001	0.033	<0.01	<0.005	<0.01
LC - GW 17	0.399	<0.01	<0.01	<0.01	<0.001	0.057	<0.01	<0.005	0.112
LC - GW 18	0.478	<0.01	<0.01	<0.01	<0.001	0.025	<0.01	<0.005	<0.01
LC - GW 19	0.364	<0.01	0.028	<0.01	<0.001	<0.01	<0.01	<0.005	0.038

The Aquatic Ecosystem Guidelines specify two values against which the assessment was made. The first is the Chronic Effect Value (CEV) and the second is the Acute Effect Value (AEV). The Chronic Effect Value is defined as the concentration of the variable at which there is expected to be a significant probability of measurable chronic effects to up to 5% of the species in the aquatic community.

The Acute Effect Value is defined as the concentration of the variable above which there is expected to be a significant probability of acute toxic effects to up to 5% of the species in the aquatic community.

Variable concentrations in the ground water which are lower than the CEV values are indicated in **Green** in Table 2.12.5.1 (c) and are classified having concentrations that are "**Fully Compliant**" with regards to the South African Water Quality Guidelines: Aquatic Ecosystems (Volume 7) concentrations.

Variable concentrations in the ground water that fall between the CEV and AEV values are indicated in **Orange** in Table 2.12.5.1 (c) and are classified as having concentrations that are "**Marginally Compliant**" with regards to the South African Water Quality Guidelines: Aquatic Ecosystems (Volume 7) concentrations.

Variable concentrations in the ground water which are higher than the AEV values are indicated in **Red** in Table 2.12.5.1 (c) and are classified as having concentrations that are "**Non-Compliant**" with regards to the South African Water Quality Guidelines: Aquatic Ecosystems (Volume 7) concentrations.

Table 2.12.5.1 (c) indicates that the variables NH_4, Al, Mn and Zn have concentrations in the background ground water that are classified as having non-compliant concentrations with regards to the Aquatic Ecosystem Standards. Zn is the most elevated variable and has non-compliant concentrations in the ground water from 7 of the 13 boreholes sampled.

The ground water sampled from only 4 of the 13 boreholes had qualities that were fully compliant with regards to the Aquatic Ecosystems concentrations. These were namely LC-GW6, LC-GW12, LC-GW15 and LC-GW18. The ground water sampled from borehole LC-GW3 on the other hand had non-compliant concentrations for 3 of the variables assessed (NH_4, Mn and Zn) as well as 1 marginally compliant variable concentration (Al).

The chemistry of the ground water sampled during the hydrocensus was statistically analysed and is summarized in Table 2.12.5.1 (d). Table 2.12.5.1 (d) indicates the minimum and maximum concentrations for each variable analysed for, as well as the Standard Deviation (SD) for that variable.

Table 2.12.5.1 (d): Background Ground Water Quality Summary

Variable		Minimum	Maximum	1 SD	1 SD + Max
pH		4.21	7.47	0.88	**8.35**
EC	mS/m	3.11	44.20	12.91	**57.11**
TDS	mg/l	15.60	275.00	76.79	**351.79**
Ca	mg/l	1.27	35.90	11.86	**47.76**
Mg	mg/l	0.86	20.90	5.89	**26.79**
Na	mg/l	2.45	23.30	7.04	**30.34**
K	mg/l	1.66	7.94	2.00	**9.94**
Si	mg/l	1.73	17.90	5.52	**23.42**
T.Alk	mg/l	0.00	139.00	42.39	**181.39**
F	mg/l	0.02	0.53	0.19	**0.72**
Cl	mg/l	1.18	58.20	15.39	**73.59**
SO_4	mg/l	0.36	179.00	48.47	**227.47**
NO_3	mg/l	0.01	5.56	1.86	**7.42**
NH_4	mg/l	0.01	6.68	1.91	**8.59**
Al	mg/l	0.01	0.11	0.03	**0.14**
As	mg/l	0.01	0.01	0.00	**0.01**
B	mg/l	0.01	0.07	0.02	**0.09**
Cd	mg/l	0.00	0.00	0.00	**0.00**
Cr(T)	mg/l	0.01	0.01	0.00	**0.01**
CR^{6+}	mg/l	0.01	0.01	0.00	**0.01**
Co	mg/l	0.01	0.01	0.00	**0.01**
Cu	mg/l	0.01	0.01	0.00	**0.01**
Fe	mg/l	0.01	0.58	0.15	**0.73**
Hg	mg/l	0.00	0.00	0.00	**0.00**
Mn	mg/l	0.01	1.55	0.42	**1.97**
Pb	mg/l	0.01	0.01	0.00	**0.01**
Sb	mg/l	0.01	0.01	0.00	**0.01**
Se	mg/l	0.01	0.01	0.00	**0.01**
V	mg/l	0.01	0.01	0.00	**0.01**
Zn	mg/l	0.01	0.45	0.12	**0.57**

The background ground water quality in the study area was calculated for each variable analysed by adding the Standard Deviation (SD) to the maximum recorded value for that variable.

Hydrochemical imaging of the background ground water samples at Lusthof was performed during which Piper and Durov Diagrams were compiled. The resulting Piper and Durov Diagrams are indicated as Figures 2.12.5.1 (c) and 2.12.5.1 (d) respectively and were compiled using the macro chemistry variables pH, EC, Ca, Mg, Na, K, Total Alkalinity, Cl, SO_4 and NO_3.

The background ground water at Lusthof has a scattered hydrochemical image, although the majority of the ground water samples are classified as having a Type-B hydrochemical facies, with dominant cations Ca^{2+} and/or Mg^{2+} and dominant anion HCO_3^-.

Two of the ground water samples (LC-GW12 and LC-GW19) had Type-A hydrochemical facies, with dominant cations Ca^{2+} and/or Mg^{2+} and dominant anions Cl^- and/or SO_4^{2-}.

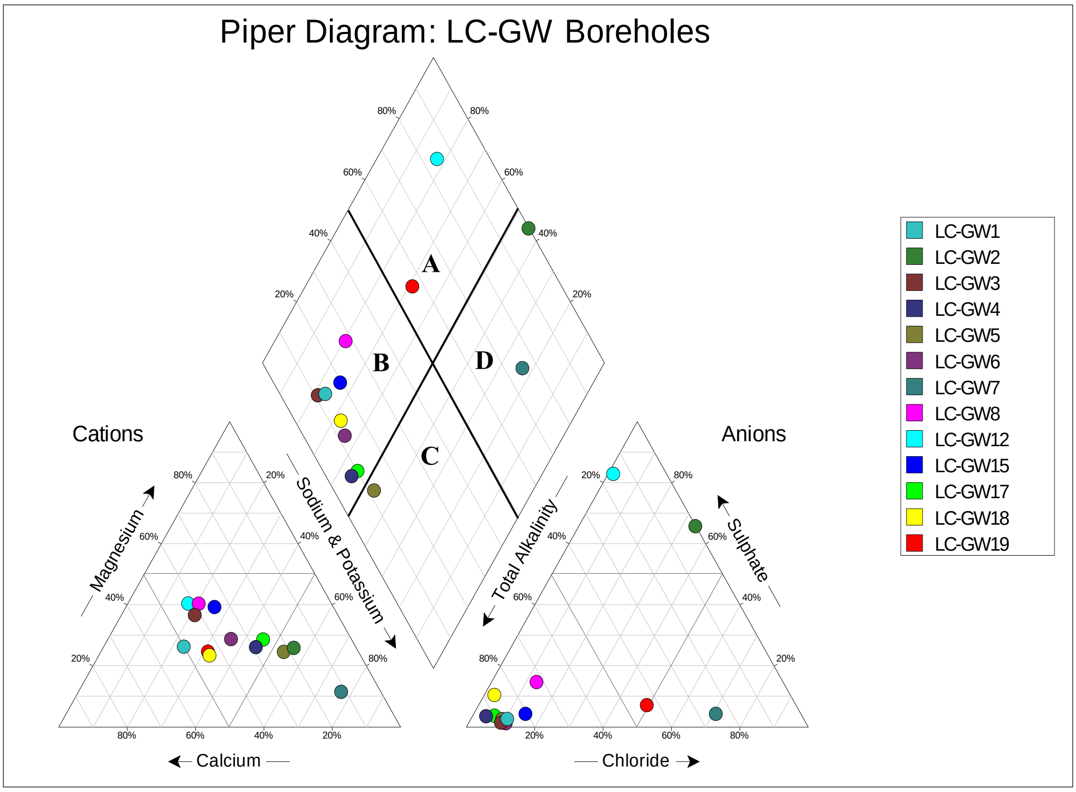


Figure 2.12.5.1 (c): Background Ground Water Quality – Piper Diagram

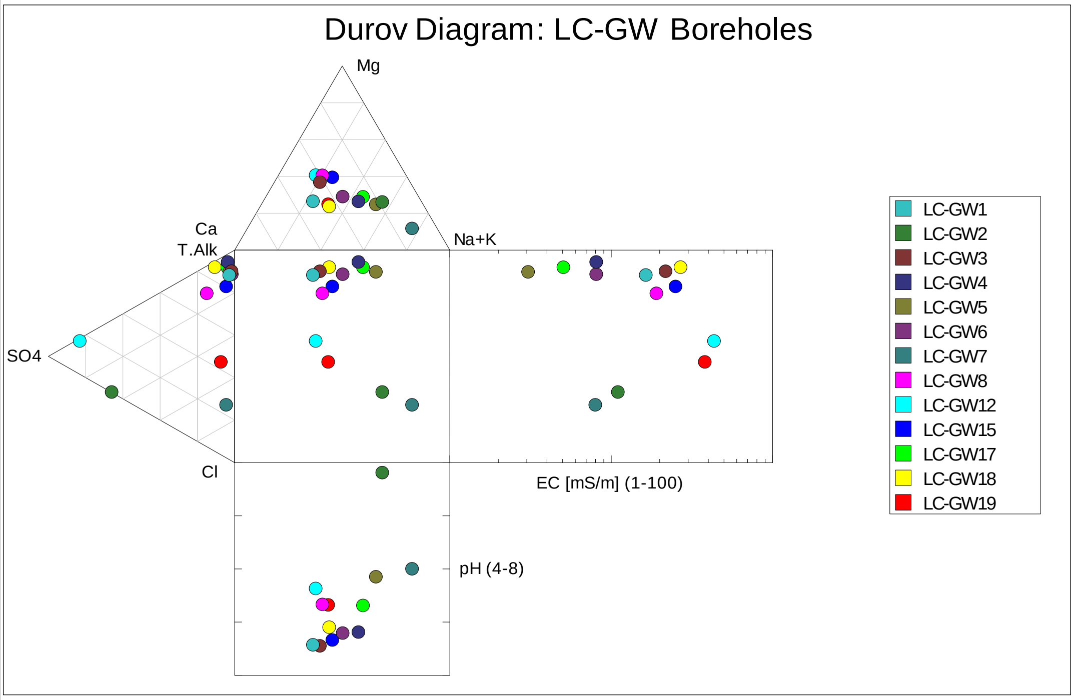


Figure 2.12.5.1 (d): Background Ground Water Quality – Durov Diagram

One ground water sample (LC-GW5) had a Type-C hydrochemical image, with dominant cations Na^+ and/or K^+ and dominant anion HCO_3^-.

The ground water sampled at boreholes LC-GW2 and LC-GW7 had a Type-D hydrochemical image, with dominant cations Na^+ and/or K^+ and dominant anions Cl^- and/or SO_4^{2-}.

The Piper Diagram indicates that the ground water sampled from boreholes LC-GW12 and LC-GW2 had elevated equivalent SO_4 concentrations as opposed to the rest of the background ground water samples. The Piper Diagram further illustrates that the ground water sampled from boreholes LC-GW19 and LC-GW9 had elevated equivalent Cl^- concentrations with regards to the rest of the background ground water samples.

2.12.5.2 Surface Impacts on the Ground Water System

The current land use on Portions 4 and 6 of farm Lusthof 60 IT entails livestock agricultural activities. There are currently no mining operations within the study area and any potential surface impact on the ground water system would have resulted from the current or previous agricultural activities.

10 deep ground water monitoring boreholes were drilled on Portions 4 and 6 of Lusthof 60 IT, in order to assess the ground water quality and verify whether there are any surface induced impacts on the ground water system or not. Ground water samples were taken from 8 of the ground water monitoring boreholes and were analysed for the following parameters: **pH, EC, TDS, T.Alk, NH_4, Ca, Cl, Mg, NO_3, PO_4, K, Na, Si, SO_4, Al, Sb, As, B, Cd, Cr(T), Cr^{6+}, Co, Cu, F, Fe, Pb, Mn, Hg, Se, V and Zn.**

The quality of the ground water sampled from the monitoring boreholes was assessed against the SANS 241:2006 Drinking Water Standard and is listed in Table 2.12.5.2(a).

Variable concentrations in the ground water that fall within Class I of the SANS 241:2006 Drinking Water Standard are indicated in **Green** in Table 2.12.5.2 (a) and are classified having concentrations that are "**Fully Compliant**" with regards to the SANS 241:2006 Drinking Water Standard.

Variable concentrations that fall within Class II are indicated in **Orange** in Table 2.12.5.2 (a) and are classified as having concentrations that are "**Marginally Compliant**" with regards to the SANS 241:2006 Drinking Water Standard.

Variable concentrations that exceed Class II are indicated in **Red** in Table 2.12.5.2 (a) and are classified as having concentrations that are "**Non-Compliant**" with regards to the SANS 241:2006 Drinking Water Standard.

Table 2.12.5.2 (a): LGW Ground Water Quality Compliance Assessment
(SANS 241:2006 Drinking Water Standard)

BH No.		LGW-3	LGW-4	LGW-5	LGW-6	LGW-7	LGW-8	LGW-9	LGW-10
pH		7.05	7.11	6.98	6.12	7.89	7.16	7.38	7.16
EC	(mS/m)	6.72	10.90	9.98	8.13	15.00	5.73	16.40	18.00
TDS	(mg/L)	33.5	54.3	48.5	48.6	78.1	29.6	82.9	94.0
T.Alk	(mg/L)	29.3	51.0	40.3	17.2	76.4	20.1	76.8	92.3
NH_4	(mg/L)	0.260	0.010	0.010	0.060	0.020	0.010	0.010	0.010
Ca	(mg/L)	3.93	8.79	6.20	0.10	14.40	2.35	10.20	15.40
Cl	(mg/L)	3.30	1.74	7.10	6.14	2.83	5.84	6.67	2.45
Mg	(mg/L)	2.58	2.92	3.02	0.01	5.02	1.28	4.79	7.44
NO_3	(mg/L)	0.190	0.240	0.140	0.350	0.180	0.160	0.200	0.150
PO_4	(mg/L)	<0.01	<0.01	<0.01	<0.01	0.070	<0.01	<0.01	0.57
K	(mg/L)	1.21	3.17	2.71	1.28	1.98	1.76	4.96	2.39
Na	(mg/L)	4.06	6.76	6.67	17.00	8.53	6.80	13.50	9.72
Si	(mg/L)	1.31	15.70	6.31	<0.01	4.01	0.14	4.53	6.50
SO_4	(mg/L)	0.33	1.86	0.19	13.00	0.01	0.17	0.07	0.56
Al	(mg/L)	0.12	0.11	0.10	0.09	0.10	0.10	0.11	0.14
Sb	(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
As	(mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
B	(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cd	(mg/L)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cr(T)	(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cr^{6+}	(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Co	(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu	(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
F	(mg/L)	0.038	0.089	0.100	0.021	0.056	0.135	0.329	0.181
Fe	(mg/L)	0.14	0.25	0.15	0.17	0.21	0.09	0.16	0.21
Pb	(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mn	(mg/L)	0.17	0.02	0.09	0.07	0.04	0.03	0.06	0.09
Hg	(mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	(mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
V	(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zn	(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 2.12.5.2 (a) indicates that the ground water sampled from each of the boreholes has a quality that is fully compliant with regards to the SANS 241:2006 Drinking Water Standard, baring iron (Fe) and manganese (Mn).

Mn is slightly elevated in one borehole sample (LGW-3) and has a Mn concentration that is marginally compliant with regards to the SANS 241 Standard. Fe is slightly elevated in 3 borehole samples (LGW-4, LGW-7 and LGW-10) with concentrations of 0.25, 0.21 and 0.21 mg/l respectively.

It is evident from Table 2.12.5.2 (a) that there is currently no impact on the ground water quality at Lusthof as a result of surface induced activities.

Hydrochemical imaging of ground water sampled from the monitoring boreholes was performed during which Piper and Durov Diagrams were compiled. The resulting Piper and Durov Diagrams are indicated as Figures 2.12.5.2 (a) and 2.12.5.2 (b) respectively.

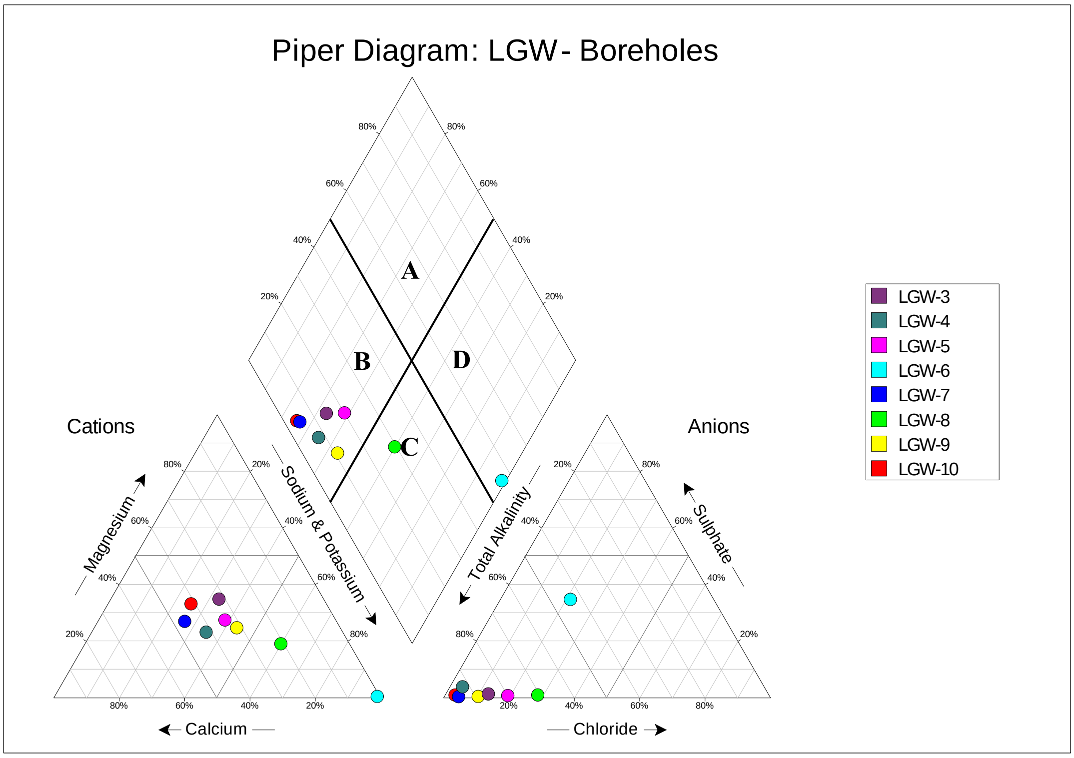


Figure 2.12.5.2 (a): Background Ground Water Quality – Piper Diagram

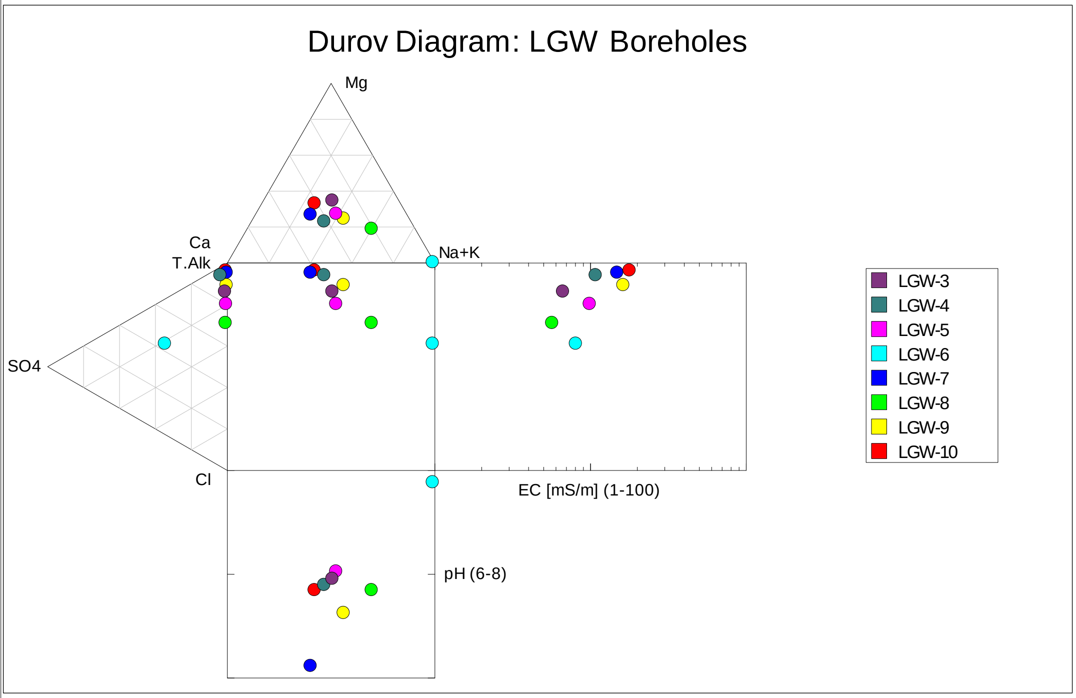


Figure 2.12.5.2 (b): Background Ground Water Quality – Durov Diagram

The ground water sampled from the LGW- boreholes has a predominantly Type B hydrochemical facie signature, (similar to that observed for the background ground water) with dominant cations Ca^{2+} and/or Mg^{2+} and dominant anion HCO_3^-.

The ground water sampled from LGW-8 had a Type C hydrochemical facies signature, with dominant cations Na^+ and/or K^+ and dominant anion HCO_3^-.

The ground water sampled from borehole LGW-6 had an elevated sulphate concentration and was classified as having a Type D hydrochemical facies signature, with Na^+ and/or K^+ and dominant anion SO_4^{2-}.

The concentrations of the variables recorded in the ground water are lower than the calculated background ground water quality (1 SD + Max variable concentration) determined at Lusthof.

The hydro-chemical information and quality of the ground water sampled from the monitoring boreholes is similar to that of the background ground water quality and indicates that there is currently no contamination of the ground water as a result of the surface activities on Portions 4 and 6 of Lusthof 60 IT.

2.12.6 Aquifer Classification

The aquifer classification is done in accordance with the formal DWAF "**South African Aquifer System Management Classification, December 1995**" protocol. Special aquifer attributes related to certain structural features (such as along dyke/fault contact zones, or karst development) have been incorporated into the classification through the "Second Variable Classification".

The aquifer classification at Lusthof is done in accordance with the following definitions of the 4 Aquifer System Management Classes:

Sole Aquifer System:

An aquifer which is used to supply 50 per cent or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.

Major Aquifer System:

Highly permeable formations, usually with a known, or probable, presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (less than 150 mS/m Electrical Conductivity).

Minor Aquifer System:

These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers.

Non-Aquifer System:

These are formations with negligible permeability that are regarded as not containing ground water in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, ground water flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Aquifer System Management Classifications

Aquifer System Management Classification		
Class	**Points**	**Shallow Weathered Zone Aquifer**
Sole Source Aquifer System:	6	-
Major Aquifer System:	4	-
Minor Aquifer System:	2	2
Non-Aquifer System:	0	-
Special Aquifer System:	0 – 6	-

The shallow weathered zone aquifer at Lusthof is classified as a Minor Aquifer System due to its low permeability and limited use for abstraction. The shallow weathered zone aquifer system is therefore assigned 2 points, according to the Aquifer System Management Classification.

Second Variable Classifications

Second Variable Classification		
Class	**Points**	**Shallow Weathered Zone Aquifer**
High:	3	-
Medium:	2	-
Low:	1	-

There are no special structural aquifer attributes at Lusthof associated with the Second Variable Classification of the shallow weathered zone aquifers. The total points assigned to the shallow weathered zone aquifer system at Lusthof therefore remains 2.

Aquifer Vulnerability

The ground water quality management classification is made with regards to the aquifer vulnerability.

Aquifer Vulnerability Classification

Aquifer Vulnerability Classification		
Class	**Points**	**Shallow Weathered Zone Aquifer**
High:	3	3
Medium:	2	-
Low:	1	-

Shallow weathered zone aquifer are highly vulnerable to surface induced impacts and Under pristine conditions, the vulnerability, tendency or likelihood for contamination to reach a specified position in the ground water system at Lusthof after introduction at some location above the uppermost aquifer, in terms of the above, is classified as high and is given a point rating of 3.

The indicated level of ground water protection is derived from the Ground Water Quality Management Index (GQM Index) and is calculated as follows:

GQM Index = Aquifer System Management x Aquifer Vulnerability Classification
= 2 x 3
= 6

The GQM Index is used to determine that level of ground water protection that is required for the shallow weathered zone aquifer systems present at Lusthof. The level of ground water protection of the shallow weathered zone aquifer at Lusthof is tabulated below:

Indicated Level of Ground Water Protection

GQM Index	Level of Protection	Shallow Weathered Zone Aquifer
< 1	Limited	-
1 - 3	Low Level	-
3 – 6	Medium Level	6
6 – 10	High Level	-
> 10	Strictly Non-Degradation	-

Aquifer Protection Classification

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a **Ground Water Quality Management Index of 6** for the shallow weathered zone aquifer systems at Lusthof, indicating that **MEDIUM level ground water protection** is required.

2.12.7 Ground Water Use

The ground water use in the study area was determined during the ground water hydrocensus conducted on Portions 4 and 6 of Lusthof 60 IT during June and July 2010. A map of the boreholes identified during the ground water hydrocensus is displayed as Figure 2.12.7 (a).

19 boreholes were identified during the ground water hydrocensus. Only 6 of the 19 boreholes were currently in use at the time of the hydrocensus investigation. The boreholes that were in use are namely: LC-GW2, LC-GW4, LC-GW8, LC-GW12, LC-GW17 and LC-GW18.

3 of the boreholes currently in use fall within 1 km of the proposed pit extent. Borehole LC-GW12 in fact falls within the proposed pit extent and will be destroyed during the mining operations at Lusthof. The locations of the boreholes in use, observed during the 2010 Hydrocensus are located on Figure 2.12.7 (a).

The ground water abstracted at the 6 abovementioned boreholes is used for either livestock, irrigation of domestic purposes. 4 of the boreholes are used to provide a source of water for domestic use, 2 of which are solely used to provide water for domestic use. 1 borehole is used to supply water for irrigational purposes only and 3 boreholes are used to provide water for livestock. The 13 boreholes that are currently not in use were initially used as water supply boreholes for livestock, irrigation and domestic use as well.

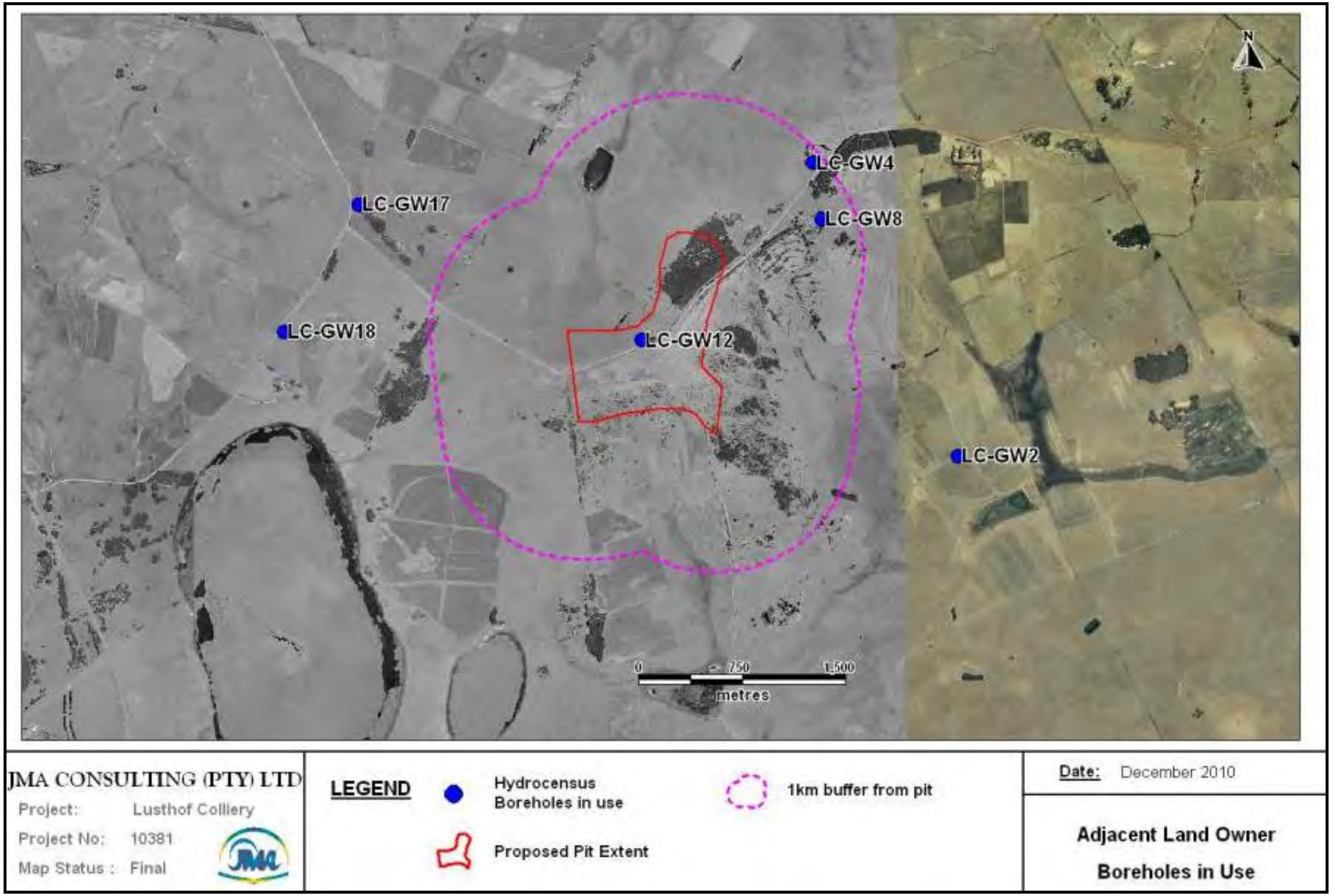


Figure 2.12.7 (a): Hydrocensus (LC-GW) Boreholes Currently in Use

Due to the agricultural surface activities adjacent to Portions 4 and 6 of Lusthof 60 IT, it is expected that ground water will continue to be abstracted and used as an additional water supply for irrigation, livestock and domestic use.

Due to the low permeabilities of the shallow weathered zone aquifer and low probability of drilling boreholes with yields in excess of 2 l/s the abstraction of ground water on and adjacent to Portions 4 and 6 of Lusthof 60 IT is limited. No large scale ground water abstraction is expected on and adjacent to Portions 4 and 6 of Lusthof 60 IT in the future

2.12.8 The Ground Water Reserve

The Ground Water Reserve is defined in the National Water Act (Act No. 36 of 1998) as "the quantity and quality of water required to satisfy the basic human needs by securing a basic water supply, as prescribed under the Water Services Act (Act 108 of 1997) for people to be supplied with water from that resource, and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of water resources".

Portions 4 and 6 of Lusthof 60 IT fall within the W55A quaternary catchment area. Each quaternary catchment in South Africa is required to have a ground water reserve determined for it, in which the required ground water quantity and quality reserves are provided.

2.12.8.1 Ground Water Quantity Reserve

A ground water quantity reserve has currently not been determined for the W55A quaternary catchment.

2.12.8.2 Ground Water Quality Reserve

A ground water quality reserve has currently not been determined for the W55A quaternary catchment.

During future ground water monitoring at Lusthof, it is therefore recommended that the quality assessments be made with regards to the calculated baseline concentrations until a ground water quality reserve has been determined.

2.13 SURFACE WATER BASE LINE

Inprocon Consulting Engineers was appointed by JMA Consulting to conduct a detailed surface water base line assessment for the Lusthof Colliery project. The surface water base line description compiled by them is reproduced in its entirety in this section.

2.13.1 Meteorology and Topography

Meteorological as well topographical data is of utmost importance with regards to the surface water and management thereof, and will thus be discussed as well as part of the surface water baseline assessment.

2.13.1.1 Precipitation

The mean annual rainfall (MAP) of the study area is in the region of 770 mm/a. There is a considerable variation in MAP for rainfall stations in the area (Table 2.13.1.1 (a) and Figure 2.13.1.1 (a)). Stations with reasonable record length are listed below. The variation may be partially due to different record lengths. The two longest records, Bothwell (52 years) and Carolina (44 years), have a difference of 21 mm or 3%. It should be noted that these stations cover vastly different periods which don't even overlap.

Table 2.13.1.1 (a): Rainfall Stations in the Vicinity of the Site

Station No	Station Name	Lat	Long	Start	End	Years	MAP
0480184	CAROLINA (MUN)	26 04	30 07	1905	1948	44	754.9
0480194	GOEDEVERWACHTING	26 14	30 07	1920	1953	25	696.5
0480347	BOTHWELL	26 18	30 12	1950	2003	52	775.9
0480377	CHRISSIESMEER (POL)	26 17	30 13	1967	2005	38	712.3
0480435	FLORENCE	26 14	30 14	1903	1938	23	781.9
0480520	FAIRVIEW	26 09	30 16	1909	1952	44	769.5
0480585	BELLEVUE	26 14	30 19	1908	1956	26	773.0
0480618	GRASSDALE	26 18	30 21	1906	1942	23	806.5

The site lies across an internal watershed of the quaternary catchment W55A. In the recently published Water Resources 2005 Report (an update of WR90) the MAP for the quaternary is given as 767 mm. This corresponds closely with the MAP recorded for Bothwell which is also one of the few currently open rainfall stations. The Bothwell record was thus accepted as representative of the rainfall at the site (Table 2.13.1.1 (b)).

Table 2.13.1.1 (b): Mean Monthly Rainfall for Bothwell (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Mean	126.7	95.6	75.7	48.4	14.5	8.4	6.2	12.4	34.2	92.5	131.4	129.9	**775.9**
%	16.33	12.32	9.76	6.24	1.87	1.08	0.80	1.60	4.41	11.92	16.94	16.74	**100**

As indicated in Table 2.13.1.1 (b), about 15% of the total annual rainfall occurs during the driest six months while only about 4.3% occurs during the driest 4 months. A third source for the MAP of the site is the Design Rainfall method, an application developed by the University of KwaZuluNatal.

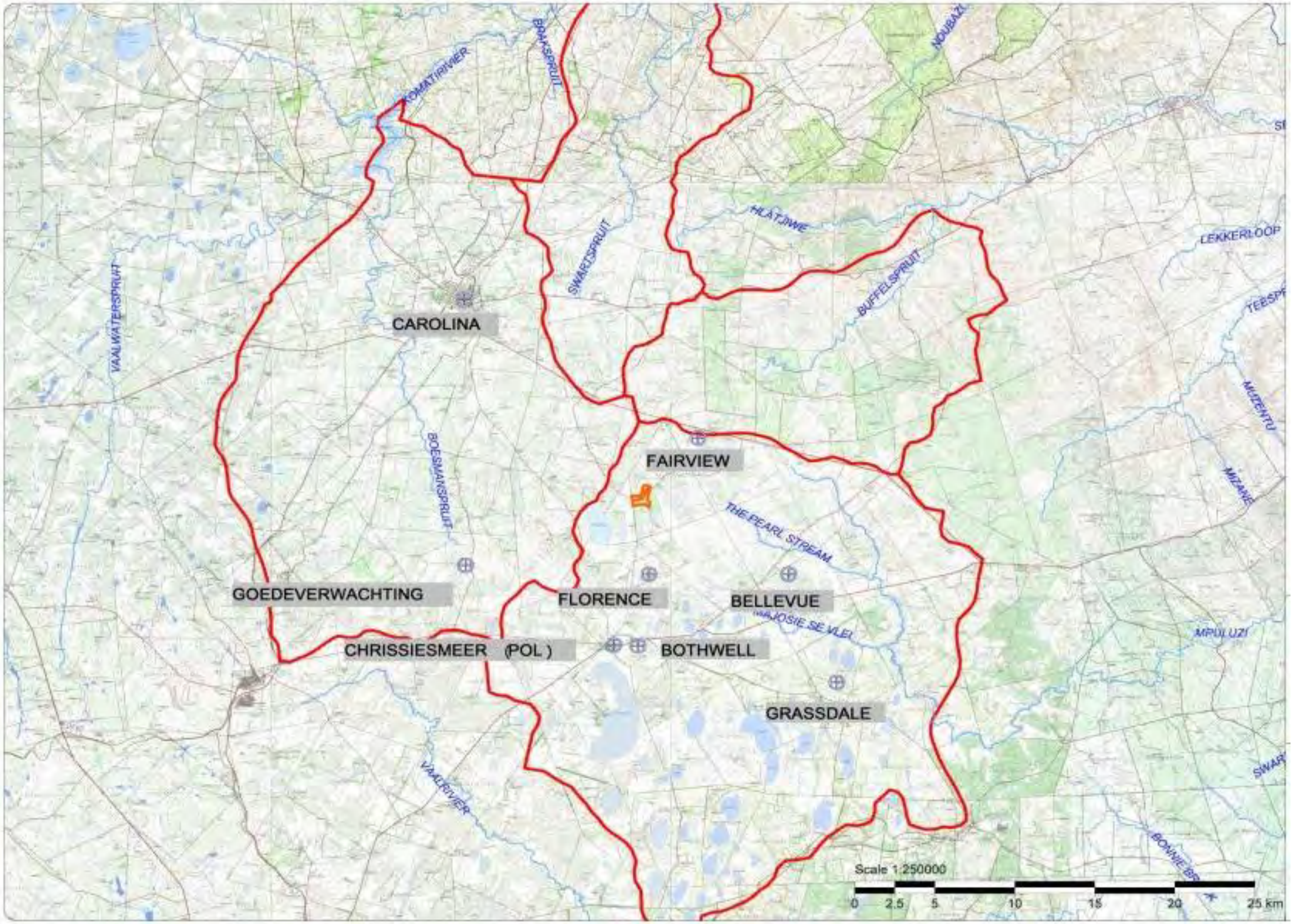


Figure 2.13.1.1 (a): Rainfall Station Localities

This method is based on statistical information of a large series of rainfall stations and uses this information together with a built in database of elevation and aspect to estimate the MAP of any one minute grid point. For this study an area of 5 min by 5 min was specified. The values that were calculated ranged from 732 to 763 with an average of 750 mm.

From these values and considering the variations and origin of each, a MAP value of 770 mm is adopted. This corresponds well with the value of 769 mm for catchment W55A and the value of 779 mm as recorded at rain station Bothwell.

2.13.1.2 Maximum Rainfall Intensities

Storm rainfall intensities are required in estimating potential flood peaks and volumes. These intensities are dependent on the duration of the storm and the storm frequency or return period. There are few autographic rain gauges in use and thus statistical analyses are limited. Prof WA Alexander recommends the use of the following storm precipitation values for the Upper Usutu River which was extracted from TR102 published by the DWAF (see Table 2.13.1.2 (a)).

Table 2.13.1.2 (a): Rainfall Intensities for given Duration and Return Periods

Duration (days)	Return Period (years)				
	5	10	20	50	100
1	76 mm	89 mm	102 mm	122 mm	138 mm
2	90 mm	106 mm	123 mm	146 mm	165 mm
3	99 mm	115 mm	132 mm	156 mm	175 mm
7	131 mm	154 mm	178 mm	211 mm	238 mm

As the catchment areas in this project are relatively small, critical storm durations will be considerably less than the one day reflected in the above. Alternate methods of obtaining storm precipitation values for shorter durations are the Design Rainfall method referred to above as well as the formulation developed by Op ten Oord which is an analytical version of the well-known monograph C2 from the HRU 1/72 Report. Both methods have been employed and the results are tabled below.

Table 2.13.1.2 (b): Storm Rainfall as per Design Rainfall Method

Duration (days)	Return Period (years)				
	5	10	20	50	100
0.25	21.5 mm	25.3 mm	29.1 mm	34.3 mm	38.4 mm
1	35.4 mm	41.5 mm	47.7 mm	56.3 mm	63.1 mm
2	45.5 mm	53.5 mm	61.5 mm	72.5 mm	81.2 mm
24	76.3 mm	89.6 mm	103.1 mm	121.5 mm	136.1 mm

Table 2.13.1.2 (c): Storm Rainfall as per Op ten Oord Formulation

Duration (days)	Return Period (years)				
	5	10	20	50	100
0.25	45.1 mm	55.5 mm	68.3 mm	89.9 mm	110.7 mm
1	53.2 mm	65.6 mm	80.8 mm	106.2 mm	130.8 mm
2	65.2 mm	79.2 mm	97.2 mm	130.8 mm	157.8 mm
24	70.8 mm	86.4 mm	106.8 mm	140.4 mm	172.8 mm

From the Tables it is clear that, for the same storm duration of 1 day (24 hrs), the TR102 values and the Design Rainfall method give almost identical results while the Design Rainfall method gives considerably higher results for higher return periods. On the other hand, the Design Rainfall Method gives lower values for shorter (1 hour) storm durations. The Op ten Oord formulation will be used in calculating storm rainfall for the various points of interest on the site based on critical storm duration for the given point.

2.13.1.3 Mean Monthly Evaporation

The Mean annual evaporation (MAE) for the area is given in WR2005 as 1400 mm. Evaporation, in terms of spatial variation, is fairly constant over the area. Limited long term evaporation records are available and the one at Morgenstond Dam is the longest and has a long term average slightly higher than that referred to above. Monthly averages are reflected in the Table below.

Table 2.13.1.3 (a): Monthly average evaporation (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Mean	171	145	141	113	102	83	92	116	138	146	155	176	**1583**
%	10.8	9.16	8.91	7.13	6.44	5.24	5.81	7.32	8.72	9.22	9.79	11.18	**100**

2.13.1.4 Topography (Hydrological)

The topography of the area is typical of the Eastern Highveld with gently rolling hills and shallow valleys where water courses often display "ox bow" configurations. As mentioned the site lies on the watershed between two minor streams, the Pearl Stream and the Mpuluzi River. This watershed is well defined and coincides with a gravel road.

Significant endoric areas (closed drainage) do occur in the neighbourhood and form pans with no outlet to the stream system. An example is the "Tevrede se Pan" just to the south west of the site. This aspect is further highlighted by the fact that the total catchment area of quaternary W55A is 690 km^2 while the net area contributing to river flow is only 380 km^2.

The catchment slopes vary but generally do not exceed 6% except in a few very small and localized areas. On the site the slope is about 5%.

2.13.2 Surface Water Quantity

2.13.2.1 Catchment Boundaries

As has been previously stated, the proposed mining area lies within the quaternary zone W55A and on the watershed of two minor tributaries. As the proposed mining area is small no discernible water courses exit and the run-off from the area is in the form of sheet flow contributing to the two tributaries. These tributaries are thus the receiving water bodies as well (Figure 2.13.2.1 (a) and Figure 2.13.2.1 (b)).

Apart from the two small areas of the mining area, four further catchment areas have been identified and were delineated on 1:50 000 topographical maps. Both of the mining areas drain to farm dams and then go on to the farm boundary.

Due to the flat topography of the area and the fact that only 20 m contours are shown on the topographical maps, it is not possible to accurately determine endoric areas. Where they exist they have been included in the values tabulated below. The areas are detailed in the Table 2.13.2.1 (a) below. They have been numbered with a prefix N for north draining areas and S for south draining areas and a numerical suffix increasing with increasing catchment size.

Table 2.13.2.1 (a): Catchment Area Detail

Catchment	Area (km^2)	Slope (%)	Water course length (km)
North draining mining area (Catcment N1)	0.35	5.2	0.31
North draining area to farm dam (Catchment N2)	3.54	0.73	0.96
North draining area to farm boundary (Catchment N3)	11.39	0.56	1.77
South draining mining area (Catchment S1)	0.58	5.9	0.34
South draining area to farm dam (Catchment S2)	13.85	0.57	3.71
South draining area to farm boundary (Catchment S3)	22.41	0.53	6.56

All four larger catchments contain farm dams which will have an impact on the hydrology of the catchments in terms of all three parameters detailed in the following sections. Since the capacities and other detail such as spillway characteristics of the dams are unknown it is not possible to evaluate their full and detailed impact. The methodology adopted is to base evaluations of the mining impact on natural flow conditions and recognizing that these are not absolute and accurate values but comparative indicators.

2.13.2.2 Water Regulating Authorities

The Mpuluzi River catchment, which ultimately drains into the Usutu River catchment (Swaziland) is a government controlled catchment. The water regulating authority in charge of the catchment is the Kwazulu Natal regional office of the Department of Water Affairs, located in Dundee.

2.13.2.3 Receiving Water Body

Lusthof open cast mine straddles a local watershed boundary on the farm Lusthof 60IT. The receiving water body is all water bodies that receive runoff from the mine site and it is the area situated radially from the site. To the north of the site is the origin of the Mpuluzi stream, to the south and east of the site is the Pearl Stream and to the west Tevrede se Pan.

The site is therefore surrounded by three water bodies. The Pearl Stream is one of many tributaries of the Mpuluzi stream that is considered to be the main receiving water body.

2.13.2.4 Mean Annual Runoff (MAR)

Mean annual runoff has been based on the relevant quaternary runoff as obtained from the recently published WR2005[(1)] . Values are given in the tables below.

Table 2.13.2.4 (a): Mean Annual Runoff Detail

Catchment	Area km^2	MAR $10^6 m^3/a$
Quaternary W55A	380.0	22.29
N1	0.35	0.021
N2	3.54	0.208
N3	11.39	0.668
S1	0.58	0.034
S2	13.85	0.812
S3	22.41	1.315

It should be noted that the MAR value obtained from WR2005 differ from those in the previous WR90 Report. The MAR has decreased from 29.54 to 22.29 $10^6 m^3/a$. The MAR values for the smaller catchments have been scaled in direct proportion to the ratio of catchment areas.

2.13.2.5 Average Dry Weather Flows

The average dry weather flows for each of the catchment was again derived from the monthly quaternary flow data set supplied in the WR2005 Report.

Table 2.13.2.5 (a): Average Dry Weather Flows

Catchment	Area km^2	MAR $10^6 m^3/a$
Quaternary W55A	610.0	235.3
N1	0.57	0.22
N2	5.68	2.19
N3	18.28	7.05
S1	0.91	0.35
S2	22.24	8.58
S3	35.96	13.87

As can be seen the average dry weather flow is very low and only about 3% of the MAR. This is to be expected since the lowest rainfall period has similar values. It also means that there is little streamflow contribution from groundwater during winter. It should be further noted that, due to possible endoric areas the runoff and dry weather flow at the catchment outlet is probably less than quoted in the Table.

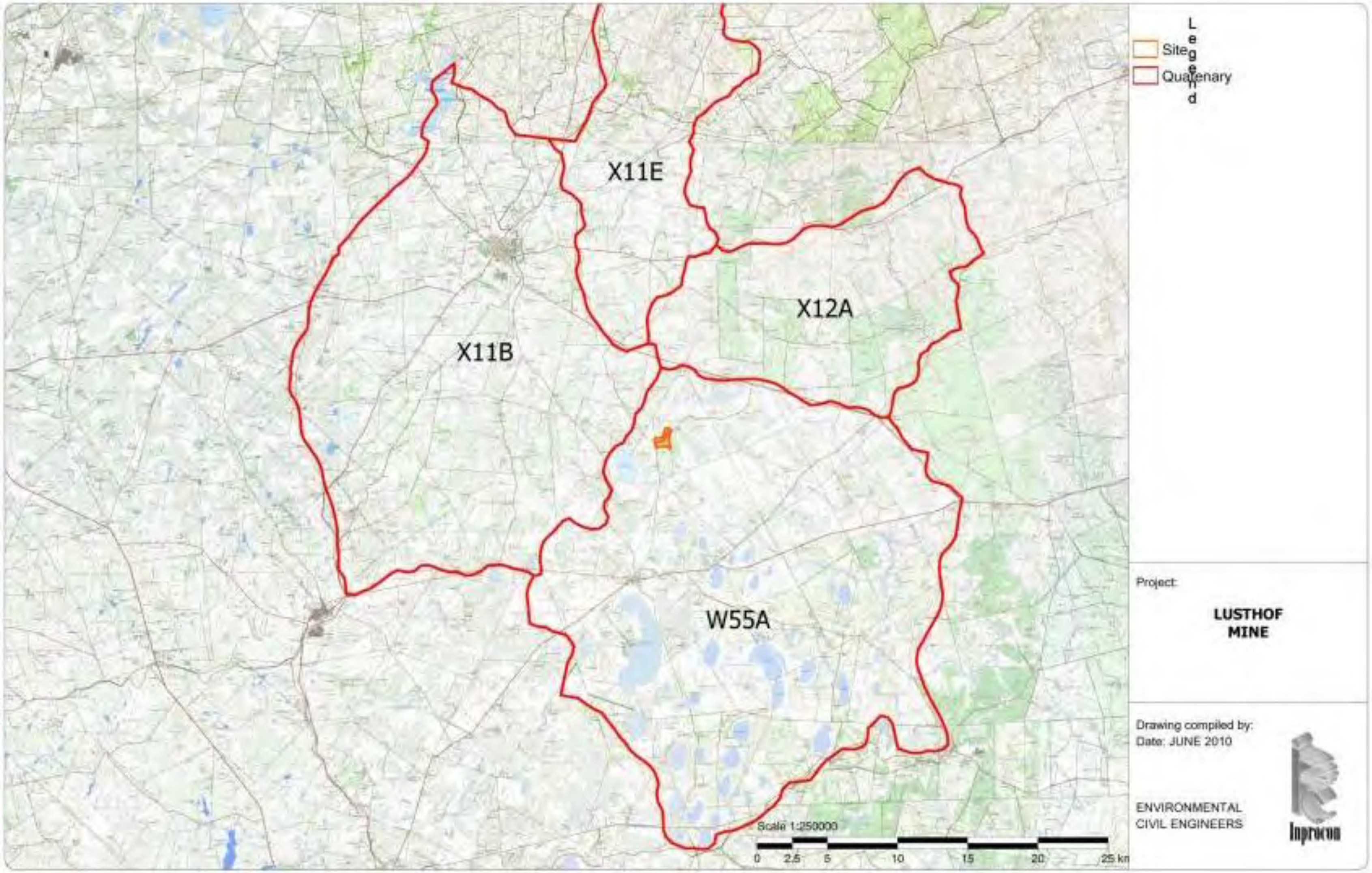


Figure 2.13.2.1 (a): Quaternary Catchments – Lusthof Colliery is Located in W55A

Figure 2.13.2.1 (b): Sub-catchments on the Lusthof Site

2.13.2.6 Flood Peaks and Volumes

For the purpose of this report only the Rational Method was used to determine flood peaks as the catchments are all relatively small. During the Design stage additional methods will be used to refine the flood peaks. For the determination of flood volumes triangular hydrographs were assumed with the peak at a time equal to the critical storm duration (Tc) and the recession limb having a time equal to 1,7 times the critical storm duration. The results are tabulated below.

Table 2.13.2.6 (a): Flood Peaks (m^3/s)

Catchment	Tc (hrs)	Return period (Yrs)				
		1:5	1:10	1:20	1:50	1:100
N1	0.63	1.1	1.4	1.7	2.8	4.1
N2	0.43	14.2	17.5	21.6	35.2	52.2
N3	0.76	32.2	39.4	48.5	79.1	117.4
S1	0.64	1.8	2.3	2.8	4.8	6.7
S2	1.33	26.2	32.0	39.4	64.3	95.3
S3	2.12	28.7	35.3	43.5	70.9	105.1

Table 2.13.2.6 (b): Flood volumes ($10^3 m^3$)

Catchment	Tc (hrs)	Return period (Yrs)				
		1:5	1:10	1:20	1:50	1:100
N1	3.4	4.3	5.2	8.6	12.6	3.4
N2	29.7	36.6	45.1	73.6	109.1	29.7
N3	118.2	145.5	179.1	292.2	433.6	118.2
S1	5.6	7.2	8.7	14.9	20.8	5.6
S2	168.1	206.8	254.7	415.6	616.0	168.1
S3	295.7	363.7	448.2	730.5	1083.0	295.7

The flood peaks and volumes given above are considered conservative as these are natural flood peaks and do not include the attenuation effect of the farm dams in the catchments nor the endoric areas. This is especially so for catchments S2 and S3 which are likely to have considerable areas of non-contributing catchment and a also a large farm dam.

2.13.2.7 Flood Lines

Relevant Area

The area proposed for mining development is situated right on a watershed divide. There are no water courses on the site. This is also true for the 100 meter wide area surrounding the proposed area. However, within a 1 kilometer radius of the site there are two non-perennial water courses, one to the north and one to the south for which flood lines were calculated for recurrence intervals of 1:50 and 1:100 years respectively.

Adjustment of Flood Peaks

The water courses respectively drain to the two farm dams for which flood peaks and volumes were calculated. As each water course only covers part of the catchment area of the dam, flood peaks for calculation of the flood lines had to be adjusted to represent the partial catchments. The normal, conservative, approach of adjusting the flood peak by the square of the ratio of the catchment areas was applied. Since the catchment of the southern water course is much more similar in size and characteristics than that of the dam in which catchment it lies, the flood peaks of the northern dam were used to compute the flood peaks of the southern stream. This is a much more conservative approach and gave rise to significantly higher flood peaks for this stream. The results of the calculations are given in Table 2.13.2.7 (a) below.

Table 2.13.2.7 (a): Flood peaks for flood line calculations.

Parameter	Catchment Area km^2	1:50 flood m^3/s	1:100 flood m^3/s
Northern farm dam	3.54	32.5	52.2
Northern stream	1.68	7.32	11.76
Southern stream	2.13	11.77	18.9

Determination of Flood Lines

A similar approach was followed in determining the flood lines for both water courses. Both exhibit similar characteristics viz a relatively wide section with a flat slope at the lower end and gradually narrowing and becoming steeper in the higher areas where the slope and cross section becomes fairly constant. The approach was to take out cross sections from the available topographic survey with 1 meter contours at about 100 meter intervals for the lower 400 to 500 meters of each stream. This was used in the HecRas software package to determine the flood lines in the lower area where characteristics are changing. Further upstream, the calculated flood lines were merely extended parallel to the stream. This approach is conservative in two ways:

- As the slope increases the velocity will increase and thus the depth and level decrease.
- The flood peak will decrease upstream as the catchment decreases.

The flood lines for the 1:50 and 1:100 year recurrence intervals are shown on Figure 2.13.2.7 (a). Typical flow characteristics for the adopted flood peaks are given in the Table 2.13.2.7 (b).

Table 2.13.2.7 (b): Typical flow characteristics.

Stream / Stream Section	Ave Flow Depth (m)		Ave Flow Velocity (m/s)	
	1:50	1:100	1:50	1:100
Northern stream upper	0.38	0.47	1.4	1.6
Northern stream lower	1.10	1.40	0.09	0.10
Southern stream upper	0.4	0.5	1.45	1.65
Southern stream lower	0.45	0.53	0.75	0.85

The high flow depth and low flow velocity for the lower part of the northern water course is due to the influence of the farm dam. In this case the flood levels in the dam due to the total dam catchment and the narrow spillway was calculated and assumed to be the boundary conditions for the calculation of the flood levels.

2.13.2.8 Watercourse alterations

There are no existing water course alterations except for the existing farm dams.

2.13.3 Surface Water Quality

The Lusthof site represents a green field's site and any impact at the surface has the potential of affecting the quantity and quality of the adjacent surface water resource. It is therefore of vital importance that the current (baseline) surface water situation be assessed and comprehensively determined.

A hydrocensus was conducted on Portions 4 and 6 of the Lusthof 60 IT as well as at the adjacent land owners in order to identify the major surface water bodies (springs, streams, rivers, pans and dams). These surface water bodies were sampled and were analyzed for the following parameters: **pH, EC, TDS, T.Alk, NH_4, Ca, Cl, Mg, NO_3, PO_4, K, Na, Si, SO_4, Al, Sb, As, B, Cd, Cr(T), Cr^{6+}, Co, Cu, F, Fe, Pb, Mn, Hg, Se, V and Zn.**

A total of 32 surface water (LC-SW) samples were taken during the surface water hydrocensus and are located on Figure 2.13.3 (a).

A surface water reserve, stipulating the quality and quantity compliance values, has currently not been determined for the quaternary catchment, and the surface water quality assessment was therefore made with reference to the SANS 241:2006 Drinking Water Standard. The SANS 241:2006 Drinking Water Standard was used as it has a comprehensive list of variables against which an assessment could be made.

The surface water variable concentrations were determined and were assessed against the SANS 241:2006 Drinking Water Standard, as listed in Table 2.13.3(a). The SANS 241:2006 Drinking Water Standard gives an indication of the "fitness of use" of the water if consumed by human beings. If the water is deemed "fit for human consumption" it is expected that it is fit for livestock and irrigation purposes as well.

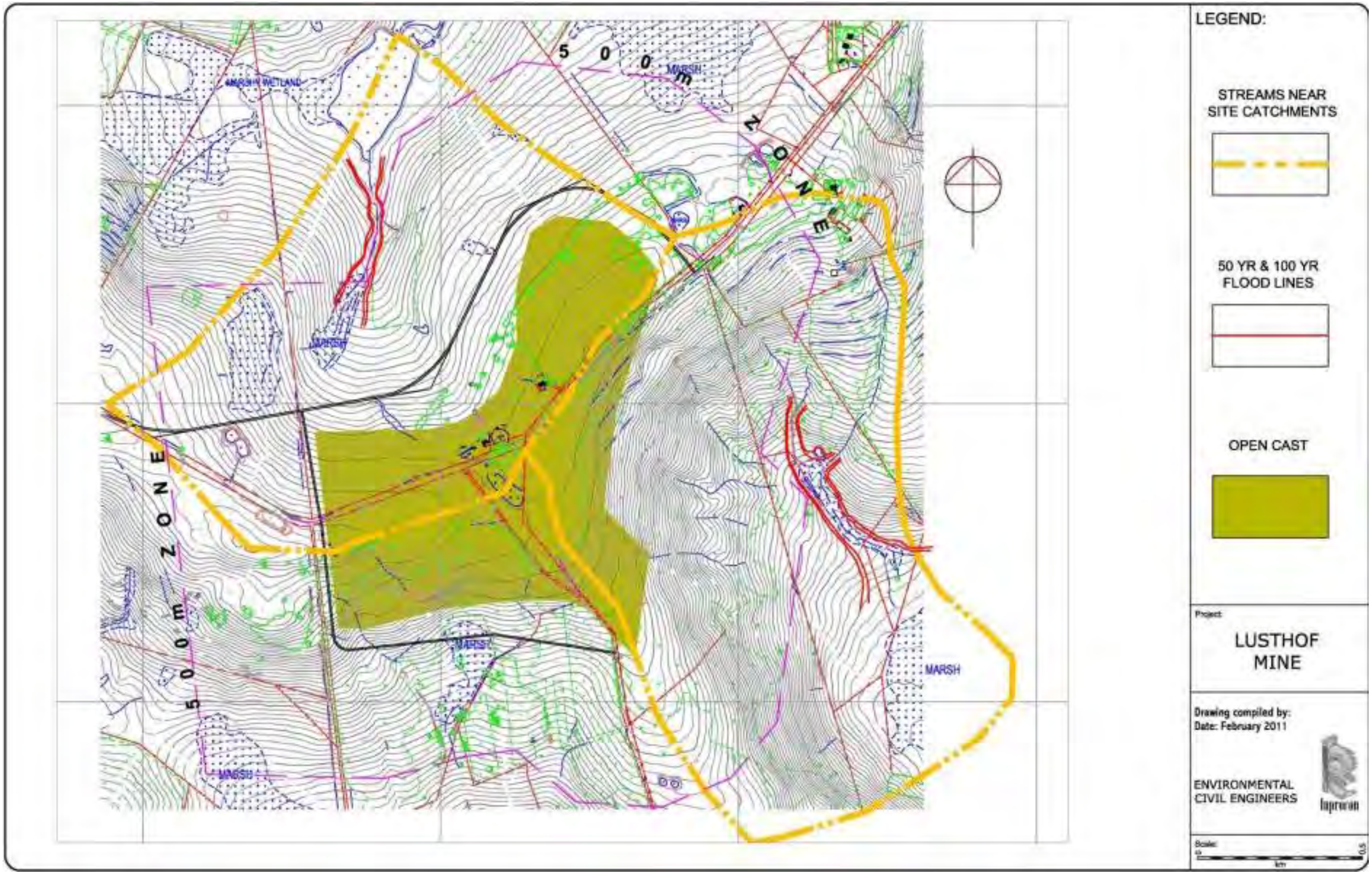


Figure 2.13.2.7 (a): Flood Lines for the 1:50 year and 1:100 year recurrence intervals

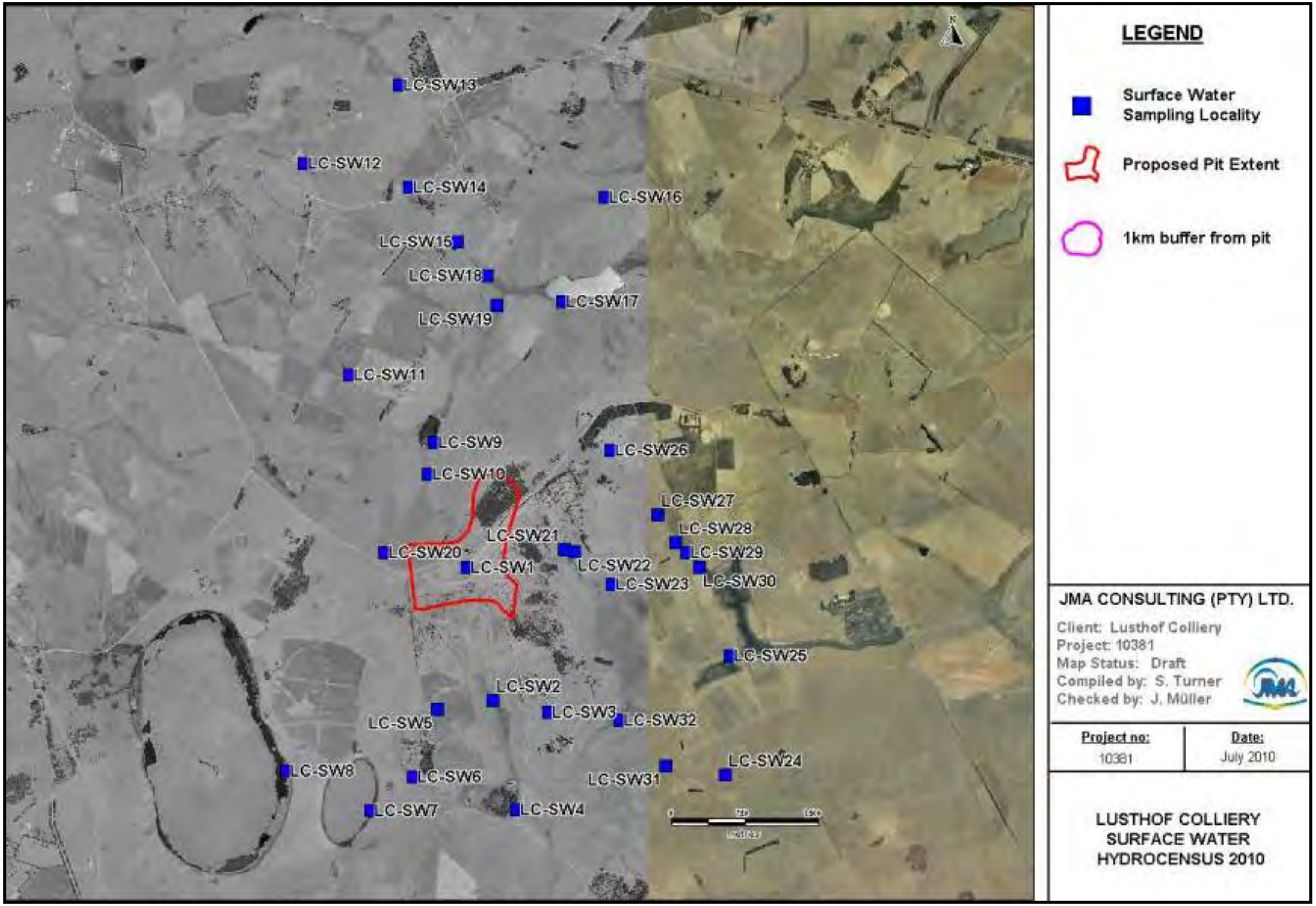


Figure 2.13.3 (a): Hydrocensus Surface Water Sampling Localities

Table 2.13.3 (a): Hydrocensus Surface Water Quality Compliance

BH No.	LC-SW 1	LC-SW 2	LC-SW 3	LC-SW 4	LC-SW 5	LC-SW 6	LC-SW 7	LC-SW 8	LC-SW 9	LC-SW10	LC-SW11	LC-SW12	LC-SW13	LC-SW14	LC-SW15	LC-SW16
pH	6.19	6.39	5.66	7.07	5.87	6.77	6.74	6.76	6.08	5.90	7.09	6.87	6.09	7.32	6.83	6.69
EC (mS/m)	19.0	5.81	7.04	36.4	26.3	18.7	25.9	38.3	7.96	3.96	58.8	6.97	11.2	26.1	8.75	7.93
TDS (mg/l)	82.7	30.8	30.2	174	105	90.9	122	174	35.9	20.6	278	35.2	48.3	97.5	43.5	38.2
T.Alk (mg/l)	17.3	9.56	3.08	66.9	6.60	16.1	36.0	62.4	5.88	6.92	98.2	11.2	8.12	44.8	18.6	12.9
NH_4 (mg/l)	0.730	0.010	0.230	0.060	0.340	0.020	0.150	0.010	0.010	0.010	0.020	0.010	0.200	1.18	0.030	0.010
Ca (mg/l)	5.11	2.44	2.32	12.8	9.32	5.43	2.75	16.0	1.46	0.940	17.6	2.30	3.21	6.93	3.31	2.58
Cl (mg/l)	32.4	7.42	16.1	60.3	51.9	34.9	52.7	60.4	16.4	5.81	117	8.49	24.1	36.2	8.38	13.9
Mg (mg/l)	3.72	1.79	1.51	8.41	6.16	4.27	3.89	13.9	1.01	0.750	19.7	1.73	2.16	3.82	2.89	2.04
NO_3 (mg/l)	0.580	0.150	0.140	0.140	0.140	0.150	0.140	0.320	0.140	0.250	0.220	0.270	0.160	0.630	0.180	0.160
PO_4 (mg/l)	0.030	0.020	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
K (mg/l)	12.3	0.220	2.51	5.26	25.0	4.25	3.62	7.17	1.49	0.820	19.3	2.78	5.47	22.7	1.66	0.810
Na (mg/l)	12.6	6.94	5.92	43.6	9.86	20.1	39.2	31.8	9.24	4.92	58.7	5.68	8.04	10.3	6.51	7.48
Si (mg/l)	2.93	3.54	0.890	3.86	0.700	6.69	2.05	5.85	1.50	2.67	9.81	11.7	6.32	2.83	0.710	2.26
SO_4 (mg/l)	11.9	5.49	0.930	7.15	21.7	15.4	0.790	12.7	3.28	2.60	3.86	7.96	2.77	4.51	10.0	3.18
Al (mg/l)	0.800	<0.01	0.100	0.020	0.130	0.130	0.020	0.040	0.030	0.030	0.100	0.480	0.950	1.64	0.070	0.070
Sb (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
As (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
B (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cd (mg/l)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cr(T) (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cr^{6+} (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Co (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
F (mg/l)	0.360	0.076	0.093	0.271	0.166	0.151	0.183	0.148	0.120	0.066	0.294	0.154	0.086	0.468	0.095	0.093
Fe (mg/l)	1.74	0.110	0.270	0.270	0.220	0.130	0.140	0.170	0.180	0.110	0.440	0.430	1.04	2.39	0.150	0.300
Pb (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mn (mg/l)	0.050	<0.01	0.170	0.020	0.020	0.020	0.020	0.020	0.020	0.030	0.020	0.030	0.020	<0.01	0.020	0.020
Hg (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
V (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.011	<0.01	<0.01	<0.01	<0.01
Zn (mg/l)	<0.01	<0.01	<0.01	<0.01	0.012	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.010	<0.01	<0.01	<0.01	<0.01

Table 2.13.3 (a)*(cont.)*: Hydrocensus Surface Water Quality Compliance

BH No.	LC-SW17	LC-SW18	LC-SW19	LC-SW20	LC-SW21	LC-SW22	LC-SW23	LC-SW24	LC-SW25	LC-SW26	LC-SW27	LC-SW28	LC-SW29	LC-SW30	LC-SW31	LC-SW32
pH	6.46	6.48	5.96	6.21	6.73	6.93	6.41	6.36	7.05	6.68	6.09	6.47	6.31	6.30	6.07	6.36
EC (mS/m)	6.83	8.07	5.86	4.65	5.73	9.01	8.64	6.69	14.7	8.78	9.63	9.83	9.06	9.87	7.19	8.82
TDS (mg/l)	37.1	40.3	28.8	20.9	28.7	40.3	40.7	32.4	71.1	45.2	46.9	48.7	42.4	45.9	35.5	45.0
T.Alk (mg/l)	5.48	7.28	6.36	6.12	8.60	17.7	7.32	5.80	20.0	16.0	8.80	8.00	7.40	8.56	6.92	21.8
NH_4 (mg/l)	0.010	0.010	0.010	0.420	0.010	0.010	0.010	0.010	0.010	0.020	0.010	0.010	0.010	0.010	0.010	0.010
Ca (mg/l)	2.18	2.63	1.07	0.620	2.09	3.78	1.98	2.21	4.14	2.83	3.09	3.58	2.72	2.79	2.37	3.75
Cl (mg/l)	10.8	10.7	9.19	6.57	9.81	15.2	10.0	9.09	25.8	14.2	16.2	16.2	15.7	17.8	9.78	11.4
Mg (mg/l)	1.47	2.15	0.689	0.050	0.840	2.13	1.91	1.17	2.98	2.28	3.30	3.62	2.54	2.59	1.79	2.50
NO_3 (mg/l)	0.230	0.150	0.150	0.170	0.360	0.290	0.200	0.160	0.160	0.160	0.300	0.170	0.140	0.140	0.140	0.160
PO_4 (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
K (mg/l)	1.95	1.68	1.28	2.94	1.33	3.93	5.96	1.77	3.37	6.01	1.50	2.12	2.12	3.02	2.11	1.92
Na (mg/l)	6.75	6.73	6.95	3.19	5.89	6.05	5.59	6.02	16.8	5.32	6.76	7.13	7.06	8.07	6.55	8.86
Si (mg/l)	1.40	2.17	<0.01	1.43	3.91	4.68	0.890	1.71	1.58	6.75	2.63	1.27	1.13	1.09	0.950	1.98
SO_4 (mg/l)	11.1	12.8	5.93	3.79	2.62	0.420	14.0	9.32	7.82	6.89	9.75	12.1	8.88	8.56	9.91	3.25
Al (mg/l)	0.060	0.030	0.090	0.520	0.266	0.170	0.850	0.130	0.160	1.71	0.380	0.170	0.140	0.110	0.120	0.570
Sb (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
As (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
B (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cd (mg/l)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cr(T) (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.044	<0.01	<0.01	<0.01	<0.01	0.036	<0.01
Cr^{6+} (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.040	<0.01	<0.01	<0.01	<0.01	0.020	<0.01
Co (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
F (mg/l)	0.100	0.076	0.098	0.118	0.067	0.093	0.090	0.083	0.188	0.133	0.070	0.099	0.088	0.072	0.039	0.121
Fe (mg/l)	0.230	0.110	0.210	1.02	0.310	0.460	0.900	0.120	0.410	1.40	0.630	0.120	0.170	0.110	0.130	0.640
Pb (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mn (mg/l)	0.020	0.020	0.060	0.030	0.040	0.020	0.020	0.020	0.020	0.020	0.080	0.020	0.020	0.020	0.020	0.080
Hg (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
V (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zn (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Variable concentrations in the surface water that fall within Class I of the SANS 241:2006 Drinking Water Standard are indicated in **Green** in Table 2.13.3(a) and are classified having concentrations that are "**Fully Compliant**" with regards to the SANS 241:2006 Drinking Water Standard.

Variable concentrations that fall within Class II are indicated in **Orange** in Table 2.13.3 (a) and are classified as having concentrations that are "**Marginally Compliant**" with regards to the SANS 241:2006 Drinking Water Standard.

Variable concentrations that exceed Class II are indicated in **Red** in Table 2.13.3 (a) and are classified as having concentrations that are "**Non-Compliant**" with regards to the SANS 241:2006 Drinking Water Standard.

Table 2.13.3 (a) indicates that the surface water sampled during the hydrocensus has a quality that is fully compliant with regards to the SANS 241:2006 Standard for most of the variables analyzed for. Aluminium (Al) and Iron (Fe) were the two elements that were often elevated in the surface water. Both of these elements are most probably elevated as a result of the underlying geology and not due to surface induced impacts.

Seven surface water samples had non-compliant Al concentrations, and two had marginally compliant concentrations. Fe was slightly elevated (marginally compliant) for 19 of the 32 surface water samples, and the only other element that exceeded the SANS 241 concentrations was Mn which had a concentration of 0.170 mg/l (LC-SW3).

It is observed that the surface water sampled from on and adjacent to Portions 4 and 6 have a quality that is predominantly classified as "fit for human consumption". The surface waters sampled from both the pans to the south-west of the proposed pit boundary have concentrations that are fully compliant with regards to the SANS 241:2006 Drinking Water Standard. There is currently no evidence of any surface induced impacts on the surface water bodies sampled.

It is known that the conservation of the aquatic ecosystems at Lusthof is of vital importance and an assessment of the background surface water quality was therefore made with regards to the variable concentrations stipulated in South African Water Quality Guidelines: Aquatic Ecosystems (Volume 7) document as well.

This Aquatic Ecosystems Standard only has nine stipulated variables against which an assessment could be made. These are namely: **F, NH_4, Al, Cu, Hg, Mn, Pb, Se and Zn.** The ground water quality compliance assessment with regards to the Aquatic Ecosystems Guideline is indicated in Table 2.13.3 (b).

The Aquatic Ecosystem Guidelines specify two values against which the assessment was made. The first is the Chronic Effect Value (CEV) and the second is the Acute Effect Value (AEV). The Chronic Effect Value is defined as the concentration of the variable at which there is expected to be a significant probability of measurable chronic effects to up to 5% of the species in the aquatic community. The Acute Effect Value is defined as the concentration of the variable above which there is expected to be a significant probability of acute toxic effects to up to 5% of the species in the aquatic community.

Table 2.13.3 (b): Background Surface Water Quality Compliance Assessment: (South African Water Quality Guidelines: Aquatic Ecosystems)

BH No.	NH_4	Al	Cu	F	Pb	Mn	Hg	Se	Zn
LC-SW1	0.73	0.80	<0.01	0.36	<0.01	0.05	<0.001	<0.005	<0.01
LC-SW2	0.01	<0.01	<0.01	0.08	<0.01	<0.01	<0.001	<0.005	<0.01
LC-SW3	0.23	0.10	<0.01	0.09	<0.01	0.17	<0.001	<0.005	<0.01
LC-SW4	0.06	0.02	<0.01	0.27	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW5	0.34	0.13	<0.01	0.17	<0.01	0.02	<0.001	<0.005	0.012
LC-SW6	0.02	0.13	<0.01	0.15	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW7	0.15	0.02	<0.01	0.18	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW8	0.01	0.04	<0.01	0.15	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW9	0.01	0.03	<0.01	0.12	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW10	0.01	0.03	<0.01	0.07	<0.01	0.03	<0.001	<0.005	<0.01
LC-SW11	0.02	0.10	<0.01	0.29	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW12	0.01	0.48	<0.01	0.15	<0.01	0.03	<0.001	<0.005	<0.01
LC-SW13	0.20	0.95	<0.01	0.09	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW14	1.18	1.64	<0.01	0.47	<0.01	<0.01	<0.001	<0.005	<0.01
LC-SW15	0.03	0.07	<0.01	0.10	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW16	0.01	0.07	<0.01	0.09	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW17	0.01	0.06	<0.01	0.10	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW18	0.01	0.03	<0.01	0.08	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW19	0.01	0.09	<0.01	0.10	<0.01	0.06	<0.001	<0.005	<0.01
LC-SW20	0.42	0.52	<0.01	0.12	<0.01	0.03	<0.001	<0.005	<0.01
LC-SW21	0.01	0.27	<0.01	0.07	<0.01	0.04	<0.001	<0.005	<0.01
LC-SW22	0.01	0.17	<0.01	0.09	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW23	0.01	0.85	<0.01	0.09	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW24	0.01	0.13	<0.01	0.08	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW25	0.01	0.16	<0.01	0.19	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW26	0.02	1.71	<0.01	0.13	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW27	0.01	0.38	<0.01	0.07	<0.01	0.08	<0.001	<0.005	<0.01
LC-SW28	0.01	0.17	<0.01	0.10	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW29	0.01	0.14	<0.01	0.09	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW30	0.01	0.11	<0.01	0.07	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW31	0.01	0.12	<0.01	0.04	<0.01	0.02	<0.001	<0.005	<0.01
LC-SW32	0.01	0.57	<0.01	0.12	<0.01	0.08	<0.001	<0.005	<0.01

Variable concentrations in the ground water which are lower than the CEV values are indicated in **Green** in Table 2.13.3 (b) and are classified having concentrations that are "**Fully Compliant**" with regards to the South African Water Quality Guidelines: Aquatic Ecosystems (Volume 7) concentrations.

Variable concentrations in the ground water that fall between the CEV and AEV values are indicated in **Orange** in Table 2.13.3 (b) and are classified as having concentrations that are "**Marginally Compliant**" with regards to the South African Water Quality Guidelines: Aquatic Ecosystems (Volume 7) concentrations.

Variable concentrations in the ground water which are higher than the AEV values are indicated in **Red** in Table 2.13.3 (b) and are classified as having concentrations that are "**Non-Compliant**" with regards to the South African Water Quality Guidelines: Aquatic Ecosystems (Volume 7) concentrations.

]

Table 2.13.3 (b) indicates that the surface water has a quality that is fully compliant with regards to the South African Water Quality Guidelines: Aquatic Ecosystems (Volume 7) concentrations for all the variables, except NH_4 and Al.

Table 2.13.3 (b) further indicates that NH_4 and specifically Al concentrations in the background surface water are non-compliant with regards to the South African Water Quality Guidelines: Aquatic Ecosystems (Volume 7) concentrations and pose the risk of acute toxic effects to up to 5% of the species in the aquatic community.

The chemistry of the surface water sampled during the hydrocensus was statistically analyzed and is summarized in Table 2.13.3 (c). Table 2.13.3 (c) indicates the minimum and maximum concentrations for each variable analyzed for, as well as the Average and Standard Deviation (SD) for that variable.

The surface water quality concentrations that will be used for each variable at the compliance point, are calculated by adding 1 standard deviation to the maximum concentration of that variable. This calculated concentration is listed in Table 2.13.3 (c) for each variable analyzed and will be used until a surface water reserve has been determined for the quaternary catchment.

Table 2.13.3 (c): Background Surface Water Quality Summary

Variable		Minimum	Maximum	Average	1 SD	1 SD + Max
EC	**mS/m**	3.96	58.80	13.83	12.12	**70.92**
TDS	**mg/l**	20.60	278	64.27	55.34	**333.34**
T.Alk	**mg/l**	3.08	98.20	18.33	21.35	**119.55**
NH_4	**mg/l**	0.01	1.18	0.11	0.25	**1.43**
Ca	**mg/l**	0.62	17.60	4.26	4.09	**21.69**
Cl	**mg/l**	5.81	117	23.59	23.28	**140.28**
Mg	**mg/l**	0.05	19.70	3.43	3.94	**23.64**
NO_3	**mg/l**	0.14	0.63	0.21	0.12	**0.75**
PO_4	**mg/l**	0.01	0.03	0.01	0.00	**0.03**
K	**mg/l**	0.22	25	4.95	6.19	**31.19**
Na	**mg/l**	3.19	58.70	12.33	12.84	**71.54**
Si	**mg/l**	0.70	11.70	3.16	2.71	**14.41**
SO_4	**mg/l**	0.42	21.70	7.54	4.90	**26.60**
Al	**mg/l**	0.02	1.71	0.33	0.44	**2.15**
Sb	**mg/l**	0.01	0.01	0.01	0.00	**0.01**
As	**mg/l**	0.01	0.01	0.01	0.00	**0.01**
B	**mg/l**	0.01	0.01	0.01	0.00	**0.01**
Cd	**mg/l**	0.00	0.00	0.00	0.00	**0.00**
Cr(T)	**mg/l**	0.01	0.04	0.01	0.01	**0.05**
Cr^{6+}	**mg/l**	0.01	0.04	0.01	0.01	**0.05**
Co	**mg/l**	0.01	0.01	0.01	0.00	**0.01**
Cu	**mg/l**	0.01	0.01	0.01	0.00	**0.01**
F	**mg/l**	0.04	0.47	0.14	0.09	**0.56**
Fe	**mg/l**	0.11	2.39	0.47	0.53	**2.92**
Pb	**mg/l**	0.01	0.01	0.01	0.00	**0.01**
Mn	**mg/l**	0.02	0.17	0.03	0.03	**0.20**
Hg	**mg/l**	0.00	0.00	0.00	0.00	**0.00**
Se	**mg/l**	0.01	0.01	0.01	0.00	**0.01**
V	**mg/l**	0.01	0.01	0.01	0.00	**0.01**
Zn	**mg/l**	0.01	0.01	0.01	0.00	**0.01**

Hydrochemical imaging of the background surface water samples collected during the hydrocensus was performed during which Piper and Durov Diagrams were compiled. The resulting Piper and Durov Diagrams are indicated as Figures 2.13.3 (b) and 2.13.3 (c) respectively and were compiled using the macro chemistry variables pH, EC, Ca, Mg, Na, K, Total Alkalinity, Cl, SO_4 and NO_3.

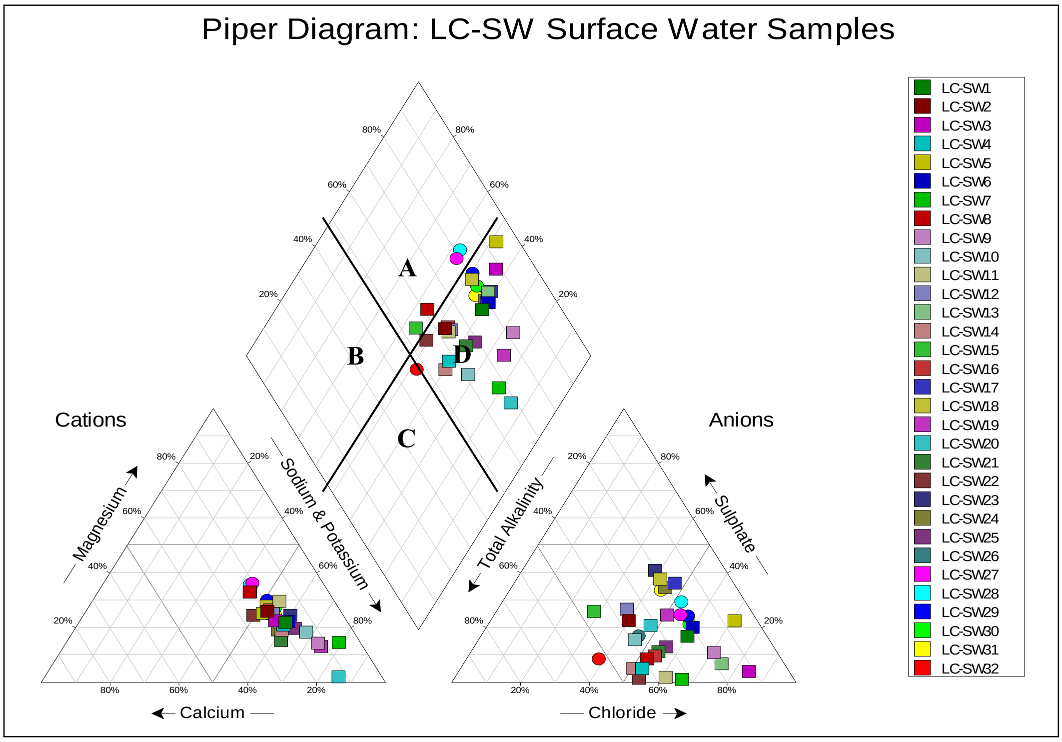


Figure 2.13.3 (b): Background Surface Water Quality – Piper Diagram

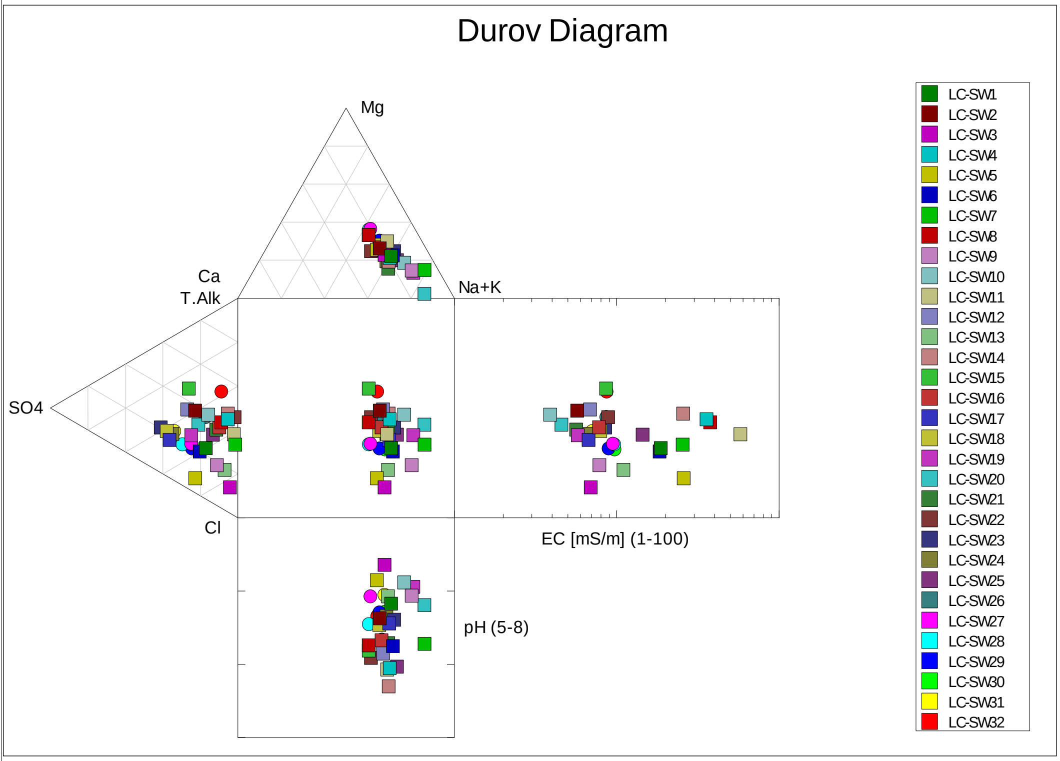


Figure 2.13.3 (c): Background Surface Water Quality – Durov Diagram

The baseline surface water at Lusthof is classified as having a predominantly Type D hydrochemical facies, with dominant cations Na^+ and/or K^+ and dominant anions Cl^-. Five surface water samples had Type-A hydrochemical facies, with dominant cations Ca^{2+} and/or Mg^{2+} and dominant anions Cl^- and/or SO_4^{2-}, whilst one surface water sample (LC-SW32) had a Type-C hydrochemical image, with dominant cations Na^+ and/or K^+ and dominant anion HCO_3^-.

2.13.4 Surface Water Use

The use of the identified surface water bodies within the delineated study area was determined during the surface water hydrocensus conducted in June 2010.

The surface water streams within the study area at Lusthof are captured by shallow pans or dams. The surface water captured by the pans and dams are used as a water source for livestock. Surface water contained within the pans or dams is currently not being used as water source for irrigational or domestic purposes.

The surface water bodies in the area are furthermore recognized as aquatic features of high importance.

2.14 PLANT LIFE BASE LINE

Wetland Consulting Services (Pty) Ltd were appointed by JMA Consulting to assess the floral biodiversity of the Lusthof site. The plant life base line description compiled by them is reproduced in its entirety in this section.

2.14.1 Regional Plant Life

Because of the generally perceived sensitivity of the site, it being located within the broader Chrissiesmeer Pan complex, the site was also assessed in a regional context.

Biological diversity" or "biodiversity" can have many interpretations. It is most commonly used to replace the more clearly defined and long established terms, species diversity and species richness. Biodiversity is not evenly distributed. Flora and fauna diversity depends on climate, altitude, soils and the presence of other species. Diversity consistently measures higher in the tropics and in other localized regions such as the Cape Floristic Province and lower in polar regions generally. What is generally recognized is that biodiversity increases with habitat heterogeneity as there are probably a greater number of potential niches in a habitat with high physical heterogeneity. Other factors that could influence biodiversity at the regional to local level include aspect and slope.

In order to establish whether the slope of the Lusthof site differed significantly from surrounding areas within the same bioclimatic area, the slopes on the site were compared with slopes over a broader geographic range. The analysis was undertaken by Geoterra Image as were other analyses that appear in this report. The objective of these analyses was an attempt to establish the uniqueness or otherwise of the site. The analysis shows that the site and the area surrounding the site are characterised by slopes in the range 0-9% with extensive areas in the 0-2% range. These latter areas represent pans and broad valley bottom wetlands. Slopes adjacent these systems are generally not greater than 5%.

It would seem from this analysis that the site, from an aspect perspective, does not seem to differ significantly from the adjacent areas.

A slope and aspect analysis of the localised region surrounding the Lusthof site were undertaken and are indicated as Figure 2.14.1 (a) and Figure 2.14.1 (b) respectively. The figures indicate that the site shares north to north west trending features in common with the greater area, in addition to other aspects.

There is nothing to suggest that the aspects on the site are in any way different from adjacent sites.

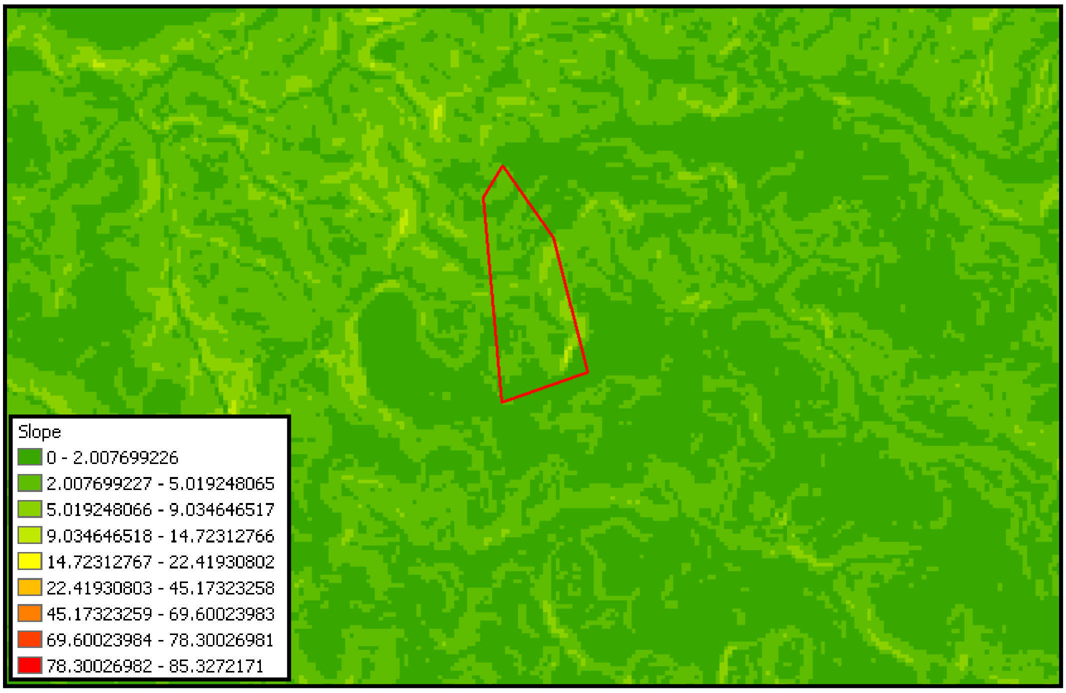


Figure 2.14.1 (a): The results of the slope analysis with the perimeter of the study area outlined in red.

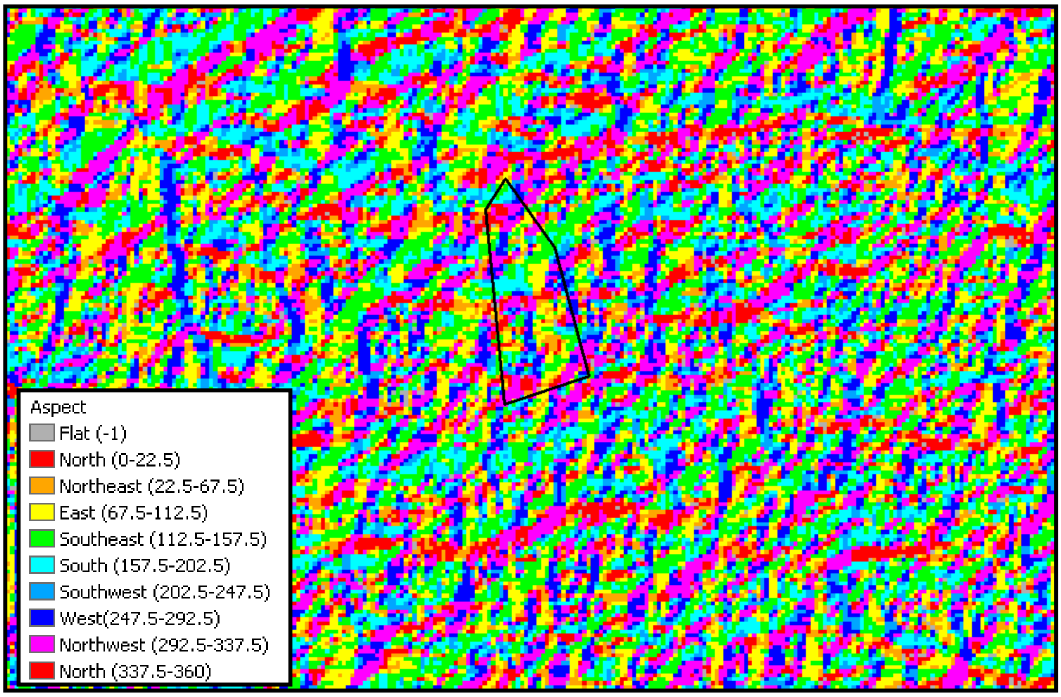


Figure 2.14.1 (b): The results of an aspect analysis. The study area is outlined in black.

It is apparent from these two analyses that the Lusthof site shares characteristics with the landscape in general, with little to differentiate it from its surrounds.

A further analysis was undertaken by Geoterra Image which was termed roughness. The analysis was based on the collective of a number of detectable attributes with the intention of determining identifiable differences in the landscape. The result of the analysis is depicted in Figure 2.14.1 (c).

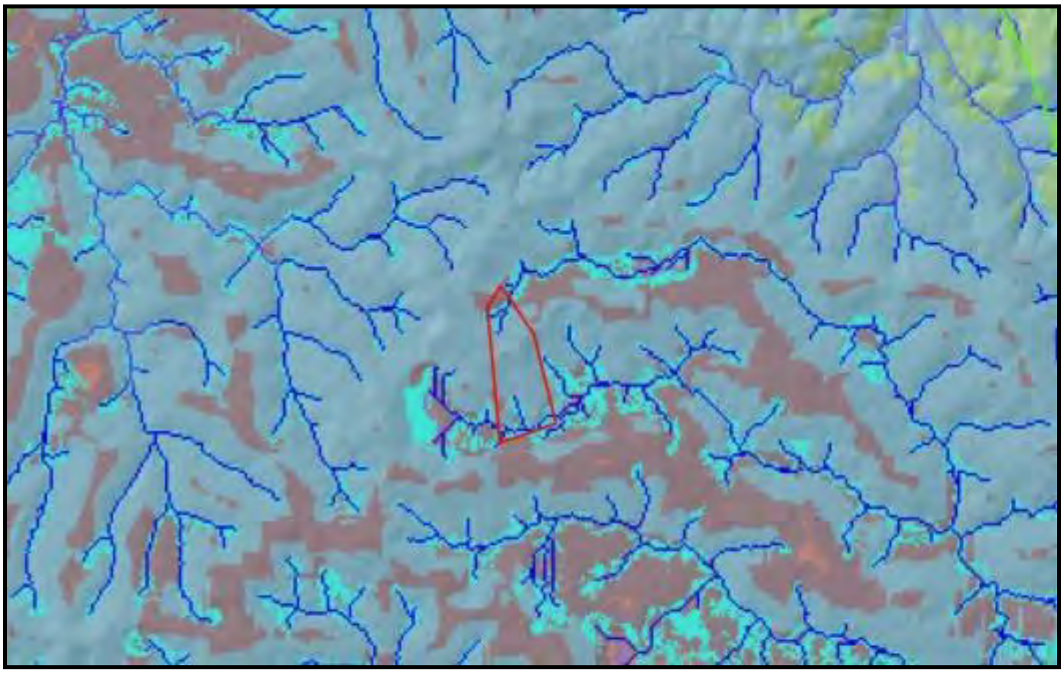


Figure 2.14.1 (c): An analysis of roughness using a combination of features with the study site outlined in red.

Ridges and flat alluvial deposits along drainage lines were detected as were isolated points, one of which is discernible within the Lusthof study area, in the footprint of the area proposed to be mined.

A vegetation sampling strategy was developed based on the results in Figure 2.14.1 (c). Vegetation was selected as a surrogate for biodiversity, as it forms the basis for food chains.

In the analysis an area of "roughness" or "smoothness" was identified within the study area occupying a high point in the landscape. Sites of similar size in the landscape surrounding the Lusthof study were identified and targeted as sites for vegetation surveys. The reason for identifying and selecting these sites was to be able to establish the uniqueness or otherwise of these particular localities. If unique, then the individual sites could, from a biodiversity perspective be considered independently.

Twenty six sites exhibited a similar signature to that recorded on Lusthof. The localities of these sites are indicated in Figure 2.14.1 (d).

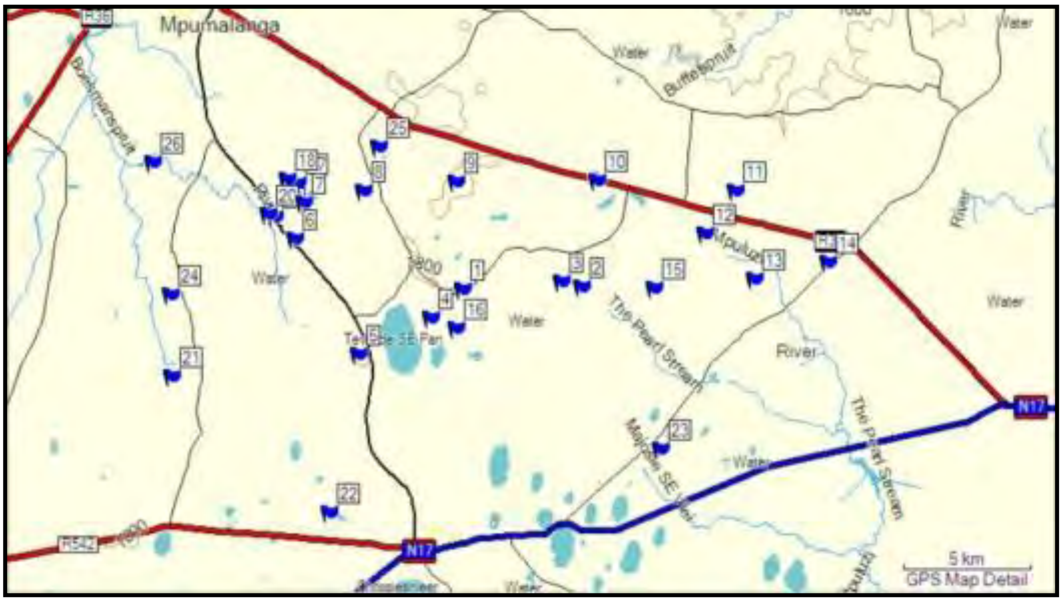


Figure 2.14.1 (d): A map showing the localities of the sites provisionally selected for vegetation sampling.

Not all the 26 sites were sampled as their positions coincided with sites where there was no natural habitat remaining (Mpumulanga Conservation & Management Plan). In total 22 sites were sampled in April 2009. The Lusthof site fell within this category

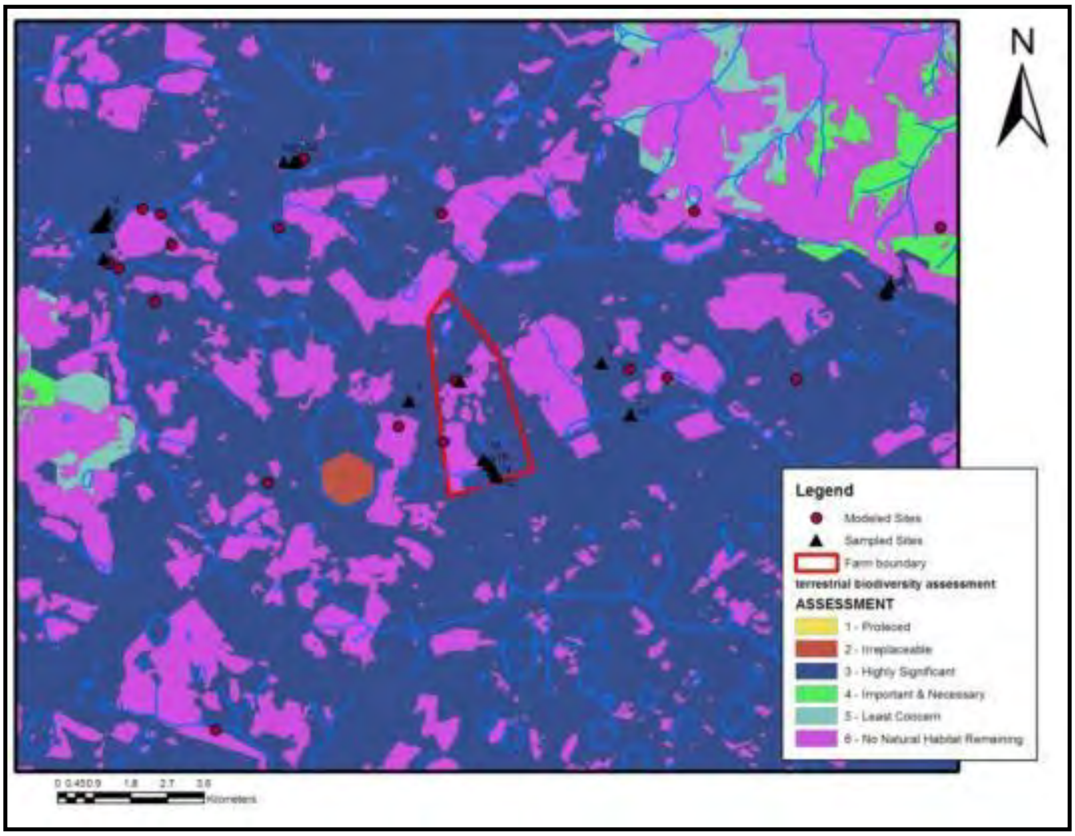


Figure 2.14.1 (e): A section of the Mpumalanga Biodiversity Conservation Map showing the relationship between the sampling sites and areas of conservation importance.

2.14.2 Vegetation

A total of 211 plant species were recorded, with the highest species richness being 75 species in a 10 m x 10 m plot, and the lowest was 5. The average number of species per plot was 29.

The analyses of the results indicate there was sufficient variability in these results that the Lusthof site could be considered independently of all the other sites.

2.14.2.1 Vegetation Type and Conservation Value

The Lusthof study area occurs within Eastern Highveld Grassland (Mucina *et al*. 2006). This is a short, dense grassland occurring in slightly to moderately undulating plains, including some low hills (Mucina *et al*. 2006). Soils are typically red to yellow and sandy. A list of expected common and dominant species in undisturbed Eastern Highveld Grassland includes the following (those with a "d" are considered to be dominant):

Graminoids

Aristida aequiglumis (d), *Aristida congesta* (d), *Aristida junciformis* subsp. *galpinii* (d), *Brachiaria serrata* (d), *Cynodon dactylon* (d), *Digitaria monodactyla* (d), *Digitaria tricholaenoides* (d), *Elionurus muticus* (d), *Eragrostis chloromelas* (d), *Eragrostis curvula (*d), *Eragrostis plana* (d), *Eragrostis racemosa* (d), *Eragrostis sclerantha (*d), *Heteropogon contortus* (d), *Loudetia simplex* (d), *Michrochloa caffra* (d), *Monocymbium ceresiiforme (*d), *Setaria sphacelata* (d), *Sporobolus africanus* (d), *Sporobolus pectinatus* (d), *Themeda triandra* (d), *Trachypogon spicatus* (d), *Tristachya leucothrix* (d), *Tristachya rehmannii* (d), *Alloteropsis semialata* subsp. *eckloniana, Andropogon appendiculatus, Andropogon schirensis, Bewsia biflora, Ctenium concinnum, Diheteropogon amplectens, Eragrostis capensis, Eragrostis gummiflua, Eragrostis patentissima, Harpochloa falx, Panicum natalense, Rendlia altera, Schizachyrium sanguineum, Setaria nigrirostris, Urelytrum agropyroides.*

Herbs

Berkheya setifera (d), *Haplocarpha scaposa* (d), *Justicia anagalloides* (d), *Pelargonium luridum* (d), *Acalypha angustata, Chamaecrista mimosoides, Euryops gilfillanii, Euryops transvaalensis* subsp. *setilobus, Helichrysum aureonitens, Helichrysum caespititium, Helichrysum callicomum, Helichrysum oreophilum, Helichrysum rugulosum, Ipomoea crassipes, Pentanisia prunellioides subsp. latifolia, Selago densiflora, Senecio coronatus, Vernonia oligocephala, Wahlenbergia undulata.*

Geophytes

Gladiolus crassifolius, Haemanthus humilus subsp. *hirsutus, Hypoxis rigidula* var. *pilosissima, Ledebouria ovatifolia.*

Succulent herb

Aloe ecklonis.

Low shrubs

Anthospermum rigidum subsp. *pumilum, Seripheum plumosum.*

According to scientific literature (Driver *et al*. 2005; Mucina *et al*., 2006), Eastern Highveld Grassland is classified as Endangered. The Draft National List of Threatened Ecosystems (GN1477 of 2009), published under the National Environmental Management: Biodiversity Act (Act No. 10, 2004), lists this vegetation type as Vulnerable (Table 3) on the basis of irreversible loss of natural habitat (criterion A1). According to the National Environmental Management: Biodiversity Act (Act No. 10, 2004), remaining areas of this vegetation type are protected.

According to the Mpumalanga Biodiversity Conservation Plan (MBCP), the remaining areas of natural vegetation within the study area are classified as "Highly Significant". The MBCP identifies Critical Biodiversity Areas (CBAs) at different hierarchical levels, which are terrestrial and aquatic features in the landscape that are critical for conserving biodiversity and maintaining ecosystem functioning. The MBCP identifies CBAs at different levels with decreasing biodiversity importance, as follows:

- Protected areas
- Irreplaceable areas
- Highly significant areas
- Important and necessary areas
- Least concern areas
- No natural habitat remaining areas

2.14.2.2 Vegetation Patterns on Site

The vegetation on the Lusthof site consists of some fragmented areas of natural grassland and some wetland vegetation (Figure 2.14.2.2 (a)). Large proportions of the site have been previously cultivated or are currently under cultivation. There are significant areas dominated by alien trees, primarily *Acacia mearnsii*. Some of these areas are dense stands of alien trees and others are scattered trees within degraded or previously transformed grassland.

The natural grassland on site is not particularly species-rich. It is dominated by the grasses, *Eragrostis curvula*, *Tristachya leucothrix* and *Themeda triandra*, and the herbs *Rumex acetosylla*, *Lobelia flaccida* and *Helichrysum aureonitens*. This species composition is typical of wet grasslands associated with the boundaries of permanent wetland areas and suggests that most of the grassland on site is within a water seepage area. The site is on a watershed (approximately through the centre of the site where the road passes through the site). This explains the low species richness, which is typical of seasonal to temporary wetlands in comparison to terrestrial grasslands.

Other species often associated with seasonal to temporary wetlands that were found within the grasslands on site are the following: *Pseudognaphalium luteo-album*, *Pelargonium luridum*, *Fuirena pubescens*, *Hyparrhenia dregeana*, *Senecio erubescens* subsp. *crepidifolia*, Hydrocotyl species*, Monopsis decipiens, Cirsium vulgare, Agrostis erianthe* and *Oenothera stricta.*

Drainage lines through the grasslands contained species more typical of permanently wet areas, such as *Cyperus denudatus*, *Andropogon appendiculatus*, *Scirpoides burkei*, *Kyllinga alata*, *Juncus lomatophyllous*, *Juncus oxycarpus, Juncus effusus, Isolepis cernua, Leersia hexandra, Diclis reptans* and *Eleocharis dregeana.*

There are many wet areas, mostly outside of the mapped grassland areas, that have been disturbed or ploughed.

Figure 2.14.2.2 (a): Vegetation patterns within the Lusthof Study site.

The transformed grasslands within the proposed mining footprint comprise predominantly the exotic kikuyu, *Pennisetum clandistenum* and *Eragrostis plana*.

The wetlands and aquatic systems have been addressed independently of this vegetation assessment.

2.15 ANIMAL LIFE BASE LINE

Wetland Consulting Services (Pty) Ltd were appointed by JMA Consulting to assess the faunal biodiversity of the Lusthof site. The animal life base line description compiled by them is reproduced in its entirety in this section.

A field survey was conducted in December 2010 to assess the study area. This assessment included identifying the types of habitat available and opportunistically surveying the site for signs of species presence (tracks, scats, skulls, visual sightings).

2.15.1 Current Habitat Status

Using information on individual mammal species habitat requirements and the data gained during the field survey it was possible to determine the likelihood of each species occurring based on the presence or absence of important habitat features and the levels of human disturbance.

The list of bird species present within the QDS's mentioned above was obtained from the South African Bird Atlas Project (SABAP 1) conducted by the Animal Demography Unit, University of Cape Town South and the South African National Biodiversity Institute.

Information on the distribution ranges of reptile and amphibian species was gained from various reference texts and Red Data books, and in the case of reptiles, additional distribution data was obtained from the website of the South African Reptile Conservation Assessment (SARCA).

The vegetation across the study area is of the Grassland Biome, and more specifically forms part of the Eastern Highveld Grassland bioregion (Figure 2.15.1(a) - Mucina and Rutherford 2006). This vegetation unit is considered Endangered due to limited protection in conservation areas and habitat destruction. Eastern Highveld Grassland is characterised by short, dense grasses dominated by species of the genus's *Aristida, Digitaria, Eragrostis, Themeda* and *Tristachya*. Small, scattered rocky outcrops with wiry, sour grasses and some woody species occur within this grassland type.

Habitat selection by an animal takes into account a number of biotic and abiotic factors, including plant species present, vegetation structure, topography, pedology, climate, distance to water, and presence of rocky outcrops, trees, predators and sufficient food. The level of human disturbance is also an important factor influencing habitat selection.

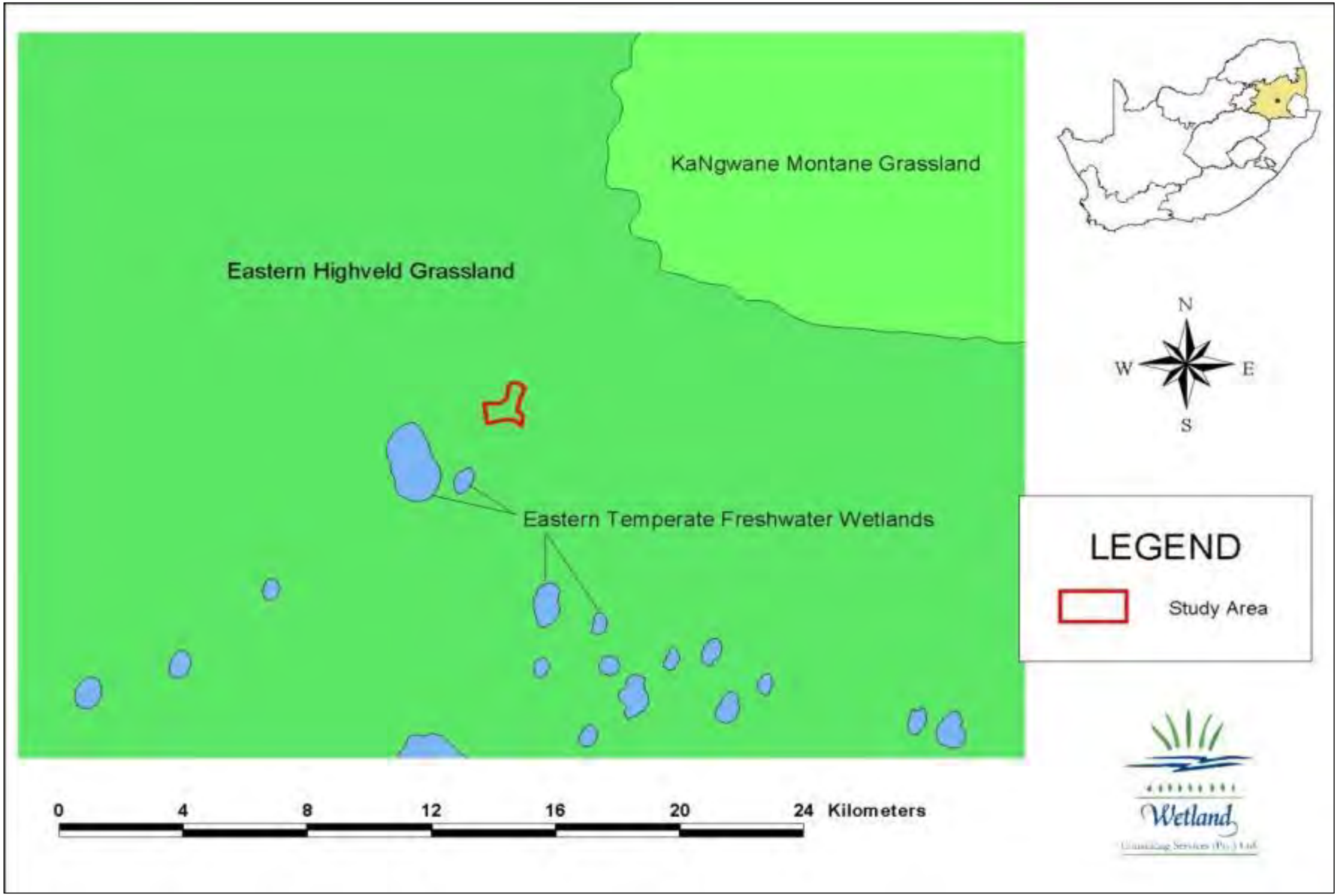


Figure 2.15.1 (a): Vegetation types across the site and in the surrounding landscape (Mucina & Rutherford 2006).

Within the study area the main habitat types available are short to medium height mesic grasslands occurring in a mosaic pattern and riparian and wetland habitat, including floodplains, channelled and unchannelled valley bottom wetlands, and hillslope seepage wetlands. Large stands of exotic black wattle also occur, providing additional habitat diversity. Therefore, the species most likely to occur are grassland specialists, species linked to wet habitats and those with wide habitat tolerances. The wooded areas provide additional cover and provide woodland species with some suitable habitat.

Some of the habitat types observed during the field survey are shown in the photographs below (Table 2.15.1 (a)). Some of the disturbances in the study area include rural dwellings, farm buildings, dirt roads, and cultivated and cattle-grazed land. Although not directly within the study area, large water impoundments occur within wetland areas close to the site.

Table 2.15.1 (a): Series of photographs showing the various habitats present.

2.15.2 Mammals

The results of the literature review suggest that 85 mammal species potentially occur within the study area based on their distribution ranges alone, 29 of these species being of conservation concern (Endangered, Near-threatened, Vulnerable) or Data Deficient. No Red Data List mammal species were observed during the field survey.

A list of all Red Data List mammal species recorded for the study is provided below, including their likelihood of occurrence based upon habitat suitability within the study area (Table 2.15.2 (a)). In addition to Red Data List species, mammal species considered endemic to South Africa, "Protected" under the National Environmental Management: Biodiversity Act (NEMBA) or of "Conservation value" according to the Mpumalanga Nature Conservation Act (MNCA) have also been highlighted. Both the Spotted-necked otter (*Lutra maculicollis*) and the Water rat (*Dasymys incomtus*), both listed as Near Threatened, are likely to occur in the study area based on their habitat requirements, the presence of suitable habitat and the levels of human disturbance.

The Oribi (*Ourebia ourebi*) is likely to occur in the area based on the current habitat availability and has been observed in the area. This does not preclude the possibility of other Red Data List species occurring in the study area, they are merely less likely to occur. A list of mammal species observed on site is included in Table 2.15.2(b). A list of mammal species potentially occurring in the area has been included as Table 2.15.2 (c).

Table 2.15.2 (a): Red Data List - Mammal species potentially occurring within QDS 2630 AA, AB, AC and AD and their likelihood of occurrence within the study area.

Species	Common Name	IUCN (Red Data List Status)	Endemic	NEMBA	MNCA	Likelihood of Occurrence
Amblysomus septentrionalis	Highveld golden mole	NT				may occur
Chrysospalax villosus	Rough-haired golden mole	CR	√	√		may occur
Aonyx capensis	Cape clawless otter	LC			√	likely
Lutra maculicollis	Spotted-necked otter	NT		√	√	likely
Mellivora capensis	Honey badger (Ratel)	NT		√	√	unlikely
Parahyaena brunnea	Brown hyaena	NT		√	√	may occur
Poecilogale albinucha	Striped weasel	DD				may occur
Vulpes chama	Cape fox	LC		√		unlikely
Miniopterus schreibersii	Schreibers' long-fingered bat	NT				unlikely
Myotis tricolor	Temminck's hairy bat	NT				unlikely
Myotis welwitschii	Welwitsch's hairy bat	NT				may occur
Rhinolophus clivosus	Geoffrey's horseshoe bat	NT				unlikely
Rhinolophus	Darling's horseshoe	NT				unlikely

Species	Common Name	IUCN (Red Data List Status)	Endemic	NEMBA	MNCA	Likelihood of Occurrence
darlingi	bat					
Atelerix frontalis	South African hedgehog	NT		√	√	may occur
Crocidura cyanea	Reddish-grey musk shrew	DD				unlikely
Crocidura flavescens	Greater musk shrew	DD				may occur
Crocidura fuscomurina	Tiny musk shrew	DD				unlikely
Crocidura hirta	Lesser red musk shrew	DD				may occur
Crocidura mariquensis	Swamp musk shrew	DD				unlikely
Crocidura silacea	Lesser grey-brown musk shrew	DD				may occur
Myosorex cafer	Dark-footed forest shrew	DD				may occur
Myosorex varius	Forest shrew	DD				likely
Suncus infinitesimus	Least dwarf shrew	DD				unlikely
Suncus varilla	Lesser dwarf shrew	DD				unlikely
Manis temminckii	Pangolin	VU		√	√	unlikely
Dasymys incomtus	Water rat	NT				likely
Georychus capensis	Cape mole-rat	LC	√			likely
Graphiurua platyops	Rock dormouse	DD				may occur
Lemniscomys rosalia	Single-striped mouse	DD				likely
Mystromys albicaudatus	White-tailed mouse	EN				may occur
Saccostomus campestris	Pouched mouse	LC			√	may occur
Tatera leucogaster	Bushveld gerbil	DD				unlikely
Oreotragus oreotragus	Klipspringer	LC			√	unlikely
Ourebia ourebi	Oribi	EN			√	Likely/observed
Raphicerus campestris	Steenbok	LC			√	likely
Felis nigripes	Black-footed Cat	VU	√			may occur
Leptailurus serval	Serval	LC				may occur
Orycteropus afer	Aardvark	LC			√	likely

Note: (DD = Data Deficient, EN = Endangered, NT = Near Threatened, VU = Vulnerable and (E) = Endemic)

Table 2.15.2 (b): List of mammal species observed during field surveys within the study area.

Order	Species	Common Name
Carnivora	*Canis mesomelas*	Black-backed jackal
Rodentia	*Otomys irroratus*	Vlei rat
Ruminantia	*Raphicerus campestris*	Steenbok
Ruminantia	*Sylvicapra grimmia*	Common duiker
Ruminantia	*Ourebia ourebi*	Oribi
Ruminantia	*Redunca arundinum*	Reedbuck
Carnivora	*Aonyx capensis*	Cape clawless otter
Carnivora	*Atilax paludinosus*	Water/Marsh mongoose
Lagomorpha	*Lepus saxatillus*	Scub hare/Savannah hare
Tubulidentata	*Orycteropus afer*	Aardvark

Table 2.15.2 (c) Mammal Species Potentially Occurring in the Area

ORDER	SPECIES	COMMON NAME
Afrosoricida	*Amblysomus septentrionalis*	Highveld golden mole
Afrosoricida	*Chrysospalax villosus*	Rough-haired golden mole
Carnivora	*Aonyx capensis*	Cape clawless otter
Carnivora	*Atilax paludinosus*	Water/Marsh mongoose
Carnivora	*Canis mesomelas*	Black-backed jackal
Carnivora	*Caracal caracal*	Caracal
Carnivora	*Cynictis penicillata*	Yellow mongoose
Carnivora	*Felis silvestris*	African wild cat
Carnivora	*Galerella sanguinea*	Slender mongoose
Carnivora	*Genetta genetta*	Small-spotted genet
Carnivora	*Genetta tigrina*	Large-spotted genet
Carnivora	*Helogale parvula*	Dwarf mongoose
Carnivora	*Ichneumia albicauda*	White-tailed mongoose
Carnivora	*Ictonyx striatus*	Striped polecat
Carnivora	*Lutra maculicollis*	Spotted-necked otter
Carnivora	*Mellivora capensis*	Honey badger (Ratel)
Carnivora	*Mungos mungo*	Banded mongoose
Carnivora	*Parahyaena brunnea*	Brown hyaena
Carnivora	*Poecilogale albinucha*	Striped weasel
Carnivora	*Proteles cristatus*	Aardwolf
Carnivora	*Suricata suricatta*	Suricate
Carnivora	*Vulpes chama*	Cape fox
Chiroptera	*Epomophorus wahlbergi*	Wahlberg's epauletted fruit bat
Chiroptera	*Miniopterus schreibersii*	Schreibers' long-fingered bat
Chiroptera	*Myotis tricolor*	Temminck's hairy bat
Chiroptera	*Myotis welwitschii*	Welwitsch's hairy bat
Chiroptera	*Neoromicia capensis*	Cape serotine bat
Chiroptera	*Nycteris thebaica*	Egyptian slit-faced bat
Chiroptera	*Pipistrellus hesperidus*	African pipistrelle
Chiroptera	*Rhinolophus clivosus*	Geoffrey's horseshoe bat
Chiroptera	*Rhinolophus darlingi*	Darling's horseshoe bat
Chiroptera	*Tadarida aegyptiaca*	Egyptian free-tailed bat
Eulipotyphla	*Atelerix frontalis*	South African hedgehog
Eulipotyphla	*Crocidura cyanea*	Reddish-grey musk shrew

ORDER	SPECIES	COMMON NAME
Eulipotyphla	*Crocidura flavescens*	Greater musk shrew
Eulipotyphla	*Crocidura fuscomurina*	Tiny musk shrew
Eulipotyphla	*Crocidura hirta*	Lesser red musk shrew
Eulipotyphla	*Crocidura mariquensis*	Swamp musk shrew
Eulipotyphla	*Crocidura silacea*	Lesser grey-brown musk shrew
Eulipotyphla	*Myosorex cafer*	Dark-footed forest shrew
Eulipotyphla	*Myosorex varius*	Forest shrew
Eulipotyphla	*Suncus infinitesimus*	Least dwarf shrew
Eulipotyphla	*Suncus varilla*	Lesser dwarf shrew
Hyracoidea	*Procavia capensis*	Rock dassie
Lagomorpha	*Lepus capensis*	Cape hare/Desert hare
Lagomorpha	*Lepus saxatillus*	Scub hare/Savannah hare
Lagomorpha	*Pronolagus crassicaudatus*	Natal red rock rabbit
Lagomorpha	*Pronolagus saundersiae*	Hewitt's red rock rabbit
Macroscelidea	*Elephantulus myurus*	Rock elephant-shrew
Pholidota	*Manis temminckii*	Pangolin
Primata	*Cercopithecus aethiops*	Vervet monkey
Primata	*Papio ursinus*	Chacma baboon
Rodentia	*Aethomys ineptus*	Tete veld rat
Rodentia	*Cryptomys hottentotus*	Common mole-rat
Rodentia	*Dasymys incomtus*	Water rat
Rodentia	*Dendromus melanotis*	Grey climbing mouse
Rodentia	*Dendromus mesomelas*	Brant's climbing mouse
Rodentia	*Dendromus mystacalis*	Chestnut climbing mouse
Rodentia	*Georychus capensis*	Cape mole-rat
Rodentia	*Graphiurua platyops*	Rock dormouse
Rodentia	*Graphiurus murinus*	Woodland dormouse
Rodentia	*Hystrix africaeaustralis*	Porcupine
Rodentia	*Lemniscomys rosalia*	Single-striped mouse
Rodentia	*Mastomys coucha*	Multimammate mouse
Rodentia	*Mastomys natalensis*	Natal multimammate mouse
Rodentia	*Micaelamys namaquensis*	Namaqua rock mouse
Rodentia	*Mus indutus*	Desert pygmy mouse
Rodentia	*Mus minutoides*	Pygmy mouse

ORDER	SPECIES	COMMON NAME
Rodentia	*Mystromys albicaudatus*	White-tailed mouse
Rodentia	*Otomys angoniensis*	Angoni vlei rat
Rodentia	*Otomys irroratus*	Vlei rat
Rodentia	*Rhabdomys pumilio*	Striped mouse
Rodentia	*Saccostomus campestris*	Pouched mouse
Rodentia	*Steatomys pratensis*	Fat mouse
Rodentia	*Tatera bransii*	Highveld gerbil
Rodentia	*Tatera leucogaster*	Bushveld gerbil
Rodentia	*Thallomys paedulcus*	Tree mouse
Rodentia	*Thryonomys swinderianus*	Greater cane rat
Ruminantia	*Oreotragus oreotragus*	Klipspringer
Ruminantia	*Ourebia ourebi*	Oribi
Ruminantia	*Raphicerus campestris*	Steenbok
Ruminantia	*Sylvicapra grimmia*	Common duiker
Ruminantia	*Redunca arundinum*	Reedbuck
Suiformes	*Phacochoerus africanus*	Warthog
Suiformes	*Potamochoerus porcus*	Bushpig
Tubulidentata	*Orycteropus afer*	Aardvark

2.15.3 Birds

The list of bird species extracted from SABAP 1 for the four QDS's are actual recent sightings of those species by individuals and therefore constitute the actual bird species assemblage within the area (although it is recognised that it may not be a complete list). The bird species list includes 280 bird species, 25 of which are of conservation concern (Table 2.15.3 (a)).

No Red Data List bird species were observed during this field survey, although two Critically Endangered species, the Eurasian Bittern and the Wattled Crane have both been sighted in the area in the past, and the Near Threatened Secretary bird and Vulnerable Grey crowned crane were both sighted within the study area by either local farmers or consultants during the scoping stage of this project.

The bulk of the species diversity is made up of grassland birds and water birds, as is expected given the nature of the available habitats in the area. A list of bird species potentially occurring in the area has been included as Table 2.15.3 (b).

Table 2.15.3 (a): Red Data List bird species occurring within QDS 2630 AA, AB, AC and AD.

Species	Common Name	Conservation Status	Observed on Site
Botaurus stellaris	Eurasian (Great) Bittern	CR	
Bugeranus carunculatus	Wattled Crane	CR	
Ciconia nigra	Black Stork	NT	
Mycteria ibis	Yellow-billed Stork	NT	
Phoenicopterus ruber	Greater Flamingo	VU	
Phoenicopterus minor	Lesser Flamingo	VU	
Sagittarius serpentarius	**Secretarybird**	**NT**	**X**
Falco biarmicus	Lanner Falcon	NT	
Eupodotis caerulescens	Blue Korhaan	NT	
Lissotis melanogaster	Black-bellied Bustard	NT	
Charadrius pallidus	Chestnut-banded Plover	NT	
Vanellus melanopterus	Black-winged Lapwing (Plover)	NT	
Glareola nordmanni	Black-winged Pratincole	NT	
Alcedo semitorquata	Half-collared Kingfisher	NT	
Geronticus calvus	Southern Bald (Bald) Ibis	VU	
Gyps coprotheres	Cape Vulture (Griffon)	VU	
Polemaetus bellicosus	Martial Eagle	VU	
Circus ranivorus	African Marsh-Harrier	VU	
Falco naumanni	Lesser Kestrel	VU	
Anthropoides paradiseus	Blue Crane	VU	
Balearica regulorum	**Grey Crowned- (Crowned) Crane**	**VU**	**X**
Neotis Denham	Denham's (Stanley's) Bustard	VU	
Eupodotis senegalensis	White-bellied Korhaan	VU	
Tyto capensis	African Grass-Owl	VU	

Note: (CR = Critically Endangered, EN = Endangered, NT = Near Threatened, VU = Vulnerable)

Table 2.15.3 (b) Bird Species Potentially Occurring in the Area

ROBERTS NUMBER	SPECIES	COMMON NAME
6	*Podiceps cristatus*	Great Crested Grebe
7	*Podiceps nigricollis*	Black-necked Grebe
8	*Tachybaptus ruficollis*	Little Grebe (Dabchick)
55	*Phalacrocorax lucidus*	White-breasted (Great) Cormorant
58	*Phalacrocorax africanus*	Reed (Long-tailed) Cormorant
60	*Anhinga rufa*	African Darter
62	*Ardea cinerea*	Grey Heron
63	*Ardea melanocephala*	Black-headed Heron
64	*Ardea goliath*	Goliath Heron
65	*Ardea purpurea*	Purple Heron
66	*Egretta alba*	Great Egret
67	*Egretta garzetta*	Little Egret
68	*Egretta intermedia*	Yellow-billed (Intermediate) Egret
69	*Egretta ardesiaca*	Black Heron
71	*Bubulcus ibis*	Cattle Egret
72	*Ardeola ralloides*	Squacco Heron
76	*Nycticorax nycticorax*	Black-crowned Night-Heron
80	*Botaurus stellaris*	Eurasian (Great) Bittern
81	*Scopus umbretta*	Hamerkop
83	*Ciconia ciconia*	White Stork
84	*Ciconia nigra*	Black Stork
85	*Ciconia abdimii*	Abdim's Stork
89	*Leptoptilos crumeniferus*	Marabou Stork
90	*Mycteria ibis*	Yellow-billed Stork
91	*Threskiornis aethiopicus*	African Sacred (Sacred) Ibis
92	*Geronticus calvus*	Southern Bald (Bald) Ibis
93	*Plegadis falcinellus*	Glossy Ibis
94	*Bostrychia hagedash*	Hadeda Ibis
95	*Platalea alba*	African Spoonbill
96	*Phoenicopterus ruber*	Greater Flamingo
97	*Phoenicopterus minor*	Lesser Flamingo
99	*Dendrocygna viduata*	White-faced (Whistling-) Duck
100	*Dendrocygna bicolor*	Fulvous (Whistling) Duck
101	*Thalassornis leuconotus*	White-backed Duck
102	*Alopochen aegyptiaca*	Egyptian Goose
103	*Tadorna cana*	South African Shelduck
104	*Anas undulata*	Yellow-billed Duck
105	*Anas sparsa*	African Black Duck
106	*Anas capensis*	Cape Teal
107	*Anas hottentota*	Hottentot Teal
108	*Anas erythrorhyncha*	Red-billed Teal (Duck)
112	*Anas smithii*	Cape Shoveler
113	*Netta erythrophthalma*	Southern Pochard
115	*Sarkidiornis melanotos*	Comb (Knob-billed) Duck
116	*Plectropterus gambensis*	Spur-winged Goose
117	*Oxyura maccoa*	Maccoa Duck
118	*Sagittarius serpentarius*	Secretarybird
122	*Gyps coprotheres*	Cape Vulture (Griffon)
126	*Milvus migrans*	Black & Yellowbilled Kite (pre-split)
127	*Elanus caeruleus*	Black-shouldered (Winged) Kite
135	*Aquila wahlbergi*	Wahlberg's Eagle
139	*Lophaetus occipitalis*	Long-crested Eagle
140	*Polemaetus bellicosus*	Martial Eagle

ROBERTS NUMBER	SPECIES	COMMON NAME
142	*Circaetuscinereus*	Brown Snake-Eagle
148	*Haliaeetus vocifer*	African Fish-Eagle
149	*Buteo vulpinus*	Steppe (Common) Buzzard
152	*Buteo rufofuscus*	Jackal Buzzard
155	*Accipiter rufiventris*	Rufous-chested (Red-breasted) Sparrowhawk
157	*Accipiter minullus*	Little Sparrowhawk
158	*Accipiter melanoleucus*	Black Sparrowhawk (Goshawk)
160	*Accipiter tachiro*	African Goshawk (incl. Red-chested)
165	*Circus ranivorus*	African Marsh-Harrier
169	*Polyboroides typus*	African Harrier-Hawk (Gymnogene)
172	*Falco biarmicus*	Lanner Falcon
179	*Falco vespertinus*	Red-footed (Western Red-footed) Falcon (Kestrel
180	*Falco amurensis*	Amur (Eastern Red-footed) Falcon (Kestrel)
181	*Falco rupicolus*	Rock Kestrel
182	*Falco rupicoloides*	Greater Kestrel
183	*Falco naumanni*	Lesser Kestrel
190	*Scleroptila africanus*	Grey-winged Francolin
192	*Scleroptila levaillantii*	Red-winged Francolin
196	*Pternistis natalensis*	Natal Spurfowl (Francolin)
199	*Pternistis swainsonii*	Swainson's Spurfowl (Francolin)
200	*Coturnix coturnix*	Common Quail
201	*Coturnix delegorguei*	Harlequin Quail
203	*Numida meleagris*	Helmeted Guineafowl
205	*Turnix sylvaticus*	Kurrichane (Small) Buttonquail
207	*Bugeranus carunculatus*	Wattled Crane
208	*Anthropoides paradiseus*	Blue Crane
209	*Balearica regulorum*	Grey Crowned- (Crowned) Crane
210	*Rallus caerulescens*	African Rail
213	*Amaurornis flavirostris*	Black Crake
217	*Sarothrura rufa*	Red-chested Flufftail
223	*Porphyrio madagascariensis*	African Purple (Purple) Swamphen (Gallinule)
226	*Gallinula chloropus*	Common Moorhen
228	*Fulica cristata*	Red-knobbed Coot
231	*Neotis denham*	Denham's (Stanley's) Bustard
233	*Eupodotis senegalensis*	White-bellied Korhaan
234	*Eupodotis caerulescens*	Blue Korhaan
238	*Lissotis melanogaster*	Black-bellied Bustard
240	*Actophilornis africanus*	African Jacana
245	*Charadrius hiaticula*	Common Ringed Plover
247	*Charadrius pallidus*	Chestnut-banded Plover
248	*Charadrius pecuarius*	Kittlitz's Plover
249	*Charadrius tricollaris*	Three-banded Plover
255	*Vanellus coronatus*	Crowned Lapwing (Plover)
257	*Vanellus melanopterus*	Black-winged Lapwing (Plover)
258	*Vanellus armatus*	Blacksmith Lapwing (Plover)
260	*Vanellus senegallus*	African Wattled Lapwing (Plover)
262	*Arenaria interpres*	Ruddy Turnstone
264	*Actitis hypoleucos*	Common Sandpiper
266	*Tringa glareola*	Wood Sandpiper
269	*Tringa stagnatilis*	Marsh Sandpiper
270	*Tringa nebularia*	Common Greenshank
272	*Calidris ferruginea*	Curlew Sandpiper
274	*Calidris minuta*	Little Stint

ROBERTS NUMBER	SPECIES	COMMON NAME
284	*Philomachus pugnax*	Ruff
286	*Gallinago nigripennis*	African (Ethiopian) Snipe
294	*Recurvirostra avosetta*	Pied (Avocet) Avocet
295	*Himantopus himantopus*	Black-winged Stilt
297	*Burhinus capensis*	Spotted Thick-knee (Dikkop)
300	*Cursorius temminckii*	Temminck's Courser
305	*Glareola nordmanni*	Black-winged Pratincole
315	*Larus cirrocephalus*	Grey-headed Gull
338	*Chlidonias hybrida*	Whiskered Tern
339	*Chlidonias leucopterus*	White-winged Tern
348	*Columba livia*	Rock (Feral) Dove (Pigeon)
349	*Columba guinea*	Speckled (Rock) Pigeon
350	*Columba arquatrix*	African Olive- (Rameron) Pigeon
352	*Streptopelia semitorquata*	Red-eyed Dove
354	*Streptopelia capicola*	Cape Turtle (Ring-necked) Dove
355	*Streptopelia senegalensis*	Laughing (Palm) Dove
356	*Oena capensis*	Namaqua Dove
358	*Turtur chalcospilos*	Emerald-spotted Wood-Dove
360	*Aplopelia larvata*	Lemon (Cinnamon) Dove
375	*Cuculus gularis*	African Cuckoo
377	*Cuculus solitarius*	Red-chested Cuckoo
378	*Cuculus clamosus*	Black Cuckoo
385	*Chrysococcyx klaas*	Klaas's Cuckoo
386	*Chrysococcyx caprius*	Dideric (Diederik) Cuckoo
392	*Tyto alba*	Barn Owl
393	*Tyto capensis*	African Grass-Owl
395	*Asio capensis*	Marsh Owl
400	*Bubo capensis*	Cape Eagle-Owl
401	*Bubo africanus*	Spotted Eagle-Owl
405	*Caprimulgus pectoralis*	Fiery-necked Nightjar
412	*Apus barbatus*	African Black (Black) Swift
415	*Apus caffer*	White-rumped Swift
417	*Apus affinis*	Little Swift
418	*Tachymarptis melba*	Alpine Swift
421	*Cypsiurus parvus*	African Palm-Swift
424	*Colius striatus*	Speckled Mousebird
426	*Urocolius indicus*	Red-faced Mousebird
428	*Ceryle rudis*	Pied Kingfisher
429	*Megaceryle maximus*	Giant Kingfisher
430	*Alcedo semitorquata*	Half-collared Kingfisher
431	*Alcedo cristata*	Malachite Kingfisher
435	*Halcyon albiventris*	Brown-hooded Kingfisher
444	*Merops pusillus*	Little Bee-eater
446	*Coracias garrulus*	European Roller
447	*Coracias garrulus*	Lilac-breasted Roller
451	*Upupu africana*	African Hoopoe
452	*Phoeniculus purpureus*	Green (Red-billed) Wood-hoopoe
464	*Lybius torquatus*	Black-collared Barbet
465	*Tricholaema leucomelas*	Acacia Pied (Pied) Barbet
473	*Trachyphonus vailantii*	Crested Barbet
474	*Indicator indicator*	Greater Honeyguide
478	*Prodotiscus regulus*	Brown-backed (Sharp-billed) Honeybird (Honeyguide)
480	*Geocolaptes olivaceus*	Ground Woodpecker
486	*Dendrospicos fuscescens*	Cardinal Woodpecker

ROBERTS NUMBER	SPECIES	COMMON NAME
488	*Dendrospicos griseocephalus*	Olive Woodpecker
489	*Jynx ruficollis*	Red-throated Wryneck
494	*Mirafra africana*	Rufous-naped Lark
495	*Mirafra sp.*	Clapper Lark (pre-split)
498	*Calendulauda sabota*	Sabota Lark
500	*Certhilauda sp.*	Longbilled Lark (pre-split)
506	*Chersomanes albofasciata*	Spike-heeled Lark
507	*Callandrella cinerea*	Red-capped Lark
508	*Spizocorys conirostris*	Pink-billed Lark
518	*Hirundo rustica*	Barn (European) Swallow
520	*Hirundo albigularis*	White-throated Swallow
522	*Hirundo smithii*	Wire-tailed Swallow
523	*Hirundo dimidiata*	Pearl-breasted Swallow
524	*Hirundo semirufa*	Red-breasted (Rufous-chested) Swallow
526	*Hirundo cucullata*	Greater Striped-Swallow
528	*Hirundo spilodera*	South African Cliff-Swallow
529	*Hirundo fuligula*	Rock Martin
530	*Delichon urbicum*	Common House-Martin
532	*Riparia riparia*	Sand Martin (Bank Swallow)
533	*Riparia paludicola*	Brown-throated (Plain) Martin
534	*Riparia cincta*	Banded Martin
536	*Psalidoprocne holomelaena*	Black Saw-wing
541	*Dicrurus adsimilis*	Fork-tailed Drongo
545	*Oriolus larvatus*	Black-headed (Eastern) Oriole
547	*Corvus capensis*	Cape (Black) Crow
548	*Corvus albus*	Pied Crow
550	*Corvus albicollis*	White-necked Raven
568	*Pycnonotus tricolor*	Dark-capped (Black-eyed) Bulbul
572	*Andropadus importunus*	Sombre Greenbul (Bulbul)
576	*Turdus libonyanus*	Kurrichane Thrush
577	*Turdus olivaceus*	Olive Thrush (pre-split)
580	*Psophocichla litsitsirupa*	Groundscraper Thrush
581	*Monticola rupestris*	Cape Rock-Thrush
582	*Monticola explorator*	Sentinel Rock-Thrush
586	*Oenanthe monticola*	Mountain Chat (Wheatear)
587	*Oenanthe pileata*	Capped Wheatear
588	*Oenanthe bifasciata*	Buff-streaked Chat (Wheatear)
589	*Cercomela familiaris*	Familiar Chat
593	*Thamnolaea cinnamomeiventris*	Mocking Cliff-Chat
595	*Myrmecocichla formicivora*	Ant-eating Chat
596	*Saxicola torquatus*	African (Common) Stonechat
601	*Cossypha caffra*	Cape Robin-Chat
613	*Cercotrichas leucophrys*	White-browed (Red-backed) Scrub-Robin
628	*Acrocephalus arundinaceus*	Great Reed-Warbler
631	*Acrocephalus baeticatus*	African (African Marsh-Warbler) Reed-Warbler
634	*Acrocephalus schoenobaenus*	Sedge Warbler
635	*Acrocephalus gracilirostris*	Lesser Swamp- (Cape Reed) Warbler
638	*Bradypterus baboecala*	Little Rush- (African Sedge) Warbler
643	*Phylloscopus trochilus*	Willow Warbler
645	*Apalis thoracica*	Bar-throated Apalis
661	*Sphenoeacus afer*	Cape Grassbird
664	*Cisticola juncidis*	Zitting (Fan-tailed) Cisticola
666	*Cisticola textrix*	Cloud (Tink-tink) Cisticola
667	*Cisticola ayresii*	Wing-snapping (Ayre's) Cisticola

ROBERTS NUMBER	SPECIES	COMMON NAME
668	*Cisticola cinnamomeus*	Pale-crowned Cisticola
670	*Cisticola lais*	Wailing Cisticola
677	*Cisticola tinniens*	Le Vaillant's (Tinkling) Cisticola
679	*Cisticola aberrans*	Lazy Cisticola
681	*Cisticola fulvicapilla*	Neddicky (Piping Cisticola)
685	*Prinia flavicans*	Black-chested Prinia
686	*Prinia hypoxantha*	Spotted Prinia (pre-split)
689	*Muscicapa striata*	Spotted Flycatcher
690	*Muscicapa adusta*	African Dusky Flycatcher
698	*Sigelus silens*	Fiscal Flycatcher
700	*Batis capensis*	Cape Batis
706	*Stenostira scita*	Fairy Flycatcher (Warbler)
710	*Trepsiphone viridis*	African Paradise-Flycatcher
711	*Motacilla aquimp*	African Pied Wagtail
712	*Motacilla clara*	Mountain (Long-tailed) Wagtail
713	*Motacilla capensis*	Cape Wagtail
714	*Motacilla flava*	Yellow Wagtail
716	*Anthus cinnamomeus*	African (Grassveld/Grassland) Pipit
717	*Anthus similis*	Long-billed Pipit
727	*Macronyx capensis*	Cape (Orange-throated) Longclaw
731	*Lanius minor*	Lesser Grey Shrike
732	*Lanius collaris*	Common Fiscal
733	*Lanius collurio*	Red-backed Shrike
736	*Laniarius ferrugineus*	Southern Boubou
744	*Tchagra senegalus*	Black-crowned Tchagra
746	*Telophorus zeylonus*	Bokmakierie
750	*Telephorus olivaceus*	Olive Bush-Shrike
753	*Prionops plumatus*	White-crested Helmet-Shrike
758	*Acridotheres tristis*	Common Myna
759	*Spreo bicolor*	Pied (African Pied) Starling
760	*Creatophora cinerea*	Wattled Starling
769	*Onychognathus morio*	Red-winged Starling
775	*Nectarinia famosa*	Malachite Sunbird
785	*Cynnyris afer*	Greater Double-collared Sunbird
792	*Chalcomitra amethystina*	Amethyst (Black) Sunbird
796	*Zosterops virens*	Cape White-eye (pre-split)
801	*Passer domesticus*	House Sparrow
803	*Passer melanurus*	Cape Sparrow
804	*Passer diffusus*	Greyheaded Sparrow (pre-split)
811	*Ploceus cucullatus*	Village (Spotted-backed) Weaver
813	*Ploceus capensis*	Cape Weaver
814	*Ploceus velatus*	Southern Masked-Weaver
821	*Quelea quelea*	Red-billed Quelea
824	*Euplectes orix*	Southern Red (Red) Bishop
826	*Euplectes afer*	Yellow-crowned (Golden) Bishop
827	*Euplectes capensis*	Yellow (Yellow-rumped) Bishop (Widow)
828	*Euplectes axillaris*	Fan-tailed (Red-shouldered) Widowbird
829	*Euplectes albonotatus*	White-winged Widowbird
831	*Euplectes ardens*	Red-collared Widowbird
832	*Euplectes progne*	Long-tailed Widowbird
840	*Lagonosticta rubricata*	African (Blue-billed) Firefinch
846	*Estrilda astrild*	Common Waxbill
852	*Ortygospiza atricollis*	African Quailfinch
854	*Sporaeginthus subflavus*	Orange-breasted (Zebra) Waxbill

ROBERTS NUMBER	SPECIES	COMMON NAME
856	*Amadina erythrocephala*	Red-headed Finch
860	*Vidua macroura*	Pin-tailed Whydah
864	*Vidua funerea*	Dusky Indigobird
869	*Crithagra mozambicus*	Yellow-fronted (eyed) Canary
870	*Crithagra atrogularis*	Black-throated Canary
872	*Serinus canicollis*	Cape (Yellow-crowned) Canary
881	*Crithagra gularis*	Streaky-headed Seedeater (Canary)
884	*Emberiza flaviventris*	Golden-breasted Bunting
885	*Emberiza capensis*	Cape Bunting
886	*Emberiza tahapisi*	Cinnamon-breasted (Rock) Bunting
888	*Milvus migrans parasitus*	Yellow-billed Kite
889	*Milvus migrans*	Black Kite

2.15.4 Reptiles and Amphibians

Though the study focused primarily on bird and mammal species distribution, a list of reptile and amphibian species potentially occurring in the area has been included as Table 2.15.4 (a).

A total of 53 reptile and 21 amphibian species have been reported for the study area or have a distribution range which includes the study area. These results likely reflect a general lack of herpetofaunal sampling rather than low species diversity. The distribution range of the Giant bullfrog (*Pyxicephalus adspersus*; Near Threatened) includes the study area (Du Preez & Carruthers 2009), and numerous pans which would provide suitable habitat are present in the area. Giant bullfrogs are known to not only use pans as habitat, but also use an extensive area surrounding the pans for foraging purposes.

A variety of reptile species potentially occur on the site, including a number of which are endemic to southern Africa. The Southern african python (*Python natalensis*), which has a "Protected" status according to the NEMBA, has been sighted in QDS 2630BA (SARCA 2010) which lies to the east of the site. The Southern african python is known to prefer open savanna regions, particularly rocky areas and riverine scrub (Branch 1998), both habitat types which, while absent from the study site, occur in small or isolated patches in the surrounding area.

The Short-headed legless skink (*Acontias brevicep*) is listed as Near Threatened according to the IUCN Red Data List (IUCN 2010), in part due to the fact that its distribution is restricted to only two isolated populations in the Eastern Cape and Mpumalanga. According to the South African Reptile Conservation Assessment (SARCA 2010), specimens of this species have been recorded in QDS 2630AD (SARCA 2010), which lies to the south east of the site. The Short-headed legless skink prefers montane grassland and is therefore, generally expected to occur further to the east in more mountainous terrain.

Table 2.15.4 (a) Reptile and Ampibian Species Potentially Occurring in the Area

FAMILY	SPECIES	COMMON NAME	CONSERVATION STATUS
Reptiles			
Pelomedusa	*Pelomedusa subrufa*	Marsh/helmeted terrapin	
Typhlopidae	*Typhlops bibronii*	Bibron's blind snake	endemic
Typhlopidae	*Typhlops Ialandei*	Delalande's blind snake	
Leptotyphlopidae	*Leptotyphlops nigricans*	Black thread snake	endemic
Leptotyphlopidae	*Leptotyphlops conjunctus*	Cape thread snake	
Leptotyphlopidae	*Leptotyphlops scutifrons*	Peter's thread snake	
Boidae	*Python natalensis*	Southern african python	
Atractaspididae	*Atractaspis bibronii*	Southern/Bibron's burrowing asp	
Atractaspididae	*Aparallactus capensis*	Cape centipede eater	
Atractaspididae	*Amblyodipsas concolor*	Natal purple-glossed snake	endemic
Colubridae	*Lycodonomorphus rufulus*	Common brown water snake	endemic
Colubridae	*Lamprophis fuliginosus*	Brown house snake	
Colubridae	*Lamprophis inornatus*	Olive house snake	endemic
Colubridae	*Lamprophis aurora*	Aurora house snake	endemic
Colubridae	*Lamprophis guttatus*	Spotted house snake	endemic
Colubridae	*Lamprophis fuscus*	Yellow-bellied house snake	endemic
Colubridae	*Lycophidion capense*	Cape wolf snake	
Colubridae	*Duberria lutrix*	Common slug eater	
Colubridae	*Pseudaspis cana*	Mole snake	
Colubridae	*Psammophylax rhombeatus*	Spotted/Rhombic skaapsteker	
Colubridae	*Psammophylax tritaeniatus*	Striped skaapsteker	
Colubridae	*Psammophis brevirostris*	Short-snouted grass snake	
Colubridae	*Psammophis crucifer*	Cross marked/Montane grass snake	endemic
Colubridae	*Philothamnus semivariegatus*	Spotted bush snake	
Colubridae	*Philothamnus hoplogaster*	Green Water Snake	
Colubridae	*Philothamnus natalensis*	Eastern green snake	endemic
Colubridae	*Dasypeltis scabra*	Common/Rhombic egg eater	
Colubridae	*Crotaphopeltis hotamboeia*	Herald/Red-lipped snake	
Elapidae	*Homoroselaps lacteus*	Spotted Harlequin snake	endemic
Elapidae	*Elapsoidea sundevallii*	Sundevall's garter snake	endemic
Elapidae	*Naja mossambica*	Mozambique Spitting Cobra	
Elapidae	*Hemachatus haemachatus*	Rinkhals	endemic
Viperidae	*Causus rhombeatus*	Common/Rhombic Night adder	
Viperidae	*Bitis arietans*	Puff Adder	
Scincidae	*Acontias breviceps*	Short-headed legless skink	endemic
Scincidae	*Acontias gracilicauda*	Thin-tailed legless skink	endemic
Scincidae	*Mabuya capensis*	Cape skink	
Scincidae	*Mabuya striata*	Striped skink	
Scincidae	*Mabuya varia*	Variable skink	
Lacertidae	*Pedioplanis lineoocellata*	Spotted sand lizard	endemic
Gerrhosauridae	*Gerrhosaurus flavigularis*	Yellow-throated plated lizard	
Cordylidae	*Chamaesara aenea*	Transvaal grass lizard	endemic
Cordylidae	*Cordylus vittifer*	Transvaal girdled lizard	
Cordylidae	*Pseudocordylus melanotus*	Drakensberg crag lizard	endemic

FAMILY	SPECIES	COMMON NAME	CONSERVATION STATUS
Varanidae	*Varanus albigularis*	Rock/White-throated monitor	
Varanidae	*Varanus niloticus*	Nile/Water monitor	
Agamidae	*Agama aculeata*	Ground agama	
Agamidae	*Agama atra atra*	Southern rock agama	
Chamaeleonidae	*Chamaeleo dilepis*	Flap-neck chameleon	
Gekkonidae	*Hemidactylus mabouia*	Moreau's tropical house gecko	
Gekkonidae	*Lygodactylus capensis*	Cape dwarf gecko	
Gekkonidae	*Pachydactylus vansoni*	Van Son's thick-toed gecko	endemic
Gekkonidae	*Pachydactylus capensis*	Cape thick-toed gecko	endemic
Amphibians			
Breviceptidae	*Breviceps mossambicus*	Mozambique rain frog	
Bufonidae	*Amietophrynus gutturalis*	Guttural Toad	
Bufonidae	*Amietophrynus rangeri*	Raucous toad	
Bufonidae	*Poyntonophrynus fenoulheti*	Northern Pygmy toad	
Hyperoliidae	*Hyperolius marmoratus taeniatus*	Painted reed frog	
Hyperoliidae	*Hyperolius semidiscus*	Yellow-striped reed frog	
Hyperoliidae	*Kassina senegalensis*	Bubbling kassina	
Hyperoliidae	*Semnodactylus wealii*	Rattling frog	
Phrynobatrachidae	*Phrynobatrachus natalensis*	Snoring puddle frog	
Pipidae	*Xenopus laevis*	Common platanna	
Ptychadenidae	*Ptychadena porosissima*	Striped grass frog	
Pyxicephalidae	*Amietia angolensis*	Common river frog	
Pyxicephalidae	*Amietia fuscigula*	Cape river frog	
Pyxicephalidae	*Cacosternum boettgeri*	Boettger's caco	
Pyxicephalidae	*Cacosternum nanum*	Bronze caco	
Pyxicephalidae	***Pyxicephalus adspersus***	**Giant bullfrog**	**NT**
Pyxicephalidae	*Strongylopus fasciatus*	Striped stream frog	
Pyxicephalidae	*Strongylopus grayii*	Clicking stream frog	
Pyxicephalidae	*Tomopterna cryptotis*	Tremolo sand frog	
Pyxicephalidae	*Tomopterna natalensis*	Natal sand frog	
Pyxicephalidae	*Tomopterna tandyi*	Tandy's sand frog	

2.15.5 Habitats of Conservation Importance

Within the study area and surrounds, the following habitats were considered to be sensitive and of conservation importance:

- Natural vegetation which has not been cultivated recently or heavily grazed;
- Wetlands and rivers;
- Large water bodies (natural or artificial); and
- Any other areas known to support Red Data List species or which have the potential to do so.

Wetlands and rivers are considered sensitive habitat as they support a different range of species than the surrounding terrestrial landscape, they are an important water and food resource for many species, the transition zone (ecotone) between aquatic and terrestrial habitats is typically species-rich, and rivers form a network of (relatively) natural vegetation along which species can migrate and disperse.

Many of the Red Data List species occurring or potentially occurring in the area are linked to water or wetland habitats, e.g.: African grass-owl, Greater and Lesser flamingo, Water rat and Spotted-necked otter. Both sub-catchments across which the study site lies are considered to be irreplaceable, according to the Mpumalanga C Plan due to their health and possible contribution to meeting Mpumalanga's aquatic biodiversity targets.

Areas of undisturbed grassland are also of significance as they support a diverse granivore and insectivore community (both birds and mammals) which forms an essential food resource for many of the small to medium-sized carnivores, omnivores and birds of prey. Very few areas of completely natural grassland remain in the immediate area due to agriculture, however, areas of wet grassland within wetlands and lightly grazed agricultural land still remain which would provide suitable habitat for grassland specialists.

According to the Mpumalanga C Plan, a portion of the study site and the landscape immediately surrounding the site are of "high significance" in terms of terrestrial biodiversity. According to the MPAES (Mpumalanga Protected Area Expansion Strategy) the study site falls within the proposed Chrissiesmeer Protected Environement and within a Proposed Ramsar site. In addition, the study site also falls within an area earmarked as an ecological corridor by the Mpumalanga C Plan.

Figure 2.15.5 (a) shows the Mpumalanga C Plan Terrestrial Biodiversity Assessment which highlights those areas of importance in meeting future conservation objectives, as well as the proposed ecological corridor, and Figure 2.15.5 (b) shows the habitats considered to be sensitive as a result of the current assessment of the study site.

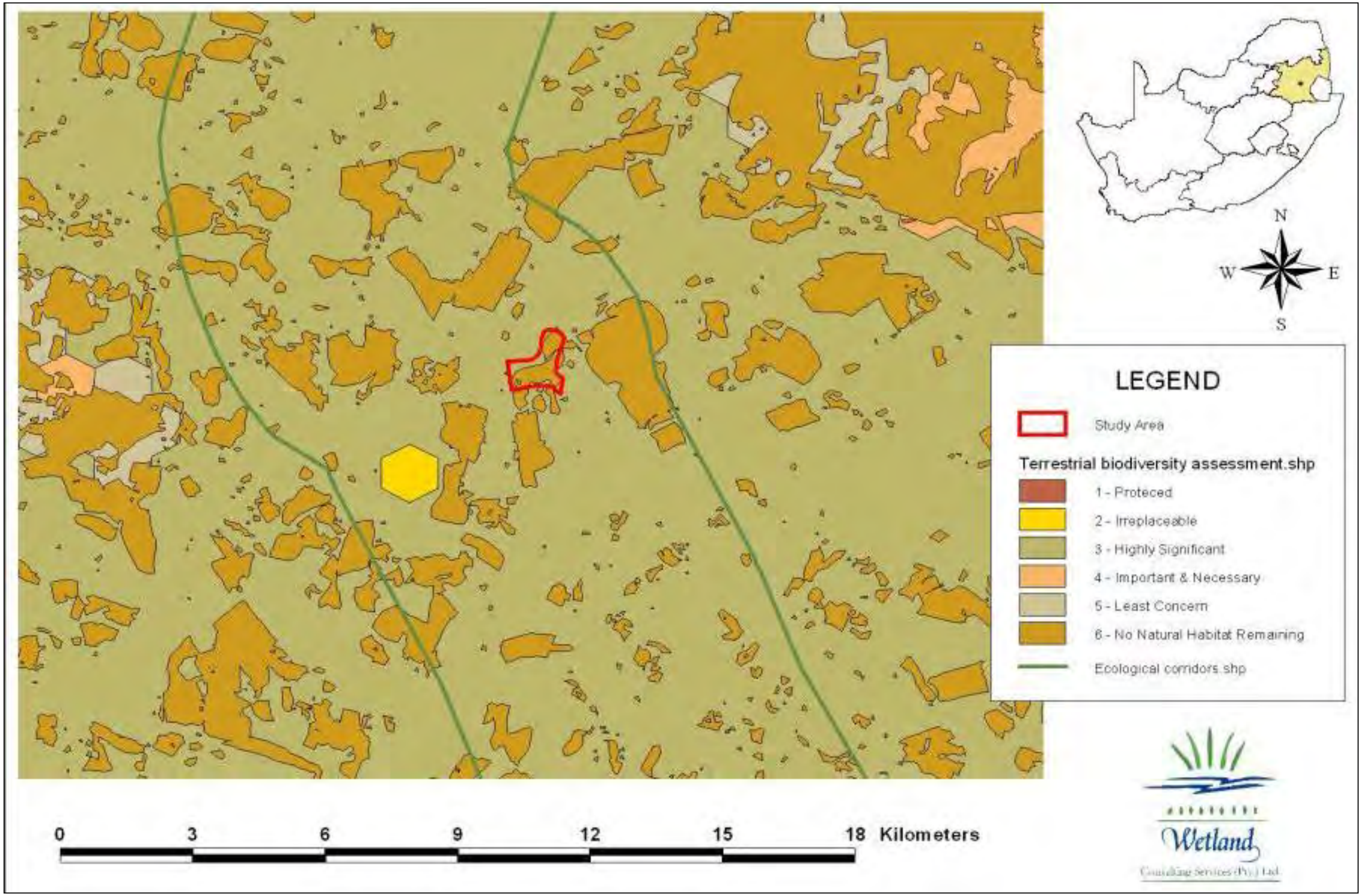


Figure 2.15.5 (a): Mpumalanga C Plan showing the relative importance of various habitats in terms of terrestrial biodiversity for meeting future conservation objectives.

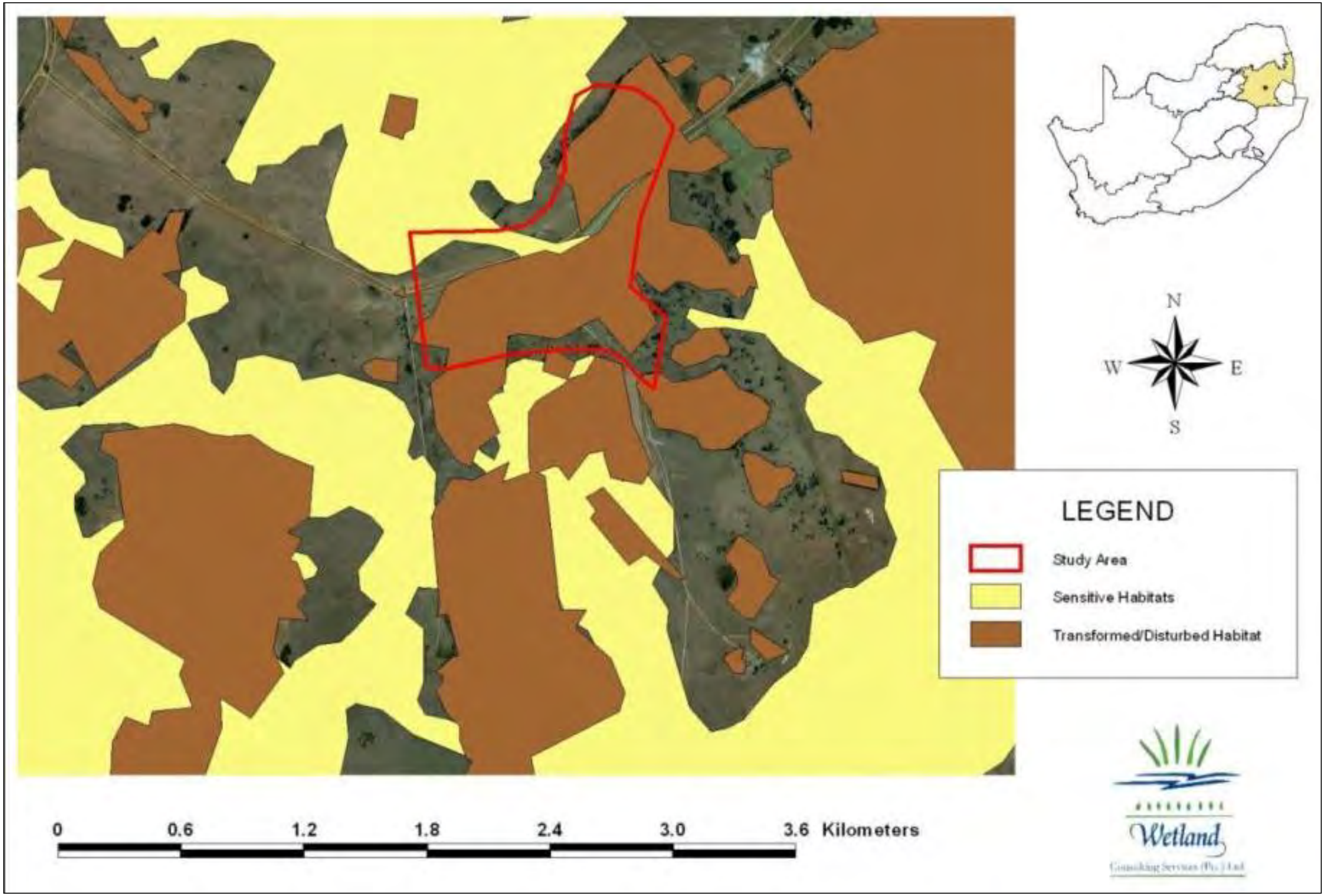


Figure 2.15.5 (b): Map of sensitive habitats and transformed areas on site.

2.16 AQUATIC ECOLOGY BASE LINE (STREAMS, WETLANDS AND PANS)

JMA Consulting (Pty) Ltd appointed Wetland Consulting Services (Pty) to undertake an assessment of aquatic ecosystems affected by proposed mining on Portions 4 and 6 of the Farm Lusthof 60 IT. The aquatic ecology base line description compiled by them is reproduced in its entirety in this section.

2.16.1 Regional Setting of the Study Area

The study area is located in primary catchment W, the Usutu River catchment. The site lies within the upper reaches of the Mpuluzi River, within quaternary catchment W55A as indicated on Figure 2.16.1 (a). The systems on the northern boundary of the farm Lusthof runs directly into the Mpuluzi River, whereas the systems on the southern boundary of the farm, firstly feed the "The Pearl Stream" before flowing into the Mpuluzi River. The site falls on the boundary between two sub-catchments that drain into a number of seasonal and perennial pans, including Tevrede-se-Pan to the southwest.

The Mpuluzi River flows into the Usutu River in Swaziland. The Usutu River, in turn, joins with the Pongola River on the boundary between South Africa and Mozambique. The entire system passes through two provinces (Mpumalanga and Kwa-Zulu Natal) as well as through three countries (South Africa, Swaziland and Mozambique).

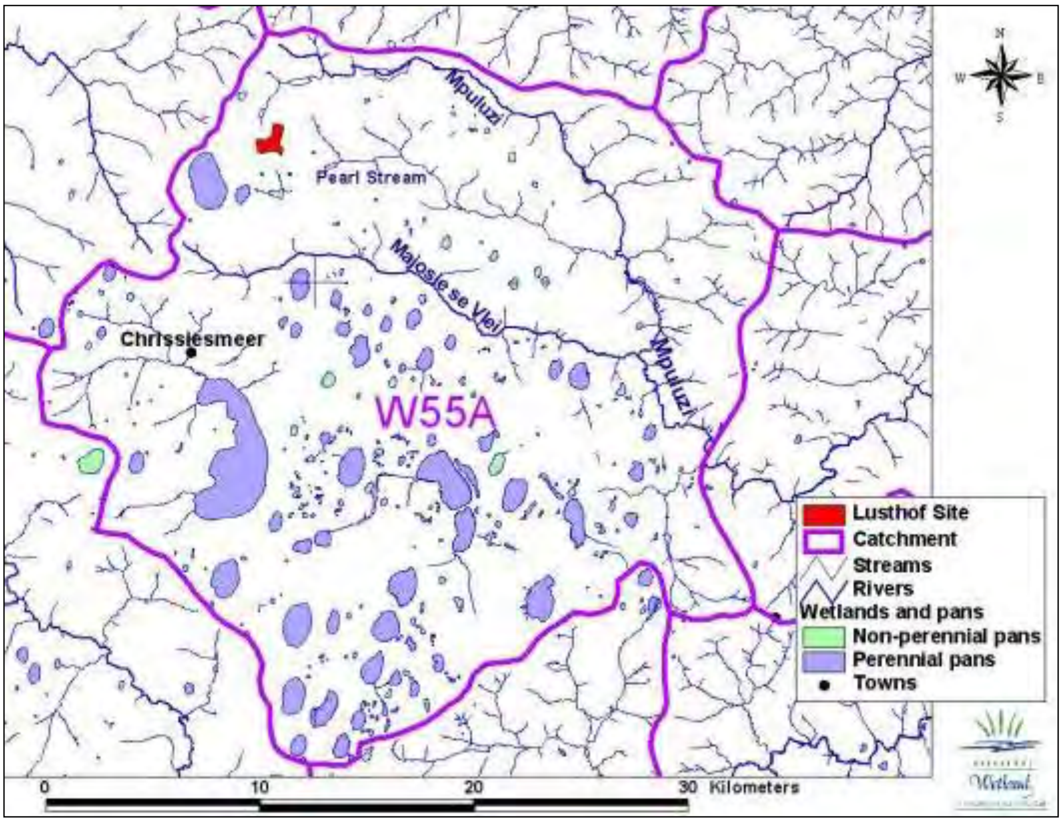


Figure 2.16.1 (a): Water Bodies and W55A Quaternary Catchment Delineation.

2.16.2 Conservation Importance of Quaternary W55A

According to the Mpumalanga Biobase (Ferrar and Lötter 2007*)*, the site falls within the following biodiversity categories:

- Irreplaceable in terms of aquatic biodiversity (Figure 2.16.2 (a))
- Highly significant in terms of terrestrial biodiversity
- A proposed ecological corridor (Figure 2.16.2 (a))

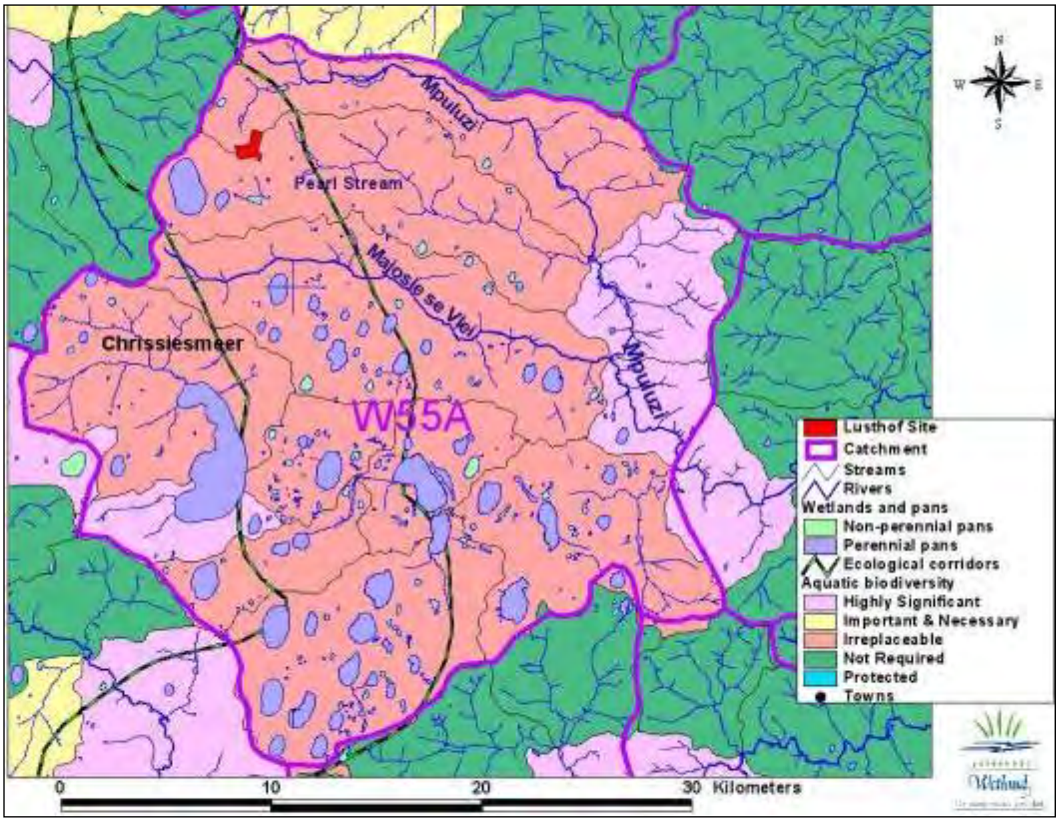


Figure 2.16.2 (a): Ecologically Sensitive & Important Sub-catchments and Corridors according to the Mpumalanga biobase.

According to DWAF Eco-classification (PES/EIS) data (1999), quaternary catchment W55A was classified as:

- High Ecological Importance and Sensitivity
- Category B/Largely Natural PES (small risk allowed)

The ecologically sensitive nature of the area is largely attributable to the prevalence of endoreic pans which usually contain highly sensitive and specialised iota specifically adapted to pan conditions (e.g. fluctuating water levels and high salt content). Pans generally increase the overall biodiversity of an area as each pan may have a signature community specifically adapted to local conditions (i.e. high beta or between-pan diversity). In addition, the abundance of planktonic organisms and invertebrates in pans provide food for a high diversity of water birds and amphibians. In fact, the pans and/or the floodplain wetlands within the vicinity of Lusthof are likely to provide valuable refuge areas for amphibians, birds and possibly fish.

An additional important contribution to biodiversity is made by hillslope seepage wetlands. Most of the area marked as irreplaceable on the above map consists of primary grassland, and is irreplaceable specifically because the life history strategy adopted by mesic grassland plants heavily favours resprouting of existing, long-lived plants following disturbance at the expense of the production of viable seed. The consequence of this is that these grasslands are essentially impossible to reproduce or recreate once the primary vegetation has been physically removed. Seepage areas within these mesic grasslands are unique in that they contain grassland and wetland obligate elements, as well as a suite of plant species that are specifically tied to the temporarily saturated soil moisture regime. The overlap of these vegetation communities produces a particularly species-rich ecotype.

2.16.3 The Base Line Survey

2.16.3.1 Wetland Delineation and Assessment

Ortho photographs of the study area, 2630 AA 20 and 25 at a standard scale of 1:10 000, were purchased from Chief Directorate: Surveys and Mapping. These were scanned and used to provide the ortho-rectified digital base map onto which the wetland boundaries were delineated using ArcView 3.2. Heads-up digitizing was used to capture the boundaries on the digital images. The wetlands were classified according to their hydro-geomorphic determinants based on a modification of the system first described by Marneweck and Batchelor (2002) and on the system developed by Kotze, Marneweck, Batchelor, Lindley and Collins (2005).

Soil auguring was used to expose soil horizons (see Kotze and Marneweck, 1999) to verify whether or not the areas delineated as wetlands met the criteria for classification as wetlands.

Wherever possible, the dominant plant species were also recorded in the wetlands, although it must be noted that the survey was done during the winter months, thus limiting the comprehensiveness of the plant survey. The site still requires a thorough plant species survey during the summer.

2.16.3.2 Present Ecological Status (PES) /Ecological Importance and Sensitivity (EIS)

In order to establish a baseline for the current status of the wetlands, and to determine their relative ecological importance, a present ecological status and ecological importance and sensitivity analysis was conducted. The scoring system applied in the procedure for determination of Resource Directed Measures for wetland ecosystems (Department of Water Affairs and Forestry, 1999) was applied for the purposes of this assessment. The categories used were modified from Kleynhans, 1996 and 1999. Air photo analysis, an assessment of the key drivers, field sampling and the findings of the faunal and floral specialist studies reviewed, were used to ascribe the individual category scores used in the assessment. For the PES, where the key driver attribute was rated 1 or less, then this lowest rating was used as the value for the PES.

2.16.3.3 Assessment of Aquatic Ecosystems

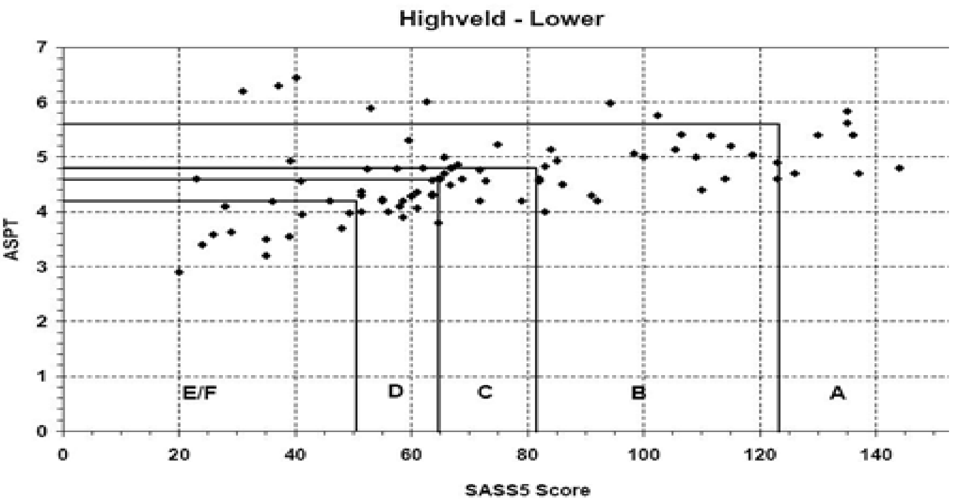
The following tools were used to assess the integrity of the aquatic ecosystems in surface water:

- Water quality: On-site assessment of Conductivity, TDS, pH and Temperature.
- The Present Ecological State: Index of Habitat Integrity for streams and valley bottom wetlands, and th Ecological Importnace and Sensitivity (EIS) analysis for wetlands. The scoring system as described in the documents "Resource Directed Measures for Protection of Water Resources. Volumes 3 and 4. River and Wetland Ecosystems" (DWAF, 1999) was applied for the determination of the PES. The scoring system is outlined in Table 2.16.3.3(b).

Table 2.16.3.3 (b): Rating Scale used for the PES Assessment

Class	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural, with few modifications.	80-90
C	Moderately modified.	60-79
D	Largely modified.	40-59
E	Extensively modified.	20-39
F	Critically modified.	<20

- Aquatic macroinvertebrates: SASS 5 (South African Scoring System) based on the presence or absence of sensitive aquatic macroinvertebrates collected and analysed according to the methods outlined in Dickens and Graham (2002). A high relative abundance and diversity of sensitive taxa present indicates a relatively healthy system with good water quality. Disturbance to water quality and habitat results in the loss of sensitive taxa. As this method was developed specifically for rivers, the methods of collection and analysis were modified for wetlands and pans. This meant sampling vegetation and mud biotopes only, as no stone biotopes were available, and interpreting the results in terms of overall diversity and taxon composition in cases where no flowing water was present. Where appropriate, data was interpreted according to guidelines provided in Dallas (2007) as indicated in Figure 2.16.3.3 (b).



Biological Band/ Ecological Category	Ecological Category Name	Description
A	Natural	Unmodified natural
B	Good	Largely natural with few modifications
C	Fair	Moderately modified
D	Poor	Largely modified
E	Seriously modified	Seriously modified
F	Critically modified	Critically or extremely modified

Figure 2.16.3.3 (b): Biological Bands & Ecological Categories for the Highveld (Lower Zone).

2.16.3.4 Sampling Sites

Five sites were sampled for the Ecological Assessment and are located on Figure 2.16.3.4 (a) and are summarized in Table 2.16.3.4 (a).

Figure 2.16.3.4 (a): Aquatic Ecosystems Sampling localities.

Note: Diatoms were only sampled from sites 1-3.

Table 2.16.3.4 (a): List of Sites Sampled for Aquatic Macroinvertebrates.

Site	River/Position	Classification	Locality
1	Farm dam in upper reaches of Mpuluzi River	Farm Dam	S26 24 52.6 E29 06 46.7
2	Seasonal Depression	Seasonal Depression	S26 24 36.9 E29 05 41.6
3	Tevrede-se-pan	Permanent Reed Pan	S26 27 14.1 E29 07 56.7
4	Pearl Stream	Channelled Valley Bottom Wetland	S26 25 39.1 E29 05 11.0
5	Mpuluzi River	Floodplain	S26 33 16.6 E29 03 04.1

The wetlands were mapped at desktop level (based on discernible changes in vegetation density and soil colour) using orthophotographs from the Chief Directorate: Surveys and Mapping. These wetland boundaries were verified by soil sampling with a Dutch auger to expose the soil profiles. The wetlands were classified according to their hydro-geomorphic determinants based on a modification of the system first described by Marneweck and Batchelor (2002) and on the system developed by Kotze, Marneweck, Batchelor, Lindley and Collins (2005).

2.16.4 General Wetland Description

Two main wetland complexes were found in the study area, and both form part of the upper catchment of the Mpuluzi River. Being at the source of the river system, these wetland complexes are thus likely to play an important role in the overall hydrology of the upper Mpuluzi River. The wetlands are linked to the expression of both perched groundwater and surface water.

Two pans occur within the 2 km radius of the mining application area. These systems also have a perched groundwater component.
A schematic diagram of how these systems are positioned in the landscape and the general topography of the study area is given in Figure 2.16.4 (a).

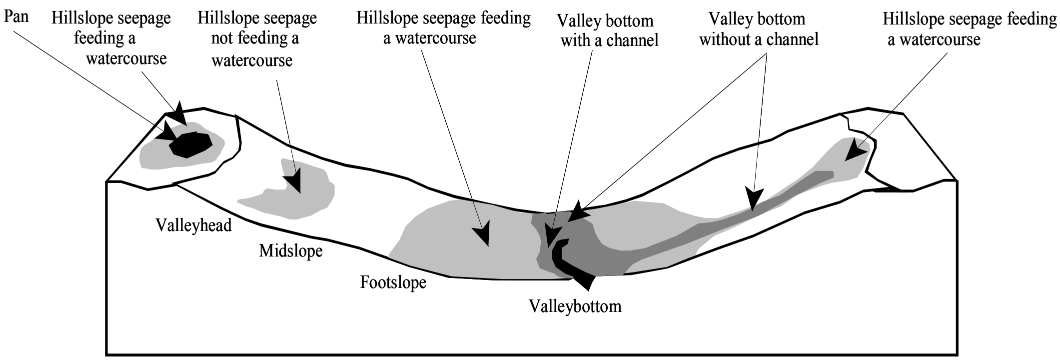


Figure 2.16.4 (a): Schematic layout of wetlands in the landscape

Four Hydro geomorphic (HGM) types of natural wetlands make up the two main wetland complexes in the study area. These are:

- Hillslope seepage feeding a watercourse;
- Valley bottom without a channel;
- Valley bottom with a channel and;
- Pans.

The area of the different wetland types within the study area are summarized in Table 2.16.4 (a).

Table 2.16.4 (a): Respective Area's of the different HGM Wetland Types.

Hydro-geomorphic Type	Area
Hillslope seepage feeding a watercourse	922.16 ha
Valley bottom with a channel	41.73 ha
Valley bottom without a channel	84.16 ha
Pans	347.17 ha
Total Area within the Study Area	**1395.22 ha**

Dams occupy 36.96 ha making it the main artificial wetland type within the study area.

The definition of the different HGM wetland types occurring within the study area, based on the system first described by Brinson (1993) and modified for the Highveld by Marneweck and Batchelor (2002), and further developed by Kotze, Marneweck, Batchelor, Lindley and Collins (2004) are summarized in Table 2.16.4 (b). The distribution of the different wetland types in the study area is shown in Figure 2.16.4 (b)

Table 2.16.4 (b): Definition of the different HGM Wetland Types occurring within the Study Area.

Wetland Type	Topographic Setting	Description	Hydrologic Components		
			Inputs	Throughputs	Outputs
Valley bottom with a channel	Occur in the steeper headward parts of the streams and in the shallow valleys that drain the slopes	Valley bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	Receive water inputs from the main channel (when channel banks overspill) and from adjacent slopes, as well as from adjacent hillslope seepage wetlands if these are present.	Surface flow and interflow.	Variable but predominantly stream flow.
Valley bottom without a channel	Occur in the shallow valleys that drain the slopes	Valley bottom areas with no clearly defined stream channel usually gently sloped and characterized by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from channel entering the wetland and also from adjacent slopes.	Receive water inputs from adjacent slopes via runoff and interflow. May also receive inputs from a channelled system. Interflow may be from adjacent slopes, adjacent hillslope seepage wetlands if these are present, or may occur longitudinally along the valley bottom.	Surface flow and interflow.	Variable but predominantly stream flow.
Hillslope seepage feeding a watercourses	Hillslopes	Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well-defined stream channel connecting the area directly to a watercourse.	Predominantly groundwater from perched aquifers and interflow.	Interflow and diffuse surface flow.	Variable including interflow, diffuse surface flow and stream flow.
Pans	In depressions and basins, often at drainage divides on top of the hills	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.	Runoff from the surrounding catchment area and lateral seepage from adjacent hillslope seepage wetlands. It may also receive sub-surface water.	None.	Evapo-transpiration and groundwater discharge from leakage.

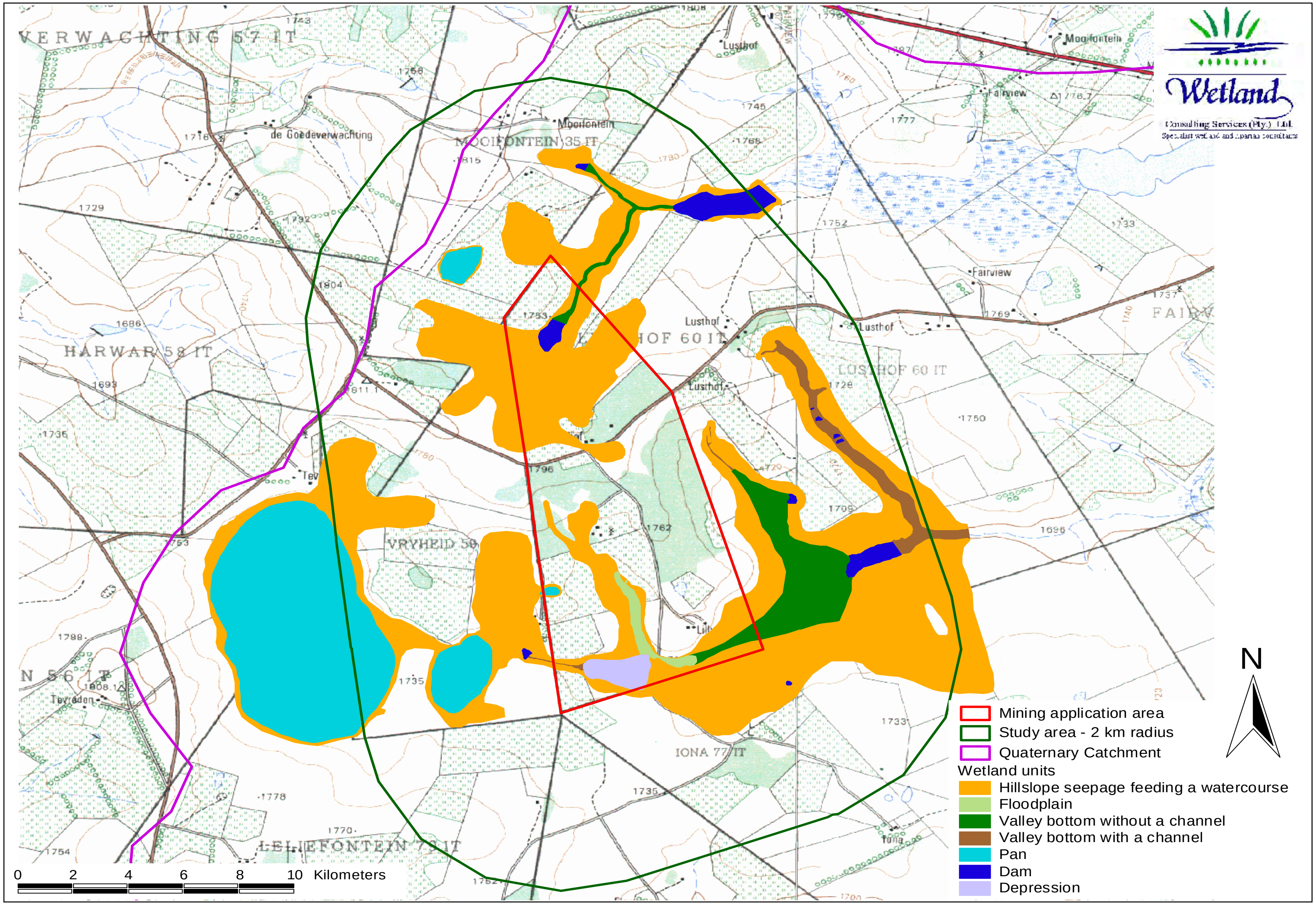


Figure 2.16.4 (b): Hydro-Geomorphic Types of Wetlands within the Study Area.

2.16.5 Description of Wetland Soils

The wetland soils vary depending on the area in which the soil samples were taken. In general though, the hillslope seepage wetlands tend to be sandy along the periphery, becoming more clayey as one progressed towards the valley bottom.

From the samples that were taken to verify the hydro-determinants of the wetland systems, it was indicated that the hillslope seepage wetlands were drier within the first 20 cm of the soil, thus indicating a deeper subsurface flow. There were also indications of a more clayey, g-horizon in places as one moved towards the valley bottom, with the soil becoming wetter in the first 20 cm. These soils also had a high organic component.

Mottles of a rusty orange colour were easily visible in all most of the wetland soils, thus leading to a reasonably accurate delineation of the boundaries in most cases apart from in some of the more extensive marginally wet zones.

2.16.6 Description of Wetland Types

2.16.6.1 Hillslope Seepage Wetlands

The hillslope seepage wetlands that occur in the study area are associated and maintained predominantly by perched sub-surface flow. The orthic horizon in all these soils commonly remains saturated during the summer months, while the boundary of the hillslope seepage wetlands and other areas in the system, only remains saturated for short periods during the summer rainfall months. The resulting vegetation in these areas comprises a mixture of wetland and grassland species. The boundaries of these systems often extend well away from the easily recognizable saturated zones, thus forming a gradual ecotone. This ecotone can extend tens of metres even kilometres, as is the case with some areas in this system, as the depth to the perched water table increases with distance away from the unconfined seep front.

The hillslope seepage wetlands that occur in the study area are of the type "Hillslope seepage connected to a watercourse" (Hydro-geomorphic classification). These types of hillslope seepage wetlands can be connected to any watercourse whether a floodplain, valley bottom or pan. In this case the hillslope seepage wetlands are mainly connected to pans and valley bottoms, thus likely to be playing a role in the flow augmentation in these systems, even if this contribution is only on a seasonal basis.

The hillslope seepage wetlands in the study area are also variable in extent, ranging from a few meters in places to almost 2 kilometres in others. Extensive marginally wet zones make accurate boundary delineation of some of these systems difficult.

The dominant grass species in the hillslope seepage wetlands were *Themeda triandra* and *Monocymbium ceresiiforme*. Other species that were noted were *Eragrostis curvula*, *Pennisetum* sp., *Setaria sphacelata*, *Aristida* sp., *Cynodon dactylon* and *Loudetia simplex*.

The areas that were not impacted by over grazing or agricultural practices had a good ground cover, thus having a high surface roughness. As most of the area adjacent to the wetland systems had been converted to agriculture, the wetlands are likely to be important for providing habitat for fauna as well as for providing linkages or corridors to other ecosystems.

With a predominance of tall grass species, these systems also provide good habitat for faunal species like rodents and birds associated with wetland systems. Species such as Grass, Marsh and Cape Eagle Owls as well as the Blue and Wattled Cranes may thus occur in the study area.

An image of a typical hillslope seepage wetland connected to a watercourse within the study area is indicated as Figure 2.16.6.1 (a).

Figure 2.16.6.1 (a): Typical Hillslope Seepage Wetland connected to a watercourse

2.16.6.2 Valley Bottom Wetlands

Valley bottom wetlands without a channel as well as valley bottom wetlands with a channel occur in the study area. The dominant type in the study area was the unchannelled type, particularly common on the farms Lusthof 60 IT and Mooifontein 35 IT.

The unchannelled valley bottom wetland systems do not have a characterised channel due to the shallow gradients along the valley bottoms. Thus the water is spread out over the entire area of the wetland. This is facilitated by the dense vegetation cover, resulting in a larger inundated area. The main drivers of these systems are diffuse horizontal surface flow and interflow. All of the valley bottom wetlands are associated with lateral seep zones which from part of the adjacent hillslope seepage wetlands.

The channelled valley bottom wetland systems have a distinctive channel. Historically it is likely that none of the valley bottom wetlands would have had channels, but due to impacts such as increased runoff from the adjacent agricultural areas, trampling and over grazing by livestock, most of these systems have been altered. In most cases the channelling appears to be the result of both erosion and the loss of vegetation cover, mainly as a result of the change in land use.

There is generally a clearly visible transition in the vegetation between the mixed grass-sedge zones that characterise the valley bottom wetlands to the more intermittently wet grassland habitats associated with the adjacent hillslope seepage wetlands. Together, both the channelled and unchannelled systems are likely to play an important roll in providing a diversity of habitats for aquatic fauna (waders) and flora (grasses and sedges), for the use of breeding, feeding and migration, thus providing an important ecological function in the landscape. Flora that were recorded in the valley bottom systems include: *Juncus* sp., *Schoenoplectus* sp., *Miscanthus junceus*, *Phragmites australis* and *Typha capensis* to name a few.

An image of a typical valley bottom wetland without a channel within the study area is indicated as Figure 2.16.6.2 (a).

Figure 2.16.6.2 (a): Typical Valley Bottom Wetland without a channel.

2.16.6.3 Floodplains

There is one wetland in the study area that can be considered as a floodplain. This system in situated on the farm Lusthof 60 IT. This system consists of a channel with gradually sloping sides to the north and a second channel with eroded and steeper sides to the east. The system has its origin on the farm Vryheid 50 IT. The first channel has a smaller hillslope seepage system than the second channel, covering an area of approximately 53.83 ha. The second channel has a larger hillslope seepage system with a surface area of approximately 68.44 ha and a small dam with a surface area of 0.73 ha.

What makes this system so interesting is that the second channel runs into a grass depression. The depression only has an inflow in the drier season (winter), but during the wetter season the first channel overspills, thus providing a hydrological connection to the main watercourse. An image of a typical floodplain wetland within the study area is indicated as Figure 2.16.6.3 (a).

Figure 2.16.6.3 (a): Typical Floodplain Wetland within the Study Area

2.16.6.4 Pans

Pans are typically described as permanent and seasonal, brackish, saline or alkaline lakes, flats, pans and marshes. In most cases they are endorheic, meaning they have no obvious surface feed or discharge and are thus are not obviously connected to a watercourse. They are usually circular to oval in shape and where two or more pans have spread and combined, they form characteristically kidney-shaped or lobed wetlands. In the grasslands of Mpumalanga and the eastern Highveld, pans are shallow, and even when fully inundated, are usually less than 3 m deep.

A number of hypotheses have been proposed to explain reasons for their formation. These reflect the influence of climate, availability of geologically susceptible surfaces, disturbance of the surface by animals and salt weathering, the lack of integrated drainage systems (streams, rivers) and deflational processes including wind. The most obvious association is with areas of poor drainage. A description of the processes likely to contribute to pan formation includes a link to dismembered palaeo-drainage systems. Others have a more local explanation of origin e.g. wind deflation and/or herbivore activity.

The occurrence of pans is not restricted by substrate. Pans are common even in sandy belts, where periodic aeolian activity produce inter-dune depressions or deflation hollows. Leaching and washing of the small quantities of primary clay into the bases of such depressions, clay formation by subsequent weathering and mineral synthesis, the accumulation of colloidal silica, iron oxides and other solutes, and the addition of fine organic residues, probably all contribute to the formation of the impermeable layer on which the water body of the pan is perched, often as a perennial feature. Few, if any, of the pans appear to be fed by deep groundwater. In the Highveld and Mpumalanga in particular, most pans occur on relatively impermeable substrates, formed largely by local pedogenic and limnological processes. In addition to being fed by shallow lateral surface flow, many of the pans in the two regions are fed by seepage from unconfined perched water tables. The source of this water is predominantly rain falling upon the limited catchment area of each pan. Water loss from pans is largely due to evaporation.

Given that the pans are maintained by rain-water falling on a confined catchment, the water level in a pan at a given time in any year is likely to reflect the antecedent rainfall events and losses from seepage and evaporation and/or evapotranspiration. In the most arid areas, pans can withstand years without surface water, while in higher rainfall areas, such as on the Highveld, pans usually hold water seasonally, filing up by the end of summer and drying out by the end of winter.

Some of the larger pans in the far eastern Transvaal Highveld have never been known to dry up. Successive seasons of above-average rainfall can cause non-perennial pans to remain inundated during the winter (dry) period. Similarly, during below-average rainfall seasons, they may remain empty for long periods. Thus when assessing whether a pan is likely to be permanent or temporary, it is necessary to take into consideration the antecedent 3-5 years.

Pans in the south-eastern Highveld range from 1 - 871 ha, with an average size of 22 ha. According to Allan (1985), 70.5% of pans in the south-eastern Highveld are non-perennial pans. The plant species composition, richness, abundance and distribution in pans is generally related to the hydrological regime and water quality, with plant species tolerant of changes in water availability being more abundant in non-perennial pans.

Pans are also the most important wetland type in the region in terms of providing habitat for Red Data bird species such as Greater and Lesser Flamingos and Painted Snipe. They are also an important habitat for owls. The seasonal changes in water levels expose a gently sloping open shoreline which is often rich in invertebrates, especially in recently exposed areas.

Exposed shorelines also provide habitat for waterfowl such as Yellowbilled Ducks and Egyptian Geese. The shoreline immediately around the water's edge provides a foraging habitat for waders such as Little Stint, Threebanded and Kittlitz's Plovers, and shallow water areas are frequented by species such as Wood Sandpipers, Ruff and Avocet. Slightly deeper water provides a niche for wading birds such as herons and egrets. Large shallow and relatively saline pans provide suitable habitat for Greater or Lesser Flamingos, which, when they do occur, often do so in substantial numbers. Large freshwater pans which include a deeper open water area may also provide suitable habitat for several waterfowl species. Emergent vegetation such as reeds and bulrushes attract a number of passerine species such as Red Bishops and warblers, while fringing sedge marshes and rank grasses attract species such as Ethiopian and Painted Snipes and Marsh and Grass Owls.

The numbers and diversity of birds is likely to vary substantially from pan to pan depending on habitat characteristics, with increasing diversity and numbers being associated with larger pans and those offering greater habitat diversity. Similarly, the dominant avifaunal elements will range widely, and could be waders for receding and dry pans, wading birds for shallow, water-dominated pans, waterfowl for deeper, water-dominated pans or those with suitable shoreline, and even passerines in the case of a pan dominated by emergent vegetation. The substantial difference in avifauna than can occur between pans is illustrated by a study of pans in the Lake Chrissie area. Allan et al. (1995) compared the avifauna of three different types of pans – reed pans, sedge pans and open pans. Reed pans had the highest diversity of waterbird species (57), followed by sedge pans (55) and open pans (43). Nine species were found only in reed pans (including Baillon's Crake, a red data species), and four each to sedge (e.g. Crowned Crane) and open pans (e.g. Knobbilled Duck).

Although aquatic invertebrates were not sampled in the pans, a general comment is that aquatic invertebrates inhabiting pans in the region appear to be characterised by high numbers and low diversity. The majority of species have life histories adapted to seasonal drying.

This usually means that at least one stage of their life cycle is capable of tolerating high temperatures and complete. Furthermore, such taxa are often capable of fast growth and desiccation reproduction.

An interesting observation is that the composition and abundance of invertebrates inhabiting a specific pan with surface water present often bears little resemblance to that in similar adjacent pans. In other words, each pan has an invertebrate fauna that reflects the specific conditions in that pan. Factors that are likely to be responsible for these differences include the length of time that the pan has been inundated, the size and depth of the pan, adjacent land use, the water quality and soil type, and types and age of the aquatic plant growth, and other biotic interactions, such as the presence or absence of fish at the time. These differences are supported by the available data on water quality, which shows significant differences between pans, even pans that are situated close to each other (Marneweck and Batchelor, 2002).

Two perennial reed pans occur within the broader study area and have a total surface area of 347.17 ha, (Tevrede Pan, of 287.77 ha and the smaller pan, 32.23 ha). Both these pans have thus a greater surface area than the average of 22 ha for the region. These pans have hillslope seepage wetlands on the slopes of the pan basins and are characteristically seasonally saturated and serve as perched aquifers that feed groundwater into the pans via interflow. Water also enters the pans from surface runoff from the slopes of the pan basins which essentially form the pan catchment areas. Neither an inlet nor outlet was present in these two pans, situated on the farms Vryheid 50 IT and Tevreden 56 IT.

Images of the typical reed-dominated and grass-dominated pan wetlands within the study area are shown in Figure 2.16.6.4 (a).

Figure 2.16.6.4 (a): Typical Reed-Dominated Pan (*top*) and Grass-Dominated Pan (*bottom*) within the Study Area

2.16.6.5 PES of the Wetlands and their relative EIS

2.16.6.5.1 Present Ecological Status (PES)

The majority of wetlands and pans in within the mining application area resemble the natural situation although most of the systems and pans have been modified to some extent as indicated on Figure 2.16.6.5.1 (a).

The percentages relating to the PES are as follows:

- 52% are natural with limited or no modifications (A);
- 28% are largely natural with few modifications (B);
- 12% are moderately modified (with a PES of C);
- 8% are largely modified (with a PES of D), mostely in the south-eastern corner of the mining application area.

The present state of 52% of the wetlands in the mining application area have some resemblance to the natural state with only 8% of the wetlands showing impacts that have largely modified the systems. These modifications / impacts are limited to agricultural practises, particularly damming, cultivation and livestock farming. The cultivation of lands occurs adjacent to the hillslope systems which impacts on the sediment load to the valley bottom wetlands.

The dams in the study area occur mainly in the valley bottoms with the exception of two dams that occur in the hillslope wetlands. These dams in relation to the entire systems have a small impact.

Despite the modifications, the systems are mostly still hydrologically intact implying that they are likely to return to their former state if the current land-use activities are discontinued. Their rehabilitation potential is thus high.

2.16.6.5.2 Ecological Importance and Sensitivity Study (EIS)

The relative ecological importance and sensitivity of the wetlands is shown in Figure 2.16.6.5.2 (a). A percentage of 60% of the wetland systems in the mining application area have a high to very high ecological importance and sensitivity score and comprise a mixture of hillslope seepage wetlands, valley bottom wetlands and pans.

These have a high EIS predominantly as a result of their relatively high migration/breeding and feeding potential for wetland species as well as their functionality of flood storage, energy dissipation and particulate/element removal.

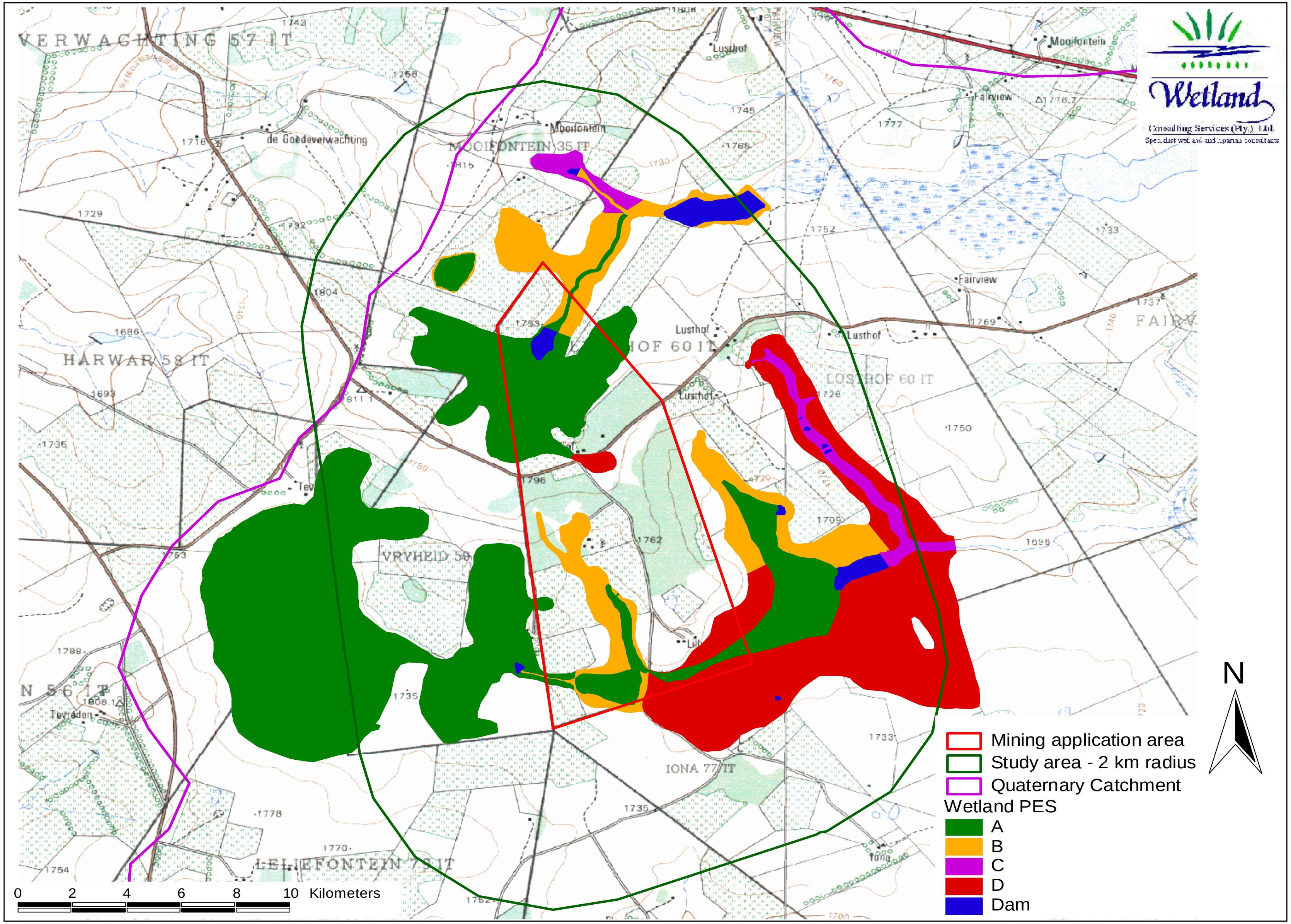


Figure 2.16.6.5.1 (a): Present Ecological Status of the Wetlands within the Study Area.

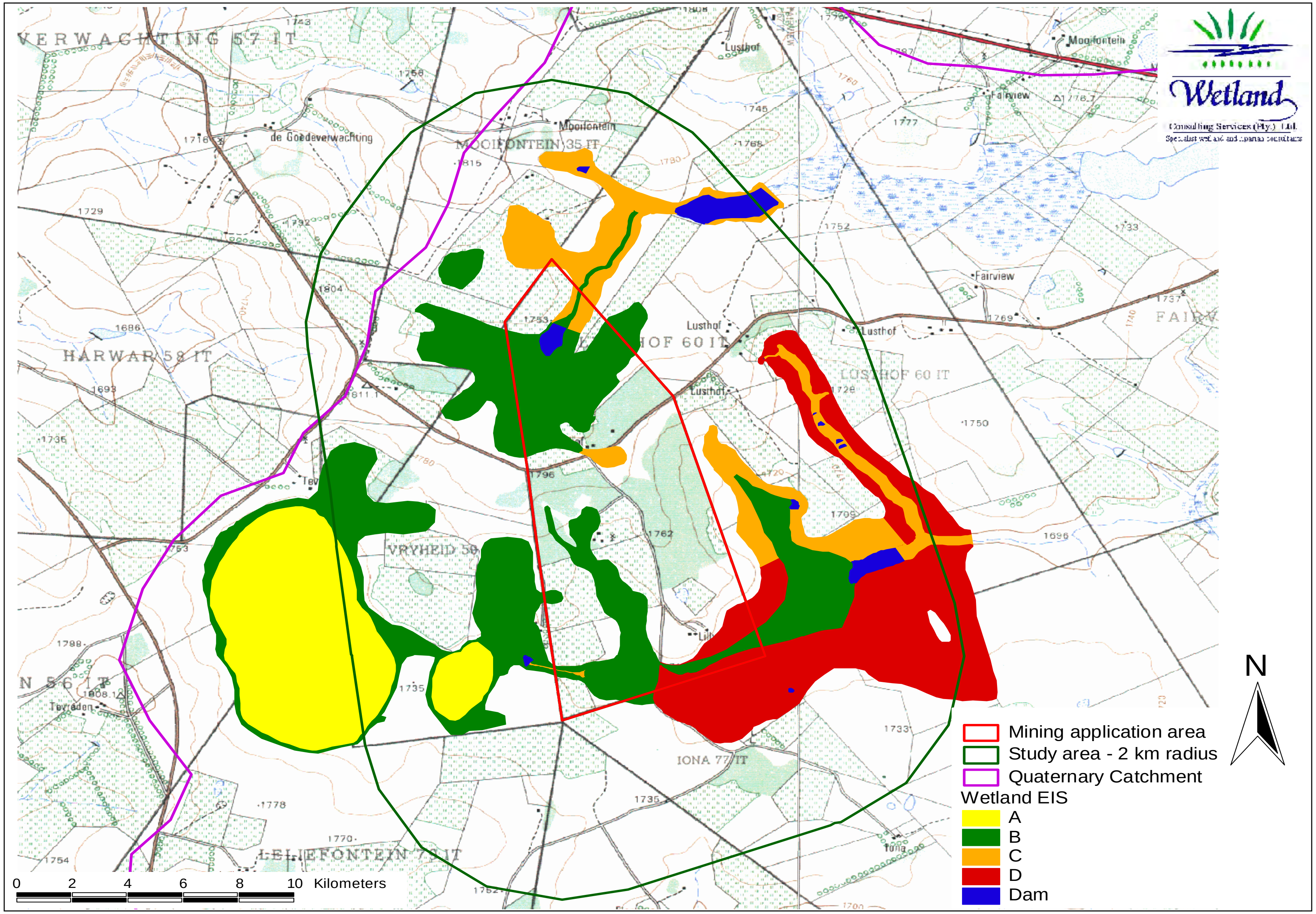


Figure 2.16.6.5.2 (a): Ecological Importance and Sensitivity of the Wetlands within the Study Area.

The EIS assessment findings are summarised as follows:

- 8% have a very high status (with an EIS of A); These systems are considered to be ecological important at a nationals as well as international scale and are sensitive to flow and habitat medications and which play a role in moderating the quality and quantity of water of major rivers.
- 52% have a high status (with an EIS of B); These are systems that are considered to be ecologically important at a regional scale and are sensitive to flow and habitat modifications and which play a role in moderating the quantity and quality of water of major rivers.
- 32% have a moderately high status (with an EIS of C); These are systems that are considered to be ecologically important and sensitive on a more local scale and which play a role in moderating the quantity and quality of water of major rivers.
- 8% have a low-marginal status (with an EIS of D); These are systems that are not ecologically important and sensitive at any scale. The biodiversity of these systems 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.

The Ecological Importance and Sensitivity of 60% of the wetlands in the mining application area is therefore high to very high, with the other 40% with a marginal to low score, when compared with what would be expected for reference conditions.

The question to ask is whether the planned mining activities can be managed in such a way that the 60% of the wetlands that scored high to very high can be separated from the 40% that scored moderate to low. This is unlikely given the hydrological interdependence of the wetlands, particularly in terms of perched groundwater linkages which is controlled by the underlying stratigraphy.

Considering the presence of seepage areas in the pan basins, the likely presence of endangered plants cannot be ruled out. Seepage wetlands are known to provide suitable habitat for species of conservation importance such as the Snapdragon *Nemesia fruticans* (considered non-threatened), and the bulb *Nerine gracilis* (considered rare). Orchids are also common in these types of systems and ideally the seepage wetlands and slopes adjacent to the pans should be sampled between October and December in order to identify these species when they are in flower.

2.16.7 Fauna

Small mammals such asyellow mongoose, grey duiker and rodents, naturally occur in the study area. A list of mammals, reptiles and amphibians likely to occur in, or utilise the wetlands is given in Table 2.16.7 (a).

In terms of avifauna, the un-channelled valley bottom wetlands are the most important habitat for birds in the area. These provide important hunting grounds for birds like the Grass, Marsh and Cape Eagle Owls as well as feeding habitat for the Blue and Wattled Cranes that may occur in the area.

The grass pans and other pans in the area provides important habitat for waders as well as reed dwelling birds. A list of birds likely to occur in the wetlands is given in Table 2.16.7 (b).

Table 2.16.7 (a): Mammals, Reptiles and Amphibians likely to occur in, or utilise the Wetlands

SCIENTIFIC NAME	COMMON NAME
Mammals	
Cryptomys hottentotus	Common mole rat
Crocidura mariquensis	Black/swamp musk shrew
Otomys irroratus	Vlei rat
Otomys angoniensis	Angoni vlei rat
Cynictis penicillata	Yellow mongoose
Atila1 paludinosus	Water mongoose
Aonyx capensis	Cape clawless otter
Lutra maculicollis	Spotted neck otter
Reptiles	
Lycodonomorphus rufulus	Brown water snake
Psammophylax rhombeatus	Spotted skaapsteker
Hemachatus haemachatus	Rinkhals
Naja haje	Egyptian cobra
Pelomedusa subrufa	Cape terrapin
Amphibians	
Xenopis laevis	Common clawed frog
Bufo gutturalis	Gutteral toad
Tomopterna cryptotis	Tremelo sand frog
Strongylopus fasciatus	Striped stream frog
Ptychadena porosissima	Striped grass frog
Phrynobatrachus natalensis	Snoring puddle frog
Kassina senegalensis	Bubbling kassina
Semnodactylus wealii	Rattling frog
Cacosternum boettgeri	Common caco

Table 2.16.7 (b): Birds likely to occur in the Wetlands

SPECIES	COMMON NAME
Tachybaptus ruficollis	Dabchick
Podiceps cristatus	Great Crested Grebe
Podiceps nigricollis	Blacknecked Grebe
Phalacrocorax carbo	Whitebreasted Cormorant
Phalacrocorax africanus	Reed Cormorant
Anhinga melanogaster	Darter
Ardea cinerea	Grey Heron
Ardea melanocephala	Blackheaded Heron
Ardea purpurea	Purple Heron
Egretta intermedia	Yellowbilled Egret
Egretta alba	Great white egret
Bubulcus ibis	Cattle Egret
Ardeola ralloides	Squacco Heron
Nycticorax nycticorax	Blackcrowned Night Heron
Ixobrychus minutus	Little Bittern
Scopus umbretta	Hamerkop
Ciconia ciconia	White Stork
Threskiornis aethiopicus	Sacred Ibis
Plegadis falcinellus	Glossy Ibis
Bostrychia hagedash	Hadeda Ibis
Platalea alba	African Spoonbill
Phoenicopterus ruber	Greater Flamingo (Near-threatened)
Phoeniconaias minor	Lesser Flamingo (Near-threatened)
Dendrocygna bicolor	Fulvous Duck
Thalassornis leuconotus	Whitebacked Duck
Dendrocygna viduata	Whitefaced duck
Alopochen aegyptiacus	Egyptian Goose
Anas undulata	Yellowbilled Duck
Anas capensis	Cape Teal
Anas Hottnetota	Hottentot Teal
Anas erythrorhyncha	Redbilled Teal
Anas smithii	Cape Shoveller
Netta erythrophthalma	Southern Pochard
Plectropterus gambensis	Spurwinged Goose
Elanus caeruleus	Blackshouldered Kite
Francolinus swainsonii	Swainson's spurfowl
Numida meleagris	Helmeted Guineafowl
Rallus caerulescens	African Rail
Amaurornis flavirostis	Black Crake
Porphyrio porphyrio	Purple Gallinule
Gallinula chloropus	Moorhen
Fulica cristata	Redknobbed Coot
Charadrius pecuarius	Kittlitz's Plover
C. tricollaris	Threebanded Plover
Vanellus coronatus	Crowned Plover
Vanellus armatus	Blacksmith Plover
V. senegallus	Wattled Plover
Tringa glareola	Wood Sandpiper
C. minuta	Little Stint
Philomachus pugnax	Ruff
Gallinago nigripennis	Ethiopian Snipe
Rostratula benghalensis	Painted Snipe
Recurvirostra avosetta	Avocet
Himantopus himantopus	Blackwinged Stilt
Glareola nordmanni	Blackwinged Pratincole
Larus cirrocephalus	Greyheaded Gull
Chlidonias leucopterus	Whitewinged Tern
C. hybrida	Whiskered Tern
Columbus arquatrix	Rock Pigeon
Streptopelia semitorquata	Redeyed Dove
Streptopelia capicola	Cape Turtle Dove

SPECIES	COMMON NAME
Streptopelia senegalensis	Laughing dove
Oena capensis	Namaqua Dove
Tyto capensis	Grass Owl (Vulnerable)
Asio capensis	Marsh Owl
Apus caffer	Whiterumped Swift
Colius indicus	Redfaced Mousebird
Ceryle rudis	Pied Kingfisher
C. maxima	Giant Kingfisher
Alcedo cristata	Malachite kingfisher
Phoeniculus purpureus	Redbilled Woodhoopoe
Mirafra sobota	Sabota lark
Hirundo rustica	European swallow
Hirundo albigularis	Whitethroated Swallow
Hirundo smithii	Wiretailed Swallow
Hirundo cucullata	Greater Striped Swallow
Hirundo abyssinica	Lesser Striped Swallow
Hirundo fuligula	Rock Martin
Riparia paludicola	Brown Throated Martin
R. cincta	Banded Martin
Pycnonotus barbatus	Blackeyed bulbul
Myrmecocichla formicivora	Anteating chat
Saxicola torquata	Stone Chat
Acrocephalus arundinaceus	Great Reed Warbler
A. gracilirostris	Cape Reed Warbler
A. baeticatus	African Marsh Warbler
A. Palustris	European Marsh Warbler
A. schoenobaeus	European Sedge Warbler
Bradypterus baboecala	African Sedge Warbler
Cisticola juncidis	Fantained cisticola
Cisticola aridula	Desert cisticola
Cisticola ayresii	Ayres' cisticola
Cisticola tinniens	Levaillant's Cisticola
Cisticola fulvicapilla	Neddicky
Sigelus silens	Fiscal Flycatcher
Motacilla capensis	Cape Wagtail
Motacilla flava	Yellow Wagtail
Macronyx capensis	Orangethroated Longclaw
Lanius collaris	Fiscal Shrike
Lanius collurio	Redbacked Shrike
Spreo bicolour	Pied Starling
Tchagra senegala	Blackcrowned Tchagra
Telephorus zeylonus	Bokmakierie
Passer melanurus	Cape Sparrow
Ploceus velatus	Masked Weaver
Euplectes orix	Red Bishop
Euplectes afer	Golden Bishop
Euplectes progne	Longtailed Widow
Euplectes albonotatus	Whitewinged Widow
Uraeginthus angolensis	Blue Waxbill
Esrilda astrild	Common Waxbill
Ortygospiza atricollis	Quail Finch
Sporeaginthus subflavus	Orangebreasted waxbill
Estrilda melanotis	Swee waxbill
Balearica regulorum	Blue Grey Crowned Crane
Bugeranus carunculatus	Wattled Crane
Sarothrura rufa	Red-chested Flufftail
Vidua macroura	Pintailed Whydah
Serinus atrogularis	Blackthroated Canary

2.16.8 Presence of Red Data Flora and Fauna

No red data plant species were recorded in the study area although *Nerine gracilis* R.A.Dyer, as well as *Eucomis Montana* Compton, and the Snapdragon *Nemesia fruticans* may occur.

In terms of fauna, the Grass Owl *Tyto capensis*, Blue Crane *Anthropoides paradiseus,* Greater (*Phoenicopterus roseus*) and Lesser Flamingo (*Phoenicopterus minor*) which is regarded as vulnerable (Barnes, 2000), the Cape Eagle Owl *Bubo capensis* which is regarded as a species for monitoring, the Bald *Ibus Geronticuscalvus* which is regarded as out of danger and the Wattled Crane *Grus carunculatus* which is regarded as Critically Endangered, occur in the area and are likely to occur in the wetlands and pans given the type of habitat present. Both the Painted Snipe *Rostratula benghalensis* and Blackwinged Pratincole *Glareola pratincola*, which are considered near-threatened species are also likely to occur there (Data supplied by the Mpumalaga Parks Board).

2.16.9 Functionality - Indirect Use Values

Despite the widely held notions about wetland functionality, extensive literature searches have revealed that very few practitioners have actually quantified these benefits (Batchelor, PC). Moreover, it appears that these functions are highly variable depending on the characteristics of the wetlands and the landscape. In the present study, it was not possible to perform the types of investigations necessary for determining functionality such as nutrient balance studies or flood attenuation quantifications. This was due both to the complexity of the task and the costs and time that would have been involved. It is therefore difficult to speculate on the functional values of the wetlands on site. Nevertheless, some general discussion is possible based on anecdotal evidence on site and experience from projects undertaken in the region. These are discussed for each of the main wetland types found within the study area.

Hillslope seepage wetlands are commonly considered to be valuable in that they perform a number of beneficial functions such as removing excess nutrients and inorganic pollutants produced by agriculture, industry and domestic waste (Rogers, Rogers and Buzer, 1985; Gren 1995; Ewel, 1997; Postel and Carpenter, 1997).

In so doing they perform a purification service that saves on purification costs of downstream water supplies, and prevent damage caused by polluted water. Besides their important contribution to biodiversity, this is likely to be their main function in the landscape. They may also play a role in replenishing or recharging groundwater supplies (Thompson and Goes, 1997). This would occur when water percolates through the topsoil to the underlying aquifer. The significance of this contribution in the study area is however not known. Since the hillslope seepage wetlands really represent the expression of ground water at or near the soil surface, it is more likely that the sandy soil landscape around the wetlands is more important (in terms of extent and depth of the soil profile) in terms of ground water recharge than the wetlands themselves.

The functions the valley bottom wetlands are likely to perform in the landscape are likely to be a combination of the functions performed by hillslope seepage wetlands and floodplains. These systems are therefore likely to contribute towards flood attenuation, as a result of both their topographic form and general resistance to flow. Their function in relation to enhancing water quality however is less clear. This will largely depend on the volume of water flowing over the surface compared to that moving in the soil. Retention time which influences the length of time that there is contact between the bulk of the water and the sediments, is the main determinant that affects the opportunity for the removal of certain nutrients.

One exception to this is suspended solids, the concentration of which will vary depending on the gradient (slope) of the valley bottom wetlands and the sources of sediment (eg. adjacent agricultural lands). Where flows permit, there may be selective deposition of particles that are deposited along the valley bottom systems. Due to the nature of the systems in the study area, this is predominantly confined to finer particles due to the slower flows.

Some nutrient removal, for example of phosphates and ammonia bound to clay minerals and soil particles, is likely to occur coincidentally with the deposition of these sediments. Sedimentation will thus tend to reduce phosphate loads in the short term. This is however likely to be recycled through plant and animal uptake and possibly re-released into the system at some later stage. Re-release may also occur if the sediments are submerged for periods long enough to result in the formation of anaerobic conditions, such as would occur in depressions and pools.

During the drying out phase, similar processes to those documented in pans can be expected, with progressive concentrating of solutes until their solubility products are exceeded. The actual mass of these precipitates is however unlikely to represent a significant proportion of the mass of elements transported during high flow events. In addition to removal, inundation can also result in the release of salts and nutrients into the water column through mineral exchange.

During the initial wetting phase for example, previously deposited salts and nutrients may be dissolved and leached from the sediments into the water column. Another effect that inundation in these systems may have on sediments is a change in the redox potential. Typically the redox potential would decrease as a function of time after inundation. The change in redox increases the solubility of a number metals such as manganese and iron and can result in the release of these and previously bound phosphates. The converse also holds when the system dries out and the sediments are re-aerated.

2.16.10 Regional Surface Water Quality

Surface water samples were collected from a number of sites in the vicinity of the proposed mining area, and in relation to the wetlands as indicated on Figure 2.16.10 (a). The samples that were collected were analysed to determine the concentrations of the more important cations and anions. Although indicated as sample sites, samples were not collected at the sites 3 and 15.

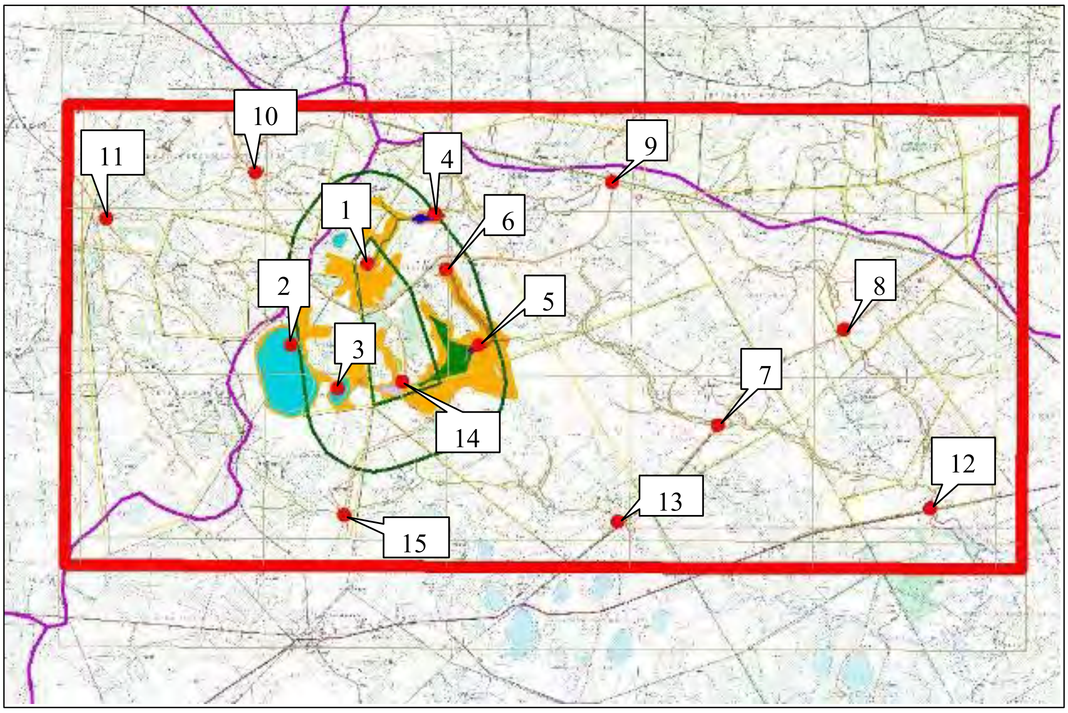


Figure 2.16.10 (a): Surface Water Sample Localities/Sites.

The results of the analyses of the water samples indicated that the surface water is of a high quality with low concentrations of most of the cations and anions. The exception to this generalisation is Site 2, Tevrede se Pan where the TDS is high, correlating with a high sodium chloride content. These high values almost certainly reflect the concentrating effect of evaporative water losses.

Although the surface waters are of high quality there is some variation in the cation and anion content. The Stiff diagrams (Figure 2.16.10 (b)) provide a graphical comparison of the concentrations of the major cations and anions in the water samples, expressed as milli-equivalents/ℓ, with samples arranged from upstream to downstream, with the exception of sites 2, 10, 11 and 13, Figure 2.16.10 (c). These are single samples collected in a pan (2) and streams with sources relatively remote from the proposed mining site.

Sodium is the dominant cation in the water samples collected in proximity to the proposed mining site, Sites 1, 2, 4, 11 and 14 while at sites 8, 10, and 13 calcium and/or magnesium is the dominant cation. At sites 7 and 9, it would seem that there may be slight shifts in the composition of the water samples where temporal differences in the dominant cation and anion concentrations are evident in samples collected in May and June respectively. For example in the sample collected at site 9 in May 2005, the dominant cation was sodium, while in a sample collected from the same site in June, calcium was the dominant cation. Differences were also recorded in the May and June samples collected at site 7. Reasons for these differences are not known.

There are no clear geographical trends with respect to the dominance of either sodium and/or calcium/magnesium in the water samples. However the results presented for Sites 7 and 9 where two samples were collected, indicate temporal shifts that could possibly be extrapolated to the other sites.

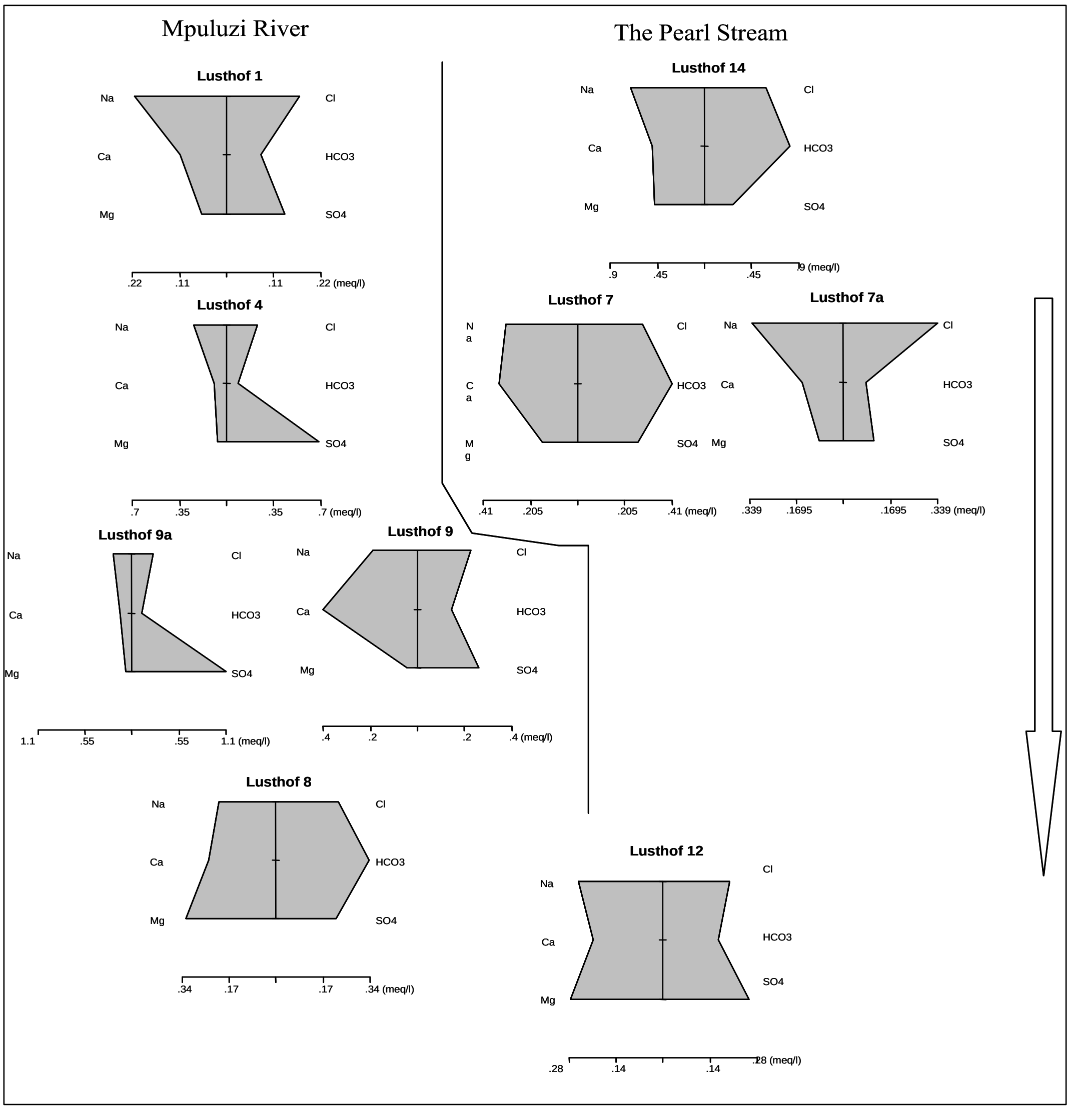


Figure 2.16.10 (b): Stiff Diagrams illustrating the comparative composition between sites & streams

Note: The arrow represents the direction of flow. (All values are given in meq/ℓ).

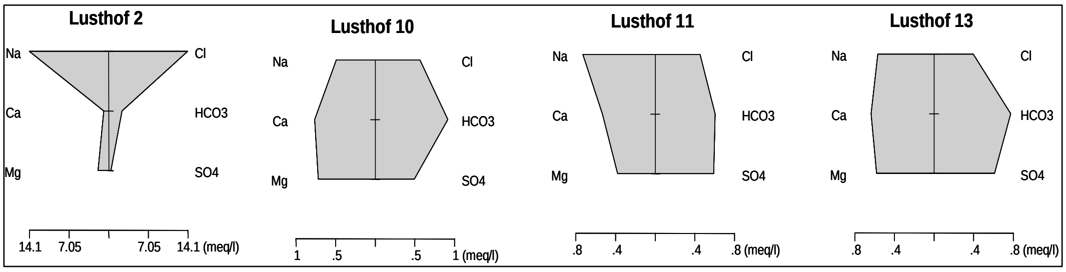


Figure 2.16.10 (c): Comparative Composition of surface water sampled at sites not directly linked to the proposed mining area

2.16.11 Correlation with Groundwater Quality

An attempt has been made to correlate the quality of the surface water samples with the quality in boreholes and springs in proximity to the sites where surface water samples were collected. The rationale for this is the connection between base flow and groundwater discharge, certainly true for springs. Data on borehole water quality was obtained from the initial specialist geohydrological report. The results of this inter site comparison is plotted in the cluster analysis diagram, indicated as Figure 2.16.11 (a).

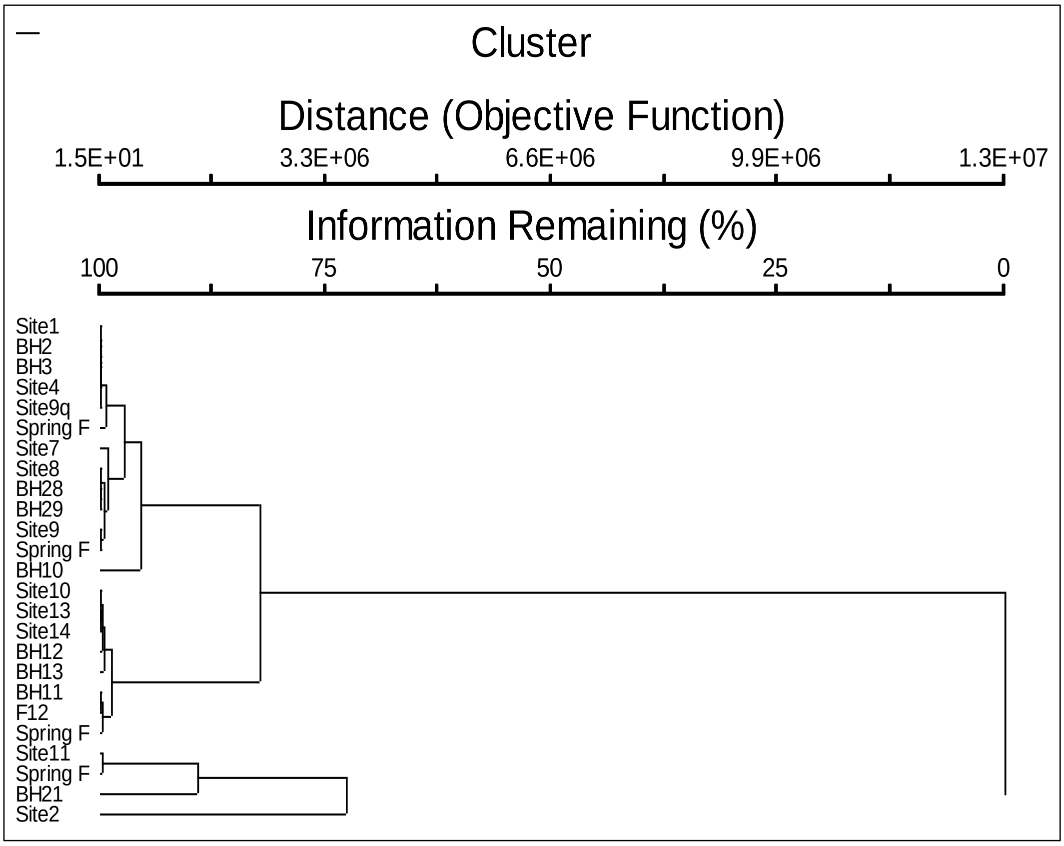


Figure 2.16.11 (a): Cluster Analysis Results.

The results of the cluster analysis identified a number of groupings with similar composition. These groupings are namely:

- Group 1: Site 1, BH2, BH3, Site 4, Site 9a, Spring F2, all sites associated with the drainage flowing to the north east
- Group 2: Site 7, Site 8, BH28, BH29, Site 9 and Spring F13, site associated with the drainage to the south east, with the exception of Site 9, which was a duplicate sample.
- Group 3: A single borehole BH10, with similarities with the previous two groups.
- Group 4: Site 10, Site 13, Site 14, BH12, BH13, BH11, Spring F12 and Spring F8.
- Group 5: Site 11, Spring F9.
- Group 6: a single borehole, BH21.
- Group 7: Tevrede se Pan, Site 2.

The last three groups have greater within group similarity with water qualities significantly different from the remaining groups, whereas the remaining groups have relatively similar water qualities.

This analysis confirms what one would expect in that there are linkages between the ground and surface water, with discernible differences in water qualities in the three drainage lines that have their sources in the vicinity of the proposed open cast mine.

All groundwater samples plotted within the (Ca,Mg)(HCO_3) field of the Piper diagram. This is in contrast to the surface water samples as discussed above, and depicted in the Stiff diagrams. The high sodium as opposed to calcium and magnesium content in Tevrede se Pan (Site 2) would suggest that in some areas sodium might well be the dominant cation, increasing the risk of salinization.

Salts do not degrade, and their concentrations can only be influenced by dilution through the use of sufficient water to move them to where they have less influence. When water with even a low salt content is added continuously to an environment, and where the water is allowed to evaporate or be lost through plant evapotranspiration, the salt remains and accumulates. For example, irrigation water with a salt content of 0,3 grams per litre applied at a rate of 10,000 cubic meters per hectare per annum transfers 3000 kg of salt per hectare per year into the soil (Oosterbaan, 2003).

Sodicity, commonly referred to as SAR, (sodium adsorption ratio), is a specific case of soil salinization involving the salts sodium, calcium, and magnesium. Sodium, through cation exchange, replaces the other two salts in the soil. One of the effects of cation exchange involving sodium is a change, generally a reduction, in the permeability of the soil. The process is reversible and involves the addition of excess calcium and magnesium salts to displace the sodium, together with sufficient quantities of water to remove the displaced sodium.

Salinization of soils in agriculture has important consequences in that high concentrations of soluble salts in the soil of the root zone affect plant growth by: restricting the uptake of water by the roots through their high osmotic pressures, and interfering with a balanced absorption of essential nutritional ions by plants. Different plants have different levels of sensitivity, so salinization can cause a shift in local plant communities.

These processes can have local economic consequences. A study on the effects of salinity changes in an irrigation area associated with the Vaal River in South Africa, suggested that income of a specific group of farmers could be reduced by up to 84% as a result of crop changes and reductions in yields. (Du Preez *et al.* 2000, Viljoen & Armour, 2002).

2.16.12 Aquatic Ecology - Habitat Integrity

Tevrede-se-Pan was considered **Unmodified/Natural (Category A)** in terms of aquatic and marginal habitat integrity. Agricultural activities (mainly livestock grazing) may have impacted slightly on water quality but this impact is considered minor considering that this is a naturally saline pan. Emergent vegetation was diverse and included a dominance of *Phragmites* reeds and marginal sedges.

The seasonal depression was considered **Largely Natural (Category B)** with some impounding due to road construction along the eastern edge, as well as water quality impacts and substrate modification due to grazing livestock and sediment accumulation due to erosion and channelization of adjacent seepage wetlands.

The farm dam was considered highly modified due to impoundment and impacts associated with livestock grazing. However, the water quality was relatively unimpacted and, for this reason, this site was considered **Moderately Modified (Category C)** in terms of aquatic ecosystems. It should be noted, however, that the adjacent wetlands (hillslope seepage and unchanneled valley bottom wetlands) were considered **Natural/Unmodified (Category A)** as they are hydrologically intact and support a high diversity of wetland vegetation. Impacts due to the dam are therefore minor within the context of the integrity of surrounding wetlands.

Downstream sites along the Muluzi River (Site 5) and Pearl Stream (Site 4) were considered **Moderately Modified** (**Category C**) and **Largely Natural (Category B)** respectively in terms of habitat integrity.

The site along Pearl Stream was impacted by a road crossing as well as notable agricultural impacts from cattle grazing and cultivation affecting water quality. Sedimentation as a result of upstream erosion has resulted in extensive colonisation by *Phragmites* reeds, thus altering instream habitats. In addition, upstream agricultural practices and impoundments have resulted in a modified flow regime and extensive channelization of the main channel.

The site along the Mpuluzi River was less impacted by grazing and cultivation although the main channel was deeply incised as a result of upstream impoundments. Nevertheless instream and riparian riparian habitats were largely intact.

Photographs of all the sampling sites are shown in Figure 2.16.12 (a) and Figure 2.16.12 (b).

Figure 2.16.12 (a):. Photographs of sites sampled within the vicinity of Lusthof: the farm dam with unchanneled valley bottom wetland downstream of it (row 1), seasonal depression (row 2) and Tevrede-se-Pan (row 3).

Figure 2.16.12 (b): Photographs of sites sampled within the vicinity of Lusthof: Mpuluzi River, Site 5 (row 1), Pearl Stream, Site 4 (row 2).

2.16.13 Aquatic Ecology - Surface Water Quality

On-site surface water quality data is given in Table 2.16.13 (a). In general, surface water is of a high quality with circum-neutral to slightly alkaline pH and low electrical conductivity (i.e. salinity).

Table 2.16.13 (a): On-site Surface Water Quality measured at sampling sites.

Site	Farm Dam	Seasonal Depression	Tevrede se Pan	Pearl Stream	Mpuluzi River
Temp (°C)	25.7	22	25.4	24.5	21.6
pH	8.85	7.81	8.4	7.3	7.47
Cond (mS/m)	6.7	45	187.8	12.1	5.3

The exception is Tevrede se Pan with a high electrical conductivity and salinity/TDS, correlating with a high sodium chloride content (Table 2.16.13 (b)). These high values almost certainly reflect the concentrating effect of evaporative water losses from the pan.

Table 2.16.13 (b): Water Quality Results for samples taken from Tevrede-se-Pan.

pH	pHs	SAR	Electric Conductivity
8.21	7.91	13.15	189.00 mS/m at 25 °C

ANIONS	mg/l	mmol(c)/l
Fluoride (1.5)	1.10	0.06
Nitrite (4.0)	0.00	0.00
Nitrate (44.0)	0.00	0.00
Chloride (250)	610.06	17.18
Sulphate (500)	3.29	0.07
Phosphate	0.00	0.00
Carbonate (20.0)	0.00	0.00
Bicarbonate	292.80	4.80
Subtotal	907.25	22.11

CATIONS	mg/l	mmol(c)/l
Sodium (400)	365.04	15.87
Potassium (400)	9.09	0.23
Calcium (200)	15.65	0.78
Magnesium (100)	25.90	2.13
Boron (1.5)	0.00	0.00
Subtotal	415.68	19.02

Sodium Carbonate	0.00	0.00
Sodium Bicarbonate	158.56	1.89
Alkalinity	240.00	4.80
Temp. Hardness	145.62	2.91
Perm. Hardness	0.00	0.00

Total	1322.00
Less (*)	146.40
Total disolved Solids	1175.60

The 2005 Wetland Assessment Report conducted a comparison between the quality of the surface water with the quality of groundwater in boreholes and springs nearby in an attempt to establish linkages between surface and groundwater. This revealed discernible differences in water qualities in the three drainage lines that have their sources in the vicinity of the proposed open-cast mine, indicating subsurface linkages within sub-catchments.

2.16.14 Diatoms

The overall species assemblages for all sites are indicative of circumneutral (i.e. species occurring around a pH of 7), fresh to brackish, eutrophic conditions (high level of nutrients), as would be expected within these systems. The species assemblages provide a baseline level against which future changes can be measured.

Table 2.16.14 (a): Diatom Results

	Dam 1	Depression	Pan
Achnanthidium sp. Kützing	86	126	51
Brachysira neoexilis Lange-Bertalot	0	56	0
Craticula sp. A. Grunow	6	0	0
Craticula halophila (Grunow ex Van Heurck) Mann	0	0	1
Caloneis bacillum (Grunow) Cleve	0	2	10
Encyonema minutum (Hilse) D.G. Mann	4	6	0
Encyonopsis subminuta Krammer & Reichardt	0	8	0
Eolimna minima(Grunow) Lange-Bertalot	0	0	14
Eunotia sp. C.G. Ehrenberg	12	24	2
Eunotia bilunaris (Ehrenberg) Mills	0	2	0
Eunotia incisa Gregory var.incisa	2	4	0
Eunotia pectinalis(Kutz.)Rabenhorst var.undulata (Ralfs) Rabenhorst	2	0	0
Eunotia rhomboidea Hustedt	0	0	18
Epithemia adnata (Kützing) Brébisson	0	0	66
Fistulifera saprophila (Lange-Bertalot & Bonik)	20	0	11
Fragilaria sp. H.C. Lyngbye	0	2	1
Fragilaria biceps (Kutzing) Lange-Bertalot	0	0	1
Fragilaria nanana Lange-Bertalot	6	4	0
Fragilaria tenera (W.Smith) Lange-Bertalot	0	2	4
Fragilaria ulna var.*acus* (Kützing) Lange-Bertalot	0	0	3
Frustulia crassinervia (Kützing) Cleve	4	0	1
Gomphonema auritum A.Braun ex Kützing	0	0	2
Gomphonema gracile Ehrenberg	0	8	0
Gomphonema parvulius Lange-Bertalot & Reichardt	0	2	4
Gomphonema parvulum (Kützing) Kützing	0	0	8
Gomphonema parvulum var exilissimum	2	10	18
Gomphonema sp. C.G. Ehrenberg	6	4	3
Lemnicola hungarica (Grunow) Round & Basson	0	0	1
Mayamaea atomus (Kutzing) Lange-Bertalot	3	0	2
Navicula arvensis Hustedt	0	0	8
Navicula cryptocephala Kützing	12	0	0
Navicula erifuga Lange-Bertalot	0	0	6
Navicula notha Wallace	12	0	0
Navicula reichardtiana Lange-Bertalot var. reichardtiana	0	2	0
Navicula riediana Lange-Bertalot & Rumrich	0	0	5
Navicula tenelloides Hustedt	2	0	1
Navicula trivialis Lange-Bertalot var. trivialis	0	0	1
Navicula sp. J.B.M. Bory de St. Vincent	22	2	3
Navicula veneta Kützing	6	0	0
Navicula zanoni Hustedt	0	4	0
Neidium sp. E. Pfitzer	2	0	0
Nitzschia acicularis(Kutzing) W.M.Smith	0	2	0
Nitzschia acidoclinata Lange-Bertalot	0	60	10
Nitzschia archibaldii Lange-Bertalot	9	6	4
Nitzschia capitellata Hustedt in A.Schmidt & al.	0	0	3
Nitzschia filiformis (W.M.Smith) Van Heurck var. filiformis	0	0	2
Nitzschia frustulum(Kutzing)Grunow var.frustulum	0	0	16
Nitzschia gracilis Hantzsch	2	0	0
Nitzschia inconspicua Grunow	0	0	8
Nitzschia microcephala Grunow	9	0	0
Nitzschia nana Grunow in Van Heurck	0	0	8
Nitzschia palea (Kützing) W.Smith	32	32	13
Nitzschia pura Hustedt	2	6	0
Nitzschia sp. A.H. Hassall	80	22	24
Pinnularia sp. C.G. Ehrenberg	6	0	1
Pinnularia gibba Ehrenberg	0	0	1
Pinnularia subcapitata Gregory var. subcapitata	0	0	6
Planothidium sp. Round & Bukhtiyarova	2	0	0
Rhopalodia gibba (Ehrenberg) O.Müller	0	4	10
Rhopalodia operculata (Agardh) Hakansson	0	0	8
Sellaphora sp. C. Mereschkowsky	6	0	0
Sellaphora pupula (Kutzing) Mereschkowksy	33	0	0
Sellaphora seminulum (Grunow) D.G. Mann	0	0	40
Stauroneis gracilior (Rabenhorst) Reichardt	4	0	0
Tabellaria flocculosa(Roth)Kutzing	6	0	0

It should be noted that the pollution-tolerant *Fistulifera saprophila* was present in Tevrede-se-Pan and the farm dam, suggesting possible contamination with pesticides. However, there is limited understanding of diatoms in dams and pans, most studies having focussed on rivers (Taylor *et al* 2007), and these results cannot be conclusively linked to a particular source of pollution. Nevertheless, the abundance of this species should be monitored as further increases would indicate continued pollution.

Tevrede-se-Pan had the highest richness (41 species), followed by the farm dam (30) and the seasonal depression (25). Tevrede-se-Pan also had a characteristic species assemblage distinct from the other two sites, with 22 unique species versus 12 and 7 for the dam and pan respectively. A range of diversity indices are given below.

S	N	d	J'	H'(loge)	1-Lambda'	
	No. species	Abundance	Margalef	Pielou	Shannon	Simpson
Dam	30	400	4.84	0.789	2.684	0.8914
Depression	25	400	4.006	0.7251	2.334	0.845
Pan	41	399	6.679	0.8277	3.074	0.931

In comparison with 47 other pans sampled within the Mpumalanga Highveld (excluding the Chrissiesmeer Lake District), Tevrede-se-Pan had the second highest number of diatom species and the highest abundance. Clearly, algal diversity is very high within this pan.

2.16.15 Aquatic Macroinvertebrates

The SASS5 aquatic macroinvertrebate results for the study area are displayed in Table 2.16.15 (a).

Dams and pans cannot be analysed according to SASS5 scores and were analysed in terms of diversity and abundance only. Tevrede se Pan had a far higher diversity relative to other pans in the Highveld. On average, based on a past sampling effort within 29 Highveld pans (excluding pans within the Chrissiesmeer Lake District), the numbers of macroinvertebrate families usually range between 10-13 families. In contrast, a taxon richness of 19 families was recorded from Tevrede-se-Pan, significantly higher than most pans within the region.

The reason for this high diversity is unclear but may be related to nutrient enrichment from the extensive *Phragmites* reed beds, together with a diversity of marginal vegetation and permanent inundation. Particularly noteworthy were two species of baetid mayfly, caenid mayflies and flatworms (Turbellaria), all seldom encountered in saline Highveld pans and therefore fairly unique. Pyralid moth larvae, which are considered highly sensitive and therefore indicate good water quality, have also been recorded from this pan. Tevrede-se-Pan was considered **Unmodified/Natural (Category A)** for aquatic macroinvertebrates.

The farm dam (Site 1) and the seasonal depression (Site 2) also reflected a relatively high richness (15-16 families) but with fewer uncommon or sensitive taxa. This reflects some disturbance from agricultural impacts as well as a more seasonal hydrological regime. These sites were considered **Largely Natural to Moderately Modified (Category B/C)** for aquatic macroinvertebrates.

Table 2.16.15(a): SASS5 Aquatic Macroinvertrebate Results for the Study Area

SITE		1. farm dam	2. seasonal depression	3. Tevredese pan	4. Pearl Stream	5. Mpuluzi River
	Temp (°C):	25.7	22	25.4	24.5	21.6
	pH:	8.85	7.81	8.4	7.3	7.47
	Cond (mS/m):	6.7	45	187.8	12.1	5.3
Biotopes Sampled (Rated 1-5)	Stones	0	0	0	0	1
	Marginal vege	3	3	4	3	4
	Sediment	1	1	1	1	1
	TOTAL No. TAXA	16	15	19	18	22
	SASS Score	71	63	87	75	109
	Average Score per Taxon	n/a	n/a	n/a	4.2	5.0
SASS5 Taxon	**SASS5 Sensitivity Score***					
Porifera	5					
Turbellaria	3			1	A	A
ANNELIDA						
Oligochaeta (Earthworms)	1				1	
Hirudinea (Leeches)	3	A	A	A		
CRUSTACEA						
Potamonautidae* (Crabs)	3				A	A
Atyidae (Freshwater Shrimps)	8					
HYDRACARINA (Mites)	8	A	A	A	A	A
EPHEMEROPTERA (Mayflies)						
Baetidae 1sp	4		A			
Baetidae 2 sp	6			B	A	A
Baetidae > 2 sp	12					
Caenidae (Squaregills/Cainfles)	6			A		A
Leptophlebiidae (Prongills)	9					
ODONATA (Dragonflies & Damselflies)						
Coenagrionidae (Sprites and blues)	4	A		A	A	A
Lestidae (Emerald Damselflies/Spreadwings)	8					
Aeshnidae (Hawkers & Emperors)	8	A		A	A	A
Gomphidae (Clubtails)	6					
Libellulidae (Darters/Skimmers)	4					
HEMIPTERA (Bugs)						
Belostomatidae* (Giant water bugs)	3	A	A	A	A	A
Corixidae* (Water boatmen)	3	B	A	A	A	B
Gerridae* (Pond skaters/Water striders)	5			A		A
Hydrometridae* (Water measurers)	6					
Naucoridae* (Creeping water bugs)	7	A	1	A		A
Nepidae* (Water scorpions)	3	A	A	B		
Notonectidae* (Backswimmers)	3			A		
Pleidae* (Pygmy backswimmers)	4	B	A	A	A	
Veliidae/M...veliidae* (Ripple bugs)	5	A	A	A	A	A
TRICHOPTERA (Caddisflies)						
Hydropsychidae 2 sp	6					A
Cased caddis:						
Hydroptilidae	6					
Leptoceridae	6					
COLEOPTERA (Beetles)						
Dytiscidae* (Diving beetles)	5	A	B	A	A	B
Noteridae*	5	A	A			
Gyrinidae* (Whirligig beetles)	5					A
Haliplidae* (Crawling water beetles)	5					
Helodidae (Marsh beetles)	12					
Hydraenidae* (Minute moss beetles)	8				1	A
Hydrophilidae* (Water scavenger beetles)	5				A	1
Limnichidae (Marsh-Loving Beetles)	10					
DIPTERA (Flies)						
Ceratopogonidae (Biting midges)	5	A	A	A		
Chironomidae (Midges)	2	A	A		A	A
Culicidae* (Mosquitoes)	1					
Dixidae* (Dixid midge)	10					
Empididae (Dance flies)	6					
Ephydridae (Shore flies)	3					
Muscidae (House flies, Stable flies)	1				A	
Psychodidae (Moth flies)	1					
Simuliidae (Blackflies)	5					A
Syrphidae* (Rat tailed maggots)	1					
Tabanidae (Horse flies)	5					
Tipulidae (Crane flies)	5					
GASTROPODA (Snails)						
Ancylidae (Limpets)	6					A
Sphaeridae	3					
Unionidae (mussels)	6					
Lymnaeidae* (Pond snails)	3	A	A			A
Physidae* (Pouch snails)	3	A		A	A	A
Planorbinae* (Orb snails)	3		A	A	A	
Thiaridae* (=Melanidae)	3					

Two downstream sites were sampled along Pearl Stream and the Mpuluzi River, in order to establish baseline data. These sites were sampled two months after the Lusthof sites and therefore had a slightly different taxon composition because of seasonal differences. In addition, stone and gravel biotopes were present within the Mpuluzi River, resulting in additional taxa specifically adapted to these biotopes. A number of highly sensitive taxa, such as hydraenid beetles, were found at both sites, as well as two species of baetid mayfly, suggesting good water quality. Previous studies (2005) have additionally recorded lestid damselflies and dixid midges at the Mpuluzi site, both these taxa being highly sensitive to water quality changes (sensitivity scores of 8 and 10 respectively). The average score per taxon (ASPT) within the Mpuluzi River was 5.0, which indicates a prevalence of sensitive families that would be affected by a deterioration in water quality. The Mpuluzi site was therefore considered **Largely Natural to Natural (Category A/B)** for aquatic invertebrates. The site sampled along Pearl Stream was considered **Moderately Modified (Category C)** for aquatic macroinvertebrates.

A desktop assessment including data extracted from the National Rivers Database reflected a high diversity, SASS5 score and ASPT for the Mpuluzi River within the downstream quaternary catchment, W55B. The mean SASS5 score for 5 sites was 180, with a mean ASPT of 6.2 and a mean of 28.4 families collected per site. These values are exceptionally high and reflect a highly sensitive biota with a limited tolerance for pollution. According to the SASS5 interpretation guidelines (Dallas 2007) these sites can be regarded as **Unmodified/Natural (Category A)** for lower foothill sites within the Highveld. In addition, the DWAF (1999) Ecoclassification data classify both W55A and the downstream catchment (W55B) as being of **High Ecological Importance and Sensitivity**, while the Mpumalanga Biobase (Ferrar and Lotter 2007) rates the affected subcatchments and downstream reaches within W55A as **Irreplaceable or Highly Significant.**

Fish were not sampled as part of this project and no data were available for downstream reaches. However, data extracted from the Rivers Database for W55E (directly below the Swaziland border) indicated a high diversity, with 9 indigenous fish species and an absence of exotic species, a fairly rare condition.
Eight of the nine species were either endemic or sensitive, including *Varichorhinus nelspruitensis*, listed as a Protected Species ("Species of high conservation value or national importance that require national protection") in Schedule B1 of DEAT (2005) Draft Lists of Threatened and Protected Species (Government Notice no 151 in terms of section 56(1) of the National Environmental Management: Biodiversity act, 2004 (ACT 10 of 2004)). In the absence of more spatially relevant data, it is strongly recommended that fish data be collected from the Mpuluzi River within catchments W55A and W55B to establish a baseline and for continued biomonitoring.

2.16.16 Ecological Importance and Sensitivity (EIS)

Tevrede se Pan was considered to be of **Very High** Ecological Importance and Sensitivity largely on account of its unique biota and species richness as well as its importance as feeding/breeding habitats and refugia for certain animals such as frogs. The high diversity of aquatic organisms, including planktonic crustacean (copepods, ostracods and cladocerans), provide an important food source for animals higher up in the food chain such as water birds and frogs.

Tevrede se Pan is hydrologically linked by hillslope seepage wetlands to the pan due east of it and these two pans should therefore be considered as a functional whole. Together they are likely to provide important migration routes for terrestrial mammals (e.g. otter, duiker, mongooses, etc.).

The farm dam and depression are also important as feeding/breeding habitats and migration routes for birds, amphibians and mammals and were considered to be of **High** Ecological Importance and Sensitivity. They form part of wetland systems occurring high up in their respective subcatchments (The Mpuluzi floodplain in the north and Pearl Stream in the south). As such, they are both important in attenuating flows, storing water and trapping nutrients and sediments, thus regulating flows and water quality further down in the catchments. Impacts to these sites may be transferred over considerable distances downstream.

It is also important to note that the depression wetland may be hydrologically linked via subsurface seepage to Tevrede se Pan and a groundwater assessment of the extent of this linkage would be prudent.

Concluding Summary

The proposed open-cast mining area at Lusthof is likely to impact upon a number of wetlands of high ecological importance and sensitivity within the upper reaches of the Mpuluzi River. The ecological sensitivity and importance of the area increases the intensity of the impacts which are primarily likely to be linked to water quality. Surface water is likely to become more acidic, saline and metal- and sulphate-rich as a result of mining activities. This may result in the loss of sensitive species and a decline in biodiversity value. These impacted will be compounded by possible future mining approvals in the area.

The Tevrede se Pan system (including the reed pan to the east of it) had a high diversity and was considered Natural/Unmodified (PES Category A) in terms of habitat integrity and aquatic macroinvertebrates, while and the Mpuluzi River downstream of the site was considered Natural/Unmodified (PES Catgory A) for aquatic macroinvertebrates. The Mpuluzi River is also considered to be important for fish, with an absence of alien fish. Both systems are at risk from mining impacts, although Tevrede-se-Pan may be less affected as decant is expected to flow eastward.

2.17 AIR QUALITY BASE LINE

JMA Consulting (Pty) Ltd appointed Airshed Planning Professionals (Pty) Ltd to conduct an air quality assessment within the study area. The air quality base line description compiled by them is reproduced in its entirety in this section.

2.17.1 Current Air Quality Status Assessment

The air quality assessment includes a cumulative assessment of air quality impacts, i.e. the impact from the additional sources of atmospheric emission in relation to existing air quality in the vicinity of the project.

This air quality assessment commenced with a baseline air quality characterisation of the Lusthof Colliery Project and includes the following:

- an overview of legislative and regulatory requirements pertaining to air quality, including dust fall assessment criteria;
- a study of the site-specific atmospheric dispersion potential through the analysis of modelled on-site meteorological data as obtained from the South African Weather Service (SAWS) Unified Model Data Set;
- the identification of existing sources of dust and gaseous emissions in the study area;
- the analysis of available ambient air quality data.

Particulate emissions are often responsible for the most significant air quality impacts around opencast mining operations. Operations at Lusthof Colliery expected to give rise to particulate emissions include construction, land clearing, drilling, blasting, materials handling (i.e. excavation, loading and unloading of trucks), light vehicle and truck movement on paved and unpaved roads, wind erosion of stockpiles and exposed areas, demolition and rehabilitation activities.

A distinction is made between Total Suspended Particulates (TSP) and PM_{10} (particulate matter with an aerodynamic diameter of less than 10 µm) and $PM_{2.5}$ (particulate matter with an aerodynamic diameter of less than 2.5 µm). Whereas TSP is of interest due to its implications in terms of nuisance dust impacts, the PM_{10} and $PM_{2.5}$ fractions are taken into account to determine the potential for human health risks. In addition to particulate emissions ($PM_{2.5}$, PM_{10} and TSP) gaseous vehicle exhaust emissions are also expected. Pollutants associated with the combustion of diesel and petrol that may result in health effects include carbon monoxide (CO), diesel particulate matter (DPM), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and organic compounds such as 1,3-butadiene and benzene (C_6H_6).

The potential health effects as well as National Ambient Air Quality Standards (NAAQS), international air quality guidelines (AQG) and dust fall limits, applicable to the pollutants that may be emitted as a result of activities at Lusthof Colliery will be assessed.

2.17.2 The National Environmental Management Air Quality Act

The National Environmental Management Air Quality Act (NEMAQA) has shifted the approach of air quality management from source-based control to the control of the receiving environment. The act has also placed the responsibility of air quality management on the shoulders of local authorities that will be tasked with baseline characterisation, management and operation of ambient monitoring networks, licensing of listed activities, and emissions reduction strategies. The main objective of the act is to ensure the protection of the environment and human health through reasonable measures of air pollution control within the sustainable (economic, social and ecological) development framework.

NEMAQA commenced on the 11th of September 2005 with the exclusion of the sections pertaining to the listing of activities and the issuing of atmospheric emissions licences. Listed Activities and associated Minimum Emission Standards were published in the Government Gazette on the 31st of March 2010 (No. 33064) as Section 21 of the Air Quality Act (AQA). The Atmospheric Pollution Prevention Act (APPA) of 1965 was repealed on the 1st of April 2010 bringing NEMAQA into full force.

According to the AQA, air quality management control and enforcement is in the hands of local government with District and Metropolitan Municipalities as the licensing authorities. Provincial government is primarily responsible for ambient monitoring and ensuring municipalities fulfil their legal obligations, with national government primarily a policy maker and co-ordinator. Each sphere of government must appoint an Air Quality Officer responsible for co-ordinating matters pertaining to air quality management. Given that air quality management under the old Act was the sole responsibility of national government, local authorities have in the past only been responsible for smoke and vehicle tailpipe emission control.

In addressing the impact of air pollution emanating from proposed operations, some background on the health effects of the various pollutants relevant to the study need to be provided.

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality guideline values and standards indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging periods or exposure periods. Generally, five averaging periods are applicable, namely an instantaneous peak, 1-hour average, 24-hour average, 1-month average, and annual average.

Reference is made to the National Ambient Air Quality Standards (NAAQS) for criteria pollutants (benzene, CO, NO_2, $PM_{2.5}$, PM_{10} and SO_2). In the assessment of non-criteria pollutants, reference is made to international AQGs such as those published by the World Health Organisation (WHO). Dustfall rates are assed according to proposed South African dustfall limits.

2.17.3 The Potential Impact of Various Pollutants on Human Health

2.17.3.1 Carbon Monoxide (CO)

The significance of carbon monoxide in ambient air lies in that it, when inhaled, forms a strong bond with the haemoglobin molecule to form carboxyhaemoglobin which impairs the oxygen carrying capacity of blood. Health effects include certain cardiovascular, pulmonary and cerebrovascular effects. Since more blood is needed to supply the same amount of oxygen to the body, the heart needs to work harder. This is the main causes of tissue hypoxia produced by CO at low exposure levels. At higher concentrations, the rest of the absorbed CO binds with other heme proteins such as myoglobin and with cytochrome oxidase and cytochrome P-450. CO uptake impairs perception and thinking, slows reflexes and may cause drowsiness, angina, unconsciousness or death (WHO, 1999).

2.17.3.2 Diesel Particulate Matter (DPM)

Diesel engine Exhaust (DE) is an intricate mixture of airborne particles and gases. DPM is composed of elemental carbon particles and adsorbed organic compounds and is the most frequently determined measure of DE and the measure reported in toxicological studies of diesel engine exhaust (US EPA, 2002). Chronic respiratory effects are the main non-cancer hazard to humans from long-term environmental exposure to diesel engine exhaust, or emissions.

2.17.3.3 Nitrogen Dioxide (NO_2)

Oxides of nitrogen (NO_x), primarily in the form of nitrogen monoxide (NO), are one of the primary pollutants emitted during combustion. NO_2 is formed through oxidation of these oxides once released in the air. NO_2 is an irritating gas that is absorbed into the mucous membrane of the respiratory tract. The most adverse health effect occurs at the junction of the conducting airway and the gas exchange region of the lungs. The upper airways are less affected because NO_2 is not very soluble in aqueous surfaces. Exposure to NO_2 is linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics and decreased pulmonary function (WHO, 1997).

2.17.3.4 Particulates ($PM_{2.5}$ and PM_{10})

The range of adverse inhalation health effects of particulate matter is broad but is predominantly associated with the respiratory and cardiovascular systems. PM_{10}, currently the indicator for particulate matter and the most routinely monitored particulate matter size, represents the particle mass that enters the respiratory tract and includes both the coarse (particle size between 2.5 and 10 µm) and fine particles (less than 2.5 µm) particles. The potential of particles to be inhaled and deposited in the lung is a function of the aerodynamic characteristics of particles in flow streams. The aerodynamic properties of particles are related to their size, shape and density. The deposition of particles in different regions of the respiratory system depends on their size. The major health effects from airborne particuates are increased mortality and aggravation of existing respiratory and cardiovascular disease.

2.17.3.5 Sulphur Dioxide (SO_2)

SO_2 is damaging to the human respiratory function. Exposure to sulphur dioxide concentrations above certain threshold levels increases the prevalence of chronic respiratory disease and the risk of acute respiratory illness. Due to it being highly soluble, sulphur dioxide is more likely to be adsorbed in the upper airways rather than penetrate to the pulmonary region (WHO, 1979).

2.17.3.6 Organic Compounds

Petrol and diesel engines emit organic compounds such as benzene and 1, 3-butadiene. Benzene, a known carcinogen, produces a number of adverse health effects off which the most frequently reported health effect is bone marrow depression leading to aplastic anemia (WHO, 1993). 1, 3-Butadiene is a carcinogenic to humans by inhalation.

The specific mechanisms of 1, 3-butadiene-induced carcinogenesis are unknown; however, it is virtually certain that the carcinogenic effects are mediated by genotoxic metabolites of 1, 3-butadiene (US EPA, 2002).

2.17.4 South African National Ambient Air Quality Standards

The South African Bureau of Standards (SABS) was engaged to assist the Department of Environmental Affairs (DEA) in the facilitation of the development of national ambient air quality standards.

This included the establishment of a technical committee to oversee the development of standards. Standards were determined based on international best practice for PM_{10}, dustfall, SO_2, NO_2, ozone (O_3), CO, lead (Pb) and benzene.

The final revised national ambient air quality standards (NAAQS) for pollutants considered in the current investigations, as published in the Government Gazette on the 24th of December 2009, are listed in Table 2.17.4 (a). Standards for $PM_{2.5}$ were published on the 29th of June 2012.

Table 2.17.4 (a): National Ambient Air Quality Standards

Pollutant	Averaging Period	Limit Value (µg/m³)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
Benzene (C_6H_6)	1 year	10	3.2	0	Immediate – 31 Dec 2014
	1 year	5	1.6	0	1 Jan 2015
Carbon Monoxide (CO)	1 hour	30000	26000	88	Immediate
	8 hour[(a)]	10000	8700	11	Immediate
Nitrogen Dioxide (NO_2)	1 hour	200	106	88	Immediate
	1 year	40	21	0	Immediate

Pollutant	Averaging Period	Limit Value (µg/m³)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
$PM_{2.5}$	24 hour	65	-	4	Immediate – 31 Dec 2015
	24 hour	40	-	4	1 Jan 2016 – 31Dec 2029
	24 hour	25	-	4	1 Jan 2030
	1 year	25	-	0	Immediate – 31 Dec 2015
	1 year	20	-	0	1 Jan 2016 – 31Dec 2029
	1 year	15	-	0	1 Jan 2030
PM_{10}	24 hour	120	-	4	Immediate to 31-Dec 2014
	24 hour	75	-	4	1-Jan-15
	1 year	50	-	0	Immediate to 31-Dec 2014
	1 year	40	-	0	1-January 2015
Sulphur Dioxide (SO_2)	10 minutes	500	191	526	Immediate
	1 hour	350	134	88	Immediate
	24 hour	125	48	4	Immediate
	1 year	50	19	0	Immediate

2.17.4.1 Inhalation Reference Concentrations for Non-Criteria Pollutants

Inhalation reference concentrations (RfCs) are derived from clinical studies. An uncertainty factor is applied to the No Observed Adverse Effect Level (NOAEL) from these studies, allowing (for instance) for application of results of animal studies to human health risks. Concentration values below the RfC imply that no risk has been identified; above the RfC does not necessarily imply risk, but further investigation might be warranted. Inhalation RfCs published by the US EPA IRIS and Agency for Toxic Substances and Disease Registry (ATSDR) for non-criteria pollutants considered in the Lusthof Colliery Project is summarised in Table 2.17.4.1 (a). Chronic and acute RfCs will be used to assess annual and hourly air quality impacts respectively.

Table 2.17.4.1 (a): Inhalation Reference Concentrations for non-criteria Pollutants

Pollutant	Chronic Inhalation Reference Concentrations		Acute Inhalation Reference Concentrations	
	RfC [µg/m³]	Reference	RfC [µg/m³]	Reference
diesel particulate matter	5	US EPA IRIS	-	-
1, 3 - butadiene	2	US EPA IRIS	220	ATSDR

2.17.4.2 Unit Risk Factors for Carcinogens

Standards for carcinogens are not set using the same methodology as for non-carcinogens, as they have no lower threshold for adverse effects. However, using an appropriate acceptable risk level, annual average concentration standards may be derived. Unit risk factors (URFs) indicate the increase in lifetime risk to an individual exposed to 1 µg/m³ of substance over a lifetime. URFs for pollutants potentially associated with the Lusthof Colliery Project are summarised in Table 2.17.4.2 (a).

Table 2.17.4.2 (a): Unit Risk Factors for Carcinogens

Pollutant	Chronic Inhalation Reference Concentrations	
	URF [(µg/m³)$^{-1}$]	Reference
benzene	7.80E-06	US EPA IRIS
1, 3 - butadiene	3.00E-05	US EPA IRIS
diesel particulate matter	3.00E-04	CALEPA

2.17.4.3 Dustfall Limits

Draft National Dust Control Regulations were published by the DEA on the 27th of May 2011. The draft regulation states that no person may conduct any activity in such way as to give rise to dust in such quantities and concentrations that:

(1) The dust, or dust fall, has a detrimental effect on the environment including health, social conditions, economic conditions, ecological conditions or cultural heritage, or has contributed to the degradation of ambient air quality beyond the premises where it originates; or
(2) The dust remains visible in the ambient air beyond the premises where it originates: or
(3) The dust fall at the boundary or beyond the boundary of the premises where it originates exceeds:
   a. 600 mg/m^2/day averaged over 30 days In residential and light commercial areas measured using reference method ASTM 01739; or
   b. 1200 mg/m^2/day averaged over 30 days in areas other than residential and light commercial areas measured using reference method ASTM 01739.

2.17.5 Atmospheric Dispersion Potential

Meteorological mechanisms govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. The meteorological characteristics of a site govern the mechanisms which allow pollution to be transported, diluted and removed from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer (planetary boundary layer or PBL). According to Arya (1999), the mixing height of the PBL is the most important parameter, which not only determines the limit on the vertical diffusion of the plume or puff of materials released, but also determines a host of other parameters and scales related to turbulence and diffusion.

Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field and atmospheric stability. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness.

The wind direction, and the variability in wind direction, therefore determines the general path pollutants will follow, and the extent of cross-wind spreading (Shaw and Munn, 1971; Pasquill and Smith, 1983; Oke, 1990). A description of the surface wind field and other climatic parameters that influence the dispersion and removal of pollutants from the atmosphere are provided in subsequent sections.

In the absence of actual on-site measurements, reference is made to modelled South African Weather Service (SAWS) Unified Model (UM) data for an on-site location for the period January 2008 to December 2009. Reference is also made to climate statistics for Carolina as recorded and reported by the SAWS. The Carolina SAWS Station has only recently (March 2011) started recording hourly meteorological parameters.

2.17.6 Surface Wind Field

Wind roses represent wind frequencies for the 16 cardinal wind directions. Frequencies are indicated by the length of the shaft of a petal when compared to the circles drawn to represent a 4% frequency of occurrence. Wind speed classes are assigned to illustrate the frequencies with high and low winds occurring for each wind vector. The frequencies of calms, defined as periods for which wind speeds are below 1 m/s, are also indicated.

Period, day and night-time wind roses are provided in Figure 2.17.6 (a). The seasonal variation in the wind field is shown in Figure 2.17.6 (b). The wind field at Lusthof is dominated by winds from the west, east and east-northeast. The strong winds (5 m/s to 10 m/s) occur most frequently from the west-southwest, west and west-northwest.

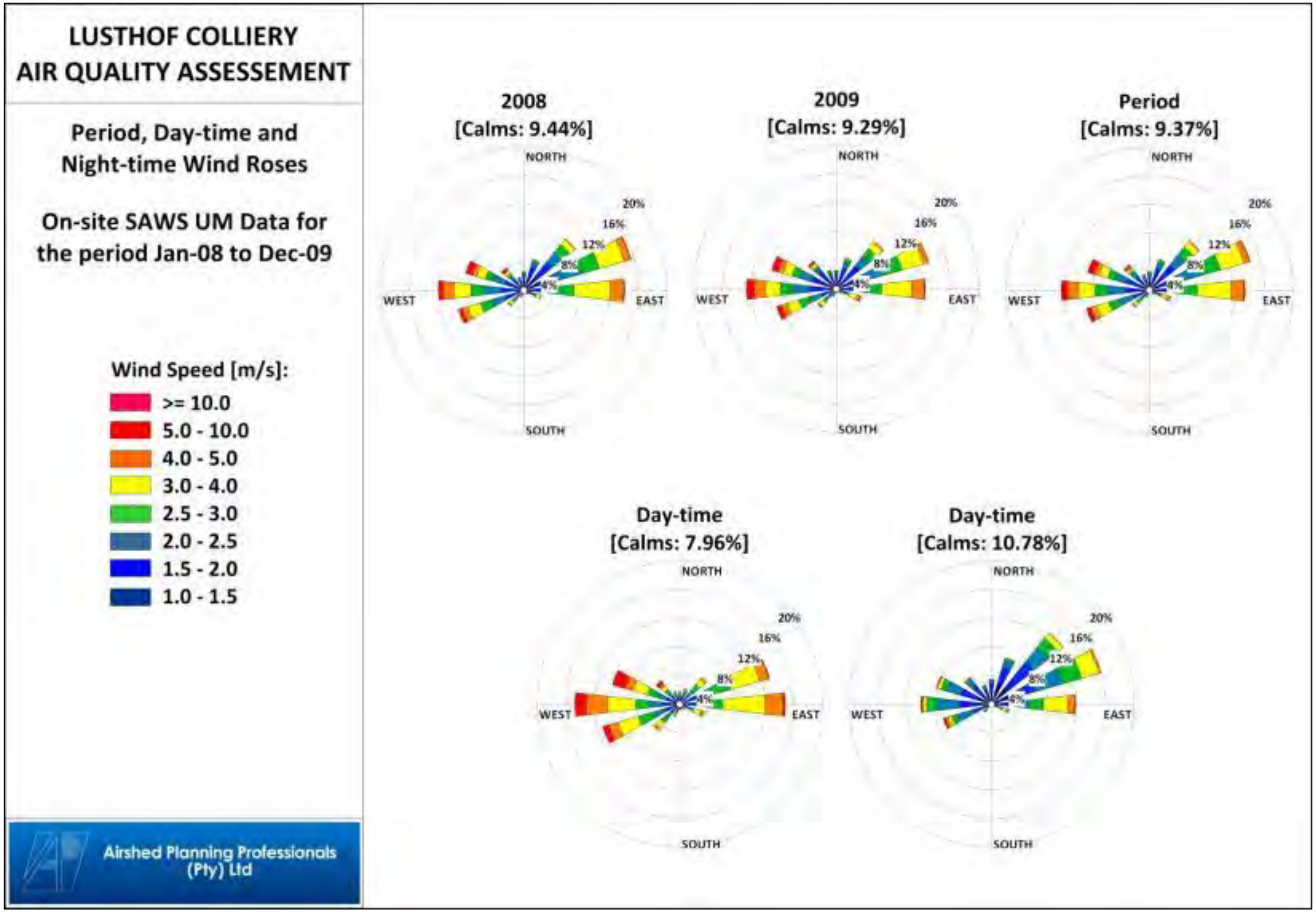


Figure 2.17.6 (a): Period, day-time and night-time Wind Roses

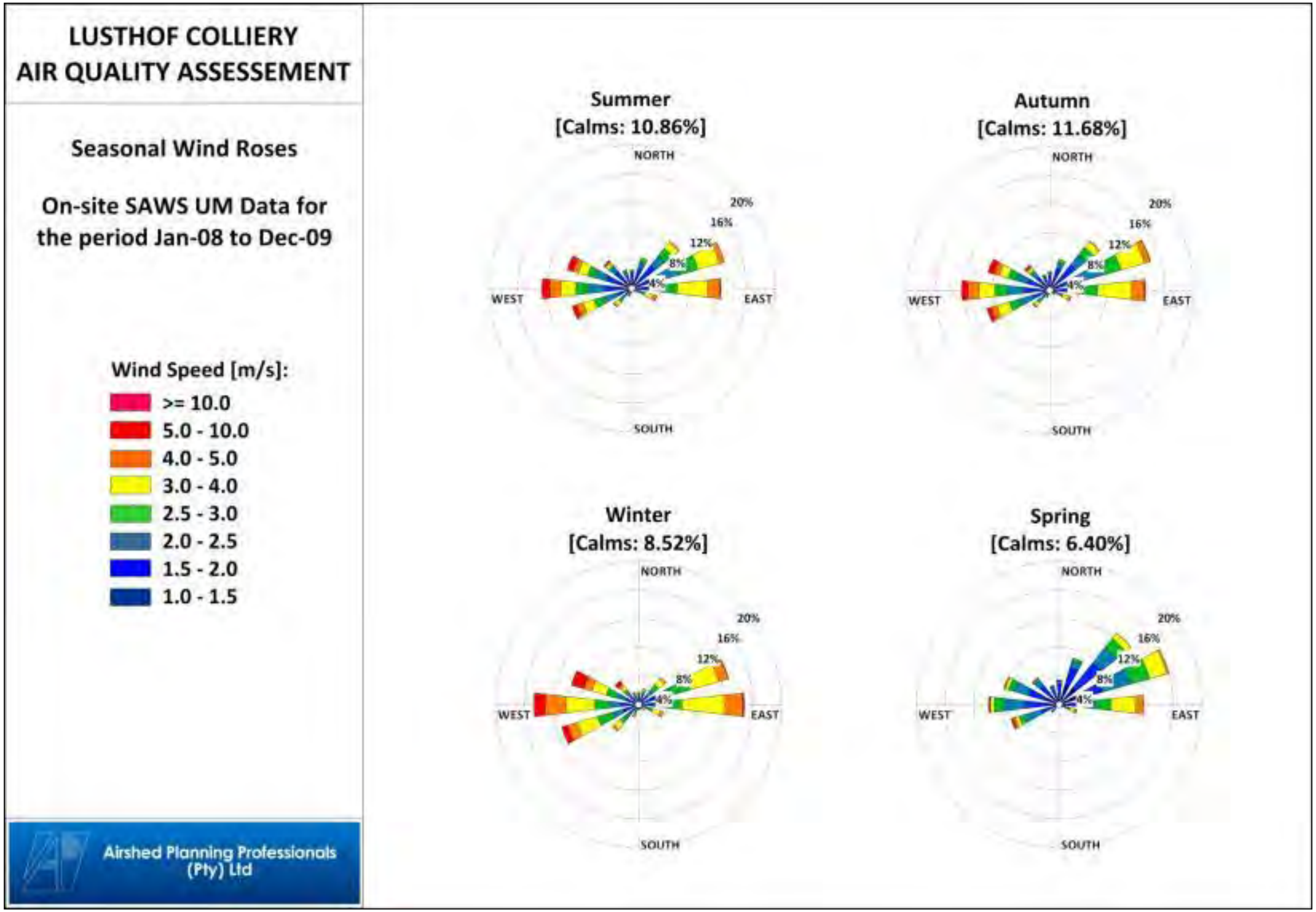


Figure 2.17.6 (b): Seasonal Wind Roses

During the daytime, prevailing winds are from the west and east with strong winds occurring more frequently than during the night. A decrease in winds from the west and an increase in winds from the east-northeast are observed during night-time hours. Calm conditions occur more frequently during the night.

The frequency at which various wind speed categories occur is indicated by the chart indicated as Figure 2.17.6 (c). Wind speed below 5 m/s occur 97% of the time. Weak winds of 2 m/s and less, generally regarded as periods of limited dilution, especially at midnight, occurred ~38% of the time.

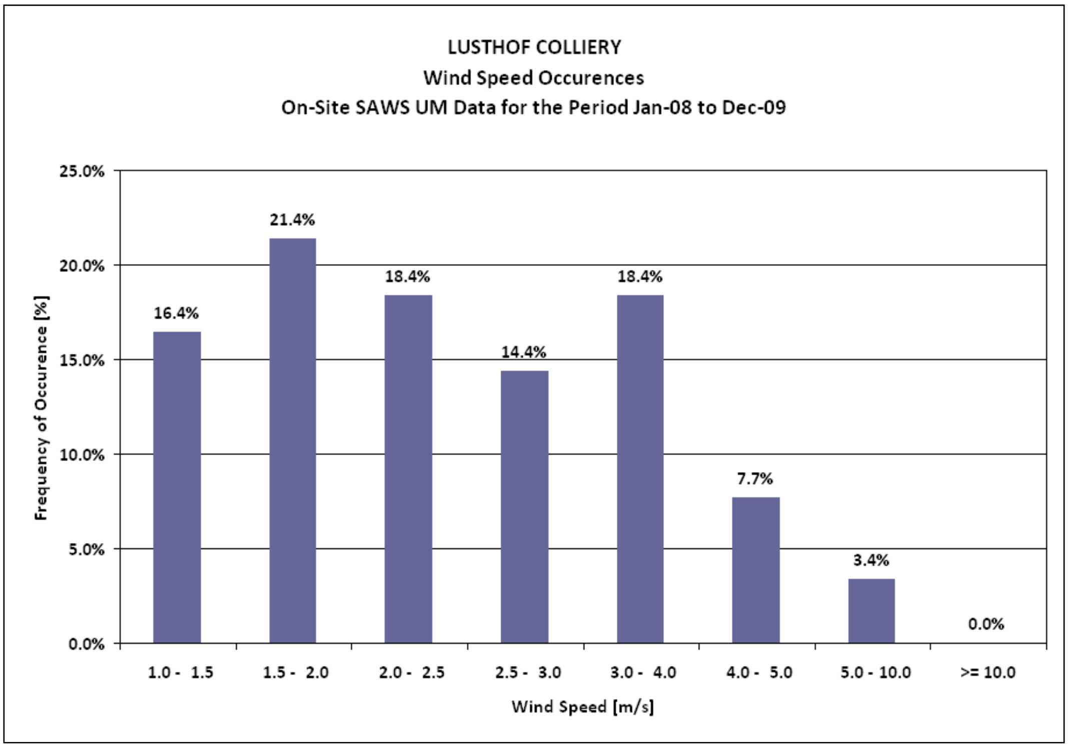


Figure 2.17.6 (c): Frequency of Wind Speeds

2.17.7 Atmospheric Stability

The new generation air dispersion models differ from the models traditionally used in a number of aspects, the most important of which are the description of atmospheric stability as a continuum rather than discrete classes. The atmospheric boundary layer properties are therefore described by two parameters; the boundary layer depth and the Monin-Obukhov length, rather than in terms of the single parameter Pasquill Class. The Monin-Obukhov length (L_{Mo}) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface.

Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface.

Night times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and less dilution potential.

Diurnal variation in atmospheric stability, as calculated from on-site SAWS UM data, and described by L_{Mo}, is provided in Figure 2.17.7 (a). The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions.

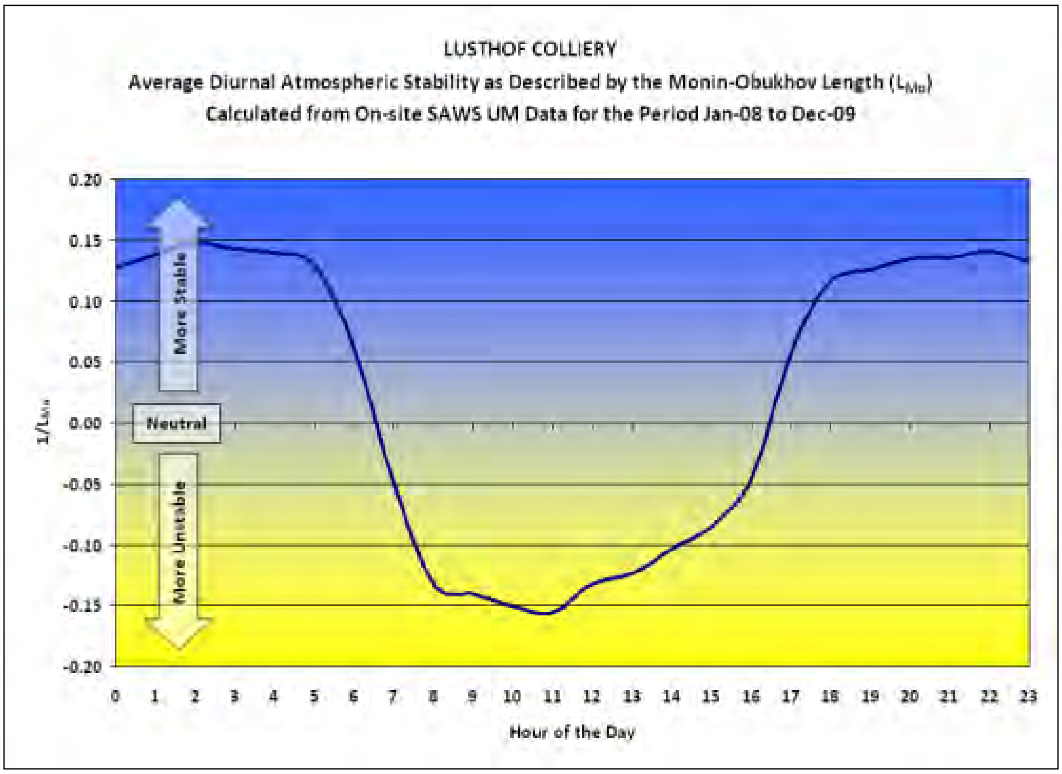


Figure 2.17.7 (a): Average diurnal atmospheric stability.

2.17.8 Existing Sources of Atmospheric Emission in the Study Area

The identification of existing sources of emissios in the region and the characterisation of existing ambient pollutant concentrations is fundamental to the assessment of the potential for cumulative impacts and synergistic effects given the current and proposed operations and their associated emissions.

Existing sources of emission in the Highveld region include, but are not limited to, the following:

- fugitive and process emissions from various coal-fired power stations;
- fugitive emissions from coal mining operations;
- vehicle tailpipe emissions from mining fleets, national and main roads;
- biomass burning (veld fires in agricultural areas within the region); and
- miscellaneous fugitive dust sources such as agricultural activities, wind erosion of open areas, vehicle-entrainment of dust along paved and unpaved roads.

There are however no Industrial and Mining activities in the immediate vicinity of the Lusthof Colliery Project and existing air quality is expected to be effected mostly by biomass burning, agricultural activities, wind erosion of open areas, vehicle-entrainment of dust along unpaved roads, vehicle exhaust emissions and stack emissions from nearby power stations.

Vehicle tailpipe emissions are localised sources and unlikely to impact far-field and traffic on the unpaved roads surrounding the project area is limited. Fugitive dust emissions may occur as a result of vehicle entrained dust from local paved and unpaved roads, and wind erosion from open areas. The extent of particulate emissions from the roads depends on the number of vehicles using the roads and on the silt loading on the roadways. The extent, nature and duration of agricultural activities and the moisture and silt content of soils will determine the amount of dust generated. The quantity of wind-blown dust is a function of the wind speed, the extent of exposed areas and the moisture and silt content of such areas.

2.17.9 Measured Ambient Air Quality

2.17.9.1 Site-specific Ambient PM_{10} Monitoring

In the absence of long term ambient air quality monitoring in the vicinity of the project area, two short term monitoring campaigns were conducted to provide an indication of current ambient PM_{10} concentrations, PM_{10} being a pollutant of concern for operations such as those proposed for the Lusthof Colliery Project.

The main objective of the monitoring campaigns was to provide background ambient PM_{10} concentrations prior to the commencement of mining operations. A Minivol sampler was placed two nearby farms adjacent to the project area from the 21st to the 25th of February 2011 and the 31st of August to the 9th of September 2011. Daily average PM_{10} concentrations measured during the two campaigns are summarised in, and subsequently compared to, the 24 hour NAAQS limit value for PM_{10}.

During the first campaign, no exceedances of the 24 hour NAAQS limit value for PM_{10} of 75 µg/m³ were recorded (Table 2.17.9.1 (a)). The actual measured PM_{10} concentrations ranged from 14 µg/m³ to 56 µg/m³. An average 24 hour concentration, over the 5 monitoring days, of 28 µg/m³ was calculated.

No exceedances were recorded during the second (dry season) campaign either. PM_{10} concentrations were found to range between 13 and 70 µg/m³. An average 24 hour concentration, over the 10 monitoring days, of 47 µg/m³ was calculated.

Table 2.17.9.1 (a): Results of ambient PM_{10} Monitoring Campaigns

Seoson	Date	24 Hour Average PM10 Concentration [µg/m³]
Wet Season Monitoring	21/02/2011	14
	22/02/2011	28
	23/02/2011	56
	24/02/2011	14
	25/02/2011	28
Dry Season Monitoring	31/08/2011	66
	01/09/2011	50
	02/09/2011	13

	03/09/2011	42
	04/09/2011	55
	05/09/2011	25
	06/09/2011	67
	07/09/2011	70
	08/09/2011	42
	09/09/2011	55

The values recorded in the above Table will be used as reference values for compliance monitoring once the mine becomes operational.

2.17.9.2 Site-specific Ambient Dustfall Monitoring

A total of 5 dustfall collection units were installed at the proposed Lusthof Colliery project area in June of 2011 (Figure 2.17.9.2 (a)). An additional unit was installed in July 2011. The dustfall network was set up in accordance with the American Society for Testing and Materials (ASTM) standard method for collection and analysis of dustfall (ATSM D1739-98 of 2010).

The ASTM method covers a procedure of collection of dustfall and its measurement and employs a simple device consisting of a cylindrical container exposed for one calendar month (30 ±2 days). The method provides for a dry bucket. The dustfall unit stand includes a wind shield at the level of the rim of the bucket to provide an aerodynamic shield. The bucket holders are connected to a 2 m galvanized steel pole, which are cemented into the ground or attached to existing infrastructure.

After 30 ±2 days of exposure, the containers are sealed and sent to a laboratory for analysis. At the laboratory, each container is rinsed with deionised water to remove residue from the sides, and the contents filtered through a coarse (>1 mm) filter to remove insects and other course organic detritus. The sample is then filtered through a pre-weighed paper filter to remove the insoluble fraction, or dustfall. This residue and filter are dried, and gravimetrically analysed.

Dustfall rates as calculated from samples collected between June 2011 and June 2012 are presented in Figure 2.17.9.2 (b). Results show that background dustfall rates in the vicinity of the Proposed Lusthof Colliery are low (less than 400 mg/m^2-day). All dustfall rates for the monitoring period were below the residential target of 600 mg/m^2-day. The highest dustfall rates were recorded at Lusthof #3 and Lusthof #5 which are both located adjacent to the unpaved road passing though the area.

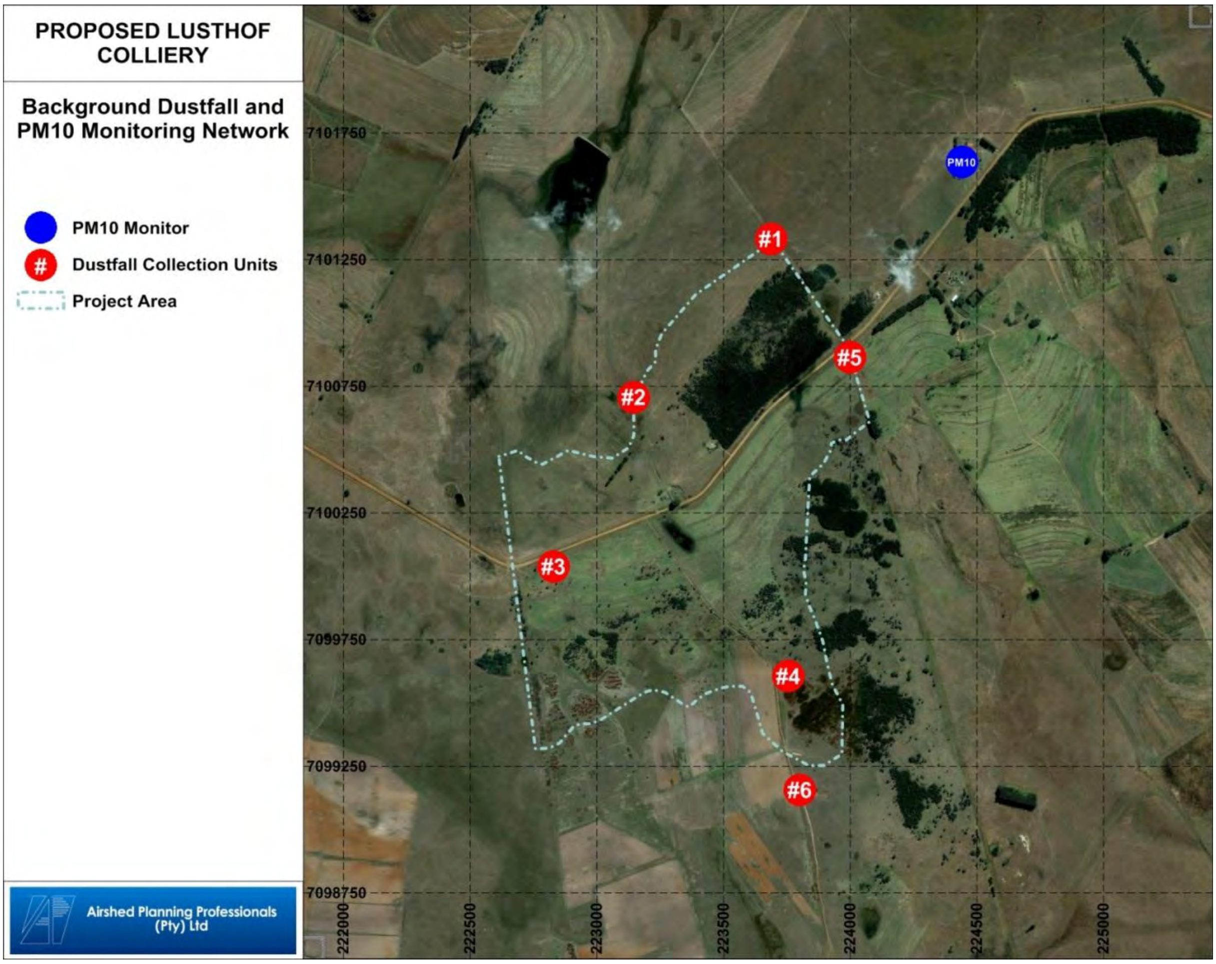
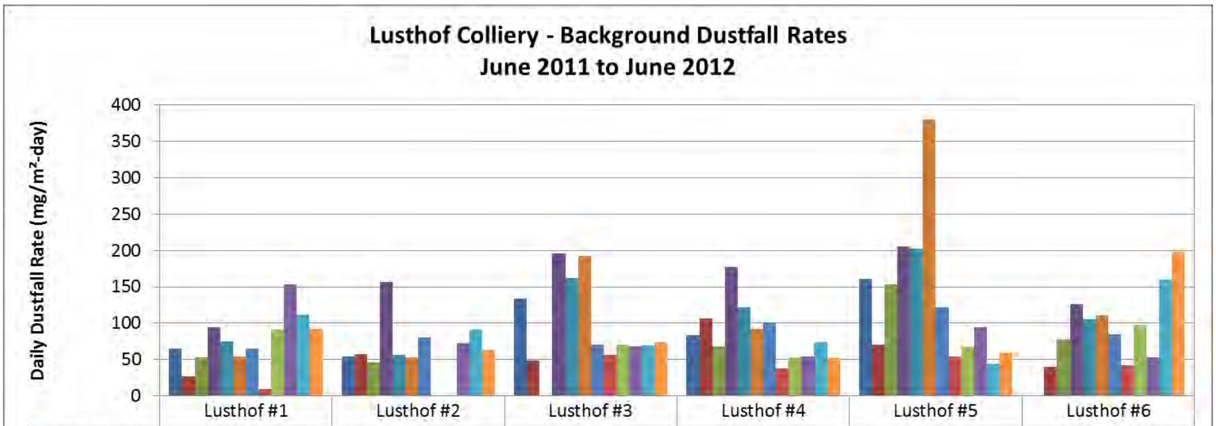


Figure 2.17.9.2 (a): Background Dustfall and PM_{10} Monitoring Network



	Lusthof #1	Lusthof #2	Lusthof #3	Lusthof #4	Lusthof #5	Lusthof #6
Jun/Jul '11	65	54	134	84	161	no data
Jul/Aug '11	27	58	49	107	71	40
Aug/Sep '11	53	47	no data	68	153	78
Sep/Oct '11	95	157	196	177	205	127
Oct/Nov '11	75	56	162	122	202	106
Nov/Dec '11	55	53	193	92	381	111
Dec/Jan '12	65	81	71	101	122	85
Jan/Feb '12	9	no data	56	38	55	43
Feb/Mar '12	91	no data	71	53	67	98
Mar/Apr '12	153	72	69	54	94	53
Apr/May '12	112	91	70	74	44	160
May/Jun '12	92	63	74	52	60	198

Figure 2.17.9.2 (b): Dustfall Results

2.17.9.3 Ambient Air Quality Monitoring in Mpumalanga

Several permanent ambient air quality monitoring stations, measuring criteria pollutants such as PM_{10}, NO_2 and SO_2 are in operation in the Mpumalanga Province. These stations are however mostly located in areas of concentrated industrial and mining activities or in residential areas and townships (DEA, 2005) and are therefore not representative of ambient air quality conditions at Lusthof Colliery. A summary of publicly available ambient air quality for Mpumalanga is provided in the State of the Air Report 2005, published by the DEA.

2.18 NOISE BASE LINE

JMA Consulting appointed specialist firm ACUSOLV to conduct a Noise Assessment for the proposed Lusthof Colliery Project. The full content of the noise base line description compiled by them is reproduced in its entirety in this section.

2.18.1 Meteorological Considerations

Outdoor noise measurement is not permitted under certain weather conditions. Rain, drizzle or fog affects the conductivity of measurement microphones, resulting in faulty readings. It may also damage the microphone and measuring equipment. Secondly, although measurement often has to be performed in the presence of wind, care should be taken to verify that wind turbulence noise on the microphone capsule is negligible compared to the sound level being measured. There is no fixed upper limit for permissible wind speed, it all depends on the level being measured. Another weather phenomenon which may cause interference and spoil measurement data, is thunder.

Meteorological conditions also affect the acoustic environment and the actual sound levels without causing interference or measurement error. Normal fluctuations in atmospheric conditions may cause large variations in noise level which cannot and should not be avoided in the planning and execution of noise monitoring surveys. These variations constitute the natural variance in both background and intrusive noise levels. Noise levels at a distance from large sources are highly dependent on meteorological conditions. In fact, the difference in characteristic day and night meteorological patterns is one reason why 24-hour mining or industrial operations always have much greater noise impacts at night.

It should be noted that, for the reasons explained above, the monitoring of meteorological conditions, such as temperature, wind and humidity on the ground can at best only serve to avoid errors and distortion of measurement data. Knowledge of cloud cover, temperature, humidity and wind which prevailed during the course of a noise survey has little if any value in the post-processing and interpretation of data.

2.18.2 Sampling Considerations

To be of any use as an environmental management tool, noise monitoring has to produce accurate and relevant data. As a minimum requirement, the right equipment should be used and measurements performed with the necessary precision and accuracy, as laid down in SANS 10103 [2]. Just as important, no matter how accurate the measurements, the data is only as good as the sample. What complicates noise sampling is that ambient noise is all but constant. As a rule, it is the net result of contributions from various constant, cyclic and randomly fluctuating sources.

To account for the intrinsic 24-hour cyclic variation, measurements should be taken within the relevant period of interest, e.g. daytime, night-time or a 24-hour cycle. Noise regulations require that the noise investigated must be measured (averaged) over a period of at least 10 minutes; i.e. 10 minutes or longer.

Occasionally, in the investigation of noise complaints, a 10 minute sample may be sufficient to obtain the data needed to make a finding. For purposes of predictive noise studies and monitoring surveys, however, much longer averaging periods are required to determine baseline or operational noise levels. Noise levels have to be averaged over periods long enough to ensure that the sample is representative of the true average.

Where this is possible, in addition to measuring the average over the day or night-time period of interest, equipment may be programmed to simultaneously determine averages in a contiguous series of short sub-intervals of say 10-minute, 30-minute, or 1 hour duration, covering the main survey period. In this way, a picture can be obtained of the noise pattern over that period. For practical reasons, it is often not possible to attend measurements for the full duration of such long recordings.

2.18.3 Noise Measurements at Lusthof

The Lusthof Colliery Project noise study was carried out in accordance with SANS 10328 [1], a South African Standard presenting guidelines on procedures to conduct noise assessments. The criteria and practical considerations which influence the selection of suitable locations for noise monitoring, include the following:

- **Community concerns**: In selecting locations for noise monitoring, concerns raised by interested and affected parties should be taken into account.
- **Worst-case impact**: Focus on areas where maximum noise impact is expected.
- **Suitability for future surveys**: As far possible, select locations likely to be accessible in future surveys.
- **Avoid interference**: As far as practically possible, stay clear of and avoid interference by localised noise sources which may distort the data. Examples are power distribution boxes, barking dogs, speech interference by curious visitors and insects in close proximity of the microphone.
- **Equipment safety**: Measurement procedure, integration periods and sample size depend on the availability of facilities for safeguarding equipment. Long duration samples are only possible at locations where facilities are available to lock away recording equipment connected via a cable to a microphone positioned outdoors at a point clear of vertical reflecting surfaces and protected from the elements.

During the baseline assessment carried out during the period 15-Nov-2010 to 19-Nov-2010, scoping and ambient noise surveys were conducted at the localities indicated on Figure 2.18.3 (a).

Figure 2.18.3 (a): Noise Monitoring Locations

The three monitoring localities were namely at the following residences:

M1, Du Hain Residence,
M2, De Jager Residence, and
M3, Neethling Residence.

At M1 and M2, noise recording equipment was programmed to measure averages in sequences of 10-minute intervals for a total duration of 24 hours or longer. At M3 where facilities suitable for long-duration unattended recordings were not available, shorter duration samples of 20 minutes were taken. In all recordings, A-weighted, equivalent continuous sound pressure levels L_{Aeq} (dBA) were measured, using an integrating sound analyser. For purposes of identifying sources of noise, third-octave spectra were examined during attended sessions, as well as in post-processing of data. This made it possible to distinguish between background ambient and mining-related noise.

The field measurements were carried out using the following equipment:

- Brüel & Kjaer Type 2260 Modular Precision Sound Analyser (Ser no. 1875497)
- Brüel & Kjaer Type 2260 Modular Precision Sound Analyser (Ser no. 1823652)
- Brüel & Kjaer Type 2250 Hand-held Precision Sound Analyser (Ser no. 2479653)
- Brüel & Kjaer Type 4231 Sound Calibrator (Ser no. 2606011)

The equipment conformed to IEC 61672-1 Electro-Acoustics – Sound Level Meters – Part 1: Specifications.

Calibration:

- M& N Calibration Services Certificates No's 2010-1164 & 2010-1165
- National Metrology Institute of SA Certificate No AV/AS-4016-R
- National Metrology Institute of SA Certificate No AV/AS-4021-R

2.18.4 Noise Regulations and Assessment Criteria

2.18.4.1 South African Noise Regulations

In 1994, with the devolution of regulatory power from governmental to provincial level, the authority to promulgate noise regulations was ceded to provinces. Each province could henceforth decide whether to develop their own regulations, or to adopt and adapt existing regulations. As yet, however, only three provinces (Gauteng, Free State and Western Cape) have promulgated such regulations. Elsewhere, including Mpumalanga Province, no provincial noise regulations have been put in place.

Consequently, in noise studies undertaken in provinces lacking official noise regulations, specialists usually consider the old national noise regulations [4] to apply by default. For further guidance, it is noted that noise criteria in all previous national and current provincial regulations, as well as current metropolitan noise policies, are all derived from SANS 10103. SANS 10103 defines the relevant acoustic parameters that should be measured, gives guidelines with respect to acceptable levels and assessment criteria and specifies test methods and equipment requirements. In this noise study, the provisions of the old national noise regulations are taken into account, but noise assessment is based by and large on the principles, guidelines and criteria of SANS 10103.

2.18.4.2 Prohibition of Disturbing Noise

In accordance with international and South African standard practice, noise impact assessments are made with respect to outdoor noise levels. Noise regulations prohibit any changes to existing facilities, or uses of land, or buildings or the erection of new buildings, if it will house activities that will cause a disturbing noise, unless precautionary measures to prevent disturbing noises have been taken to the satisfaction of the local authority.

Noise is deemed to be disturbing, if it exceeds certain limits. Depending on what data is available, SANS 10103 allows for different formulations of the excess.

- **If the actual residual ambient level is known**: The excess is taken to be the difference between the noise under investigation and the residual noise measured in the absence of the specific noise under investigation. This definition, based on the noise emergence criterion, finds application in both predictive and noise monitoring assessments, if baseline noise data is available.

- **If the actual residual ambient level is unknown**: Alternatively, the excess may also be defined as the difference between the ambient noise under investigation and the acceptable ambient rating for the type of district under consideration in accordance with SANS 10103. This definition, based on the acceptable level criterion, is employed in predictive noise studies and in noise monitoring assessments, if there is no baseline data available or if an existing source of intrusive noise cannot be switched off for purposes of measuring the residual background level.

In terms of the old national noise regulations, a disturbing noise means a noise that causes the ambient sound level to increase by 7 dB or more above the designated zone level, or if no zone level has been designated, the ambient sound level measured at the same point. Noise regulations also require that the measurement and assessment of ambient noise comply with the guidelines of SANS 10103.

It should be cautioned, however, that the legal limit of 7 dB should not be construed as the upper limit of acceptability. SANS 10103 warns that an increase of 5 dB is already significant and that an increase of 7 dB can be expected to evoke widespread complaints from the community. Hence, although the applicant would be within legal limits if the noise impact is prevented from exceeding 7 dB, that would not prevent a community from being disturbed and to complain about the noise. In the EIA phase, i.e. in the design and planning stage of a new development, it is advised the target be set much lower at 3 dB, with 5 dB considered to be a significant impact.

2.18.4.3 Prohibition of a Noise Nuisance

Noise regulations also prohibit the creation of a noise nuisance, defined as any sound which disturbs, or impairs the convenience or piece of any person. The intent of this clause is to make provision for the control of types of noise not satisfactorily covered by measurement and assessment criteria applicable to disturbing noises. These are noises which are either difficult to capture, or noises for which the readings registered on sound level meters do not correlate satisfactorily with the annoyance it causes, when assessed against standard criteria. Noise regulations list specific activities which are prohibited if exercised in a manner to cause a noise nuisance, such as:

- The playing of musical instruments and amplified music;
- Allowing an animal to cause a noise nuisance;
- Discharging fireworks;
- Discharge of explosive devices, firearms or similar devices which emit impulsive sound, except with the prior consent in writing of the local authority concerned and subject to conditions as the local authority may deem necessary;
- Load, unload, open, shut or in any other way handle a crate, box, container, building material, rubbish container or any other article, or allow it to be loaded, unloaded, opened, shut or handled, (if this may cause a noise nuisance);
- Drive a vehicle on a public road in such a manner that it may cause a noise nuisance;

- Use any power tool or power equipment used for construction work, drilling or demolition work in or near a residential area, (if this may cause a noise nuisance);
- Except in an emergency, emit a sound, or allow a sound to be emitted, by means of a bell, carillon, siren, hooter, static alarm, whistle, loudspeaker or similar device (if it may cause a noise nuisance).

One or more of these activities may occur on industrial sites and in project activities. A common cause of noise nuisance is reverse hooters, the last item listed above.

The essential difference between a disturbing noise and a noise nuisance is as follows:

- **Noise disturbance** – Is quantifiable and its assessment is based on estimated or measured sound levels, expressed in decibel (dBA). Investigation and assessment of existing noise disturbance problems involve the measurement of ambient levels in the presence of a specific source under investigation and comparison of this level with either the level measured in the absence of the source, or a table value deemed to be an acceptable level for the type of district under consideration.
- **Noise nuisance** – Is difficult to quantify and is not confirmed or assessed by measurement. Judging whether a noise qualifies as a nuisance is based purely on its character and audibility, in conjunction with subjective considerations such as the perceived intent of the noise maker and connotations attributable to the source of noise. Where measurement is possible, measured data may serve as supplementary information.

2.18.4.4 SANS 10103

As mentioned before, noise regulations require that the measurement and assessment of noise comply with the guidelines of in SANS 10103. The concept of noise nuisance, however, only features in the regulations. SANS 10103 only deals with quantifiable noise (noise disturbance) without any guidelines for, or reference to, noise nuisance whatsoever.

It is normally expected of EIA noise studies as well as EMP surveys to make findings based on quantitative assessment of predicted or actual noise levels, i.e. based on noise disturbance considerations. But once an industrial site or mine starts operating, predictable as well as unexpected sources of noise nuisance may emerge.
If present, they often constitute a major cause of complaints. It is therefore imperative that, in addition to quantitative predictions and measurements, noise studies as well as monitoring surveys also identify potential and actual sources of noise nuisance.

2.18.4.5 SANS 10103 - Acceptable Ambient Levels

Noise regulations require that the rating level of the ambient noise be compared with the rating level of the residual noise (where this can be measured), or alternatively (where the noise source cannot be switched off or interrupted), with the appropriate rating level given in Table 2 of SANS 10103.

Neither the noise regulations, nor SANS 10103 defines or refers to the term noise impact. It is however generally understood and defined for purposes of this study, as the amount in dB by which the total noise level exceeds the nominal or the measured ambient level rating, whichever is applicable, for the area under consideration.

Table 2.18.4.5 (a) in this report summarises SANS 10103 criteria for acceptable ambient levels in various districts. Note that ratings increase in steps of 5 dB from one to the next higher category and that, in general, regardless of the type of district, ambient noise levels tend to decline by typically 10 dB from daytime to night-time. It follows that, for the same level of intrusive noise, the noise impact would typically increase by 10 dB from daytime to night-time.

Table 2.18.4.5 (a): Typical Outdoor Ambient Noise Levels in various Districts

Type of District		Noise level Equivalent continuous level L_{Aeq} (dBA)		
		Day-Night L_{dn}	**Day-time** L_d	**Night-time** L_n
(a)	**Rural**	45	45	35
(b)	**Suburban – With little road traffic**	50	50	40
(c)	**Urban**	55	55	45
(d)	**Urban - With some workshops, business premises & main roads**	60	60	50
(e)	**Central business districts**	65	65	55
(f)	**Industrial districts**	70	70	60

A 24 hour cycle is divided into the following periods:

Day-time (06:00 – 22:00)
Night-time (22:00 – 06:00)
Day-Night (24-hour day-night period)

The day-night level L_{dn} represents a 24-hour average of the ambient noise level, with a weighting of +10 dB applied to night-time levels, yielding numerically equal values for daytime and day-night levels.

SANS 10103 also gives guidelines in relation to expected community response to different levels of noise impact (increase in noise level), as summarized in Table 2.18.4.5(b).

Table 2.18.4.5 (b): Expected Community Response to an Increase in Ambient Noise Level (SANS 10103)

Increase in Ambient Level [dB]	Expected Community Reaction
0 - 10	Sporadic complaints
5 - 15	Widespread complaints
10 - 20	Threats of community action
More than 15	Vigorous community action

2.18.4.6 Practical Considerations

By defining the actual predevelopment ambient sound level as the reference, noise regulations applicable in Mpumalanga effectively apply what is known as noise emergence criteria. An alternative approach (as employed in the Gauteng Noise Regulations), is to use nominal table values recommended in SANS 10103. This is known as acceptable level criteria. Both methods have advantages and disadvantages.

Caution should be exercised in applying noise criteria, bearing in mind that no single principle or criterion will perfectly fit and be adequate or fair in all applications. The sensibility and fairness of any given criterion depend on the nature and origin of the existing ambient noise. In situations where existing ambient levels are on the high side, it is of crucial importance in the assessment of noise impact of a new development, to establish whether the existing ambient sound is primarily a result of interior or domestic activity (self-noise), or whether it is primarily caused by external sources of noise (intrusive noise).

Where the pre-development ambient sound is dominated by noise emanating from external sources, such as industrial plants, mining activity and road traffic on external main roads, special precaution needs to be exercised not to aggravate conditions. If the existing ambient level is already higher than what is regarded as typical or recommended, specific noise from a proposed new development should not be allowed to exceed the nominal value regarded as acceptable for the type of district under consideration. It would be more fitting in such instances, to apply acceptable level criteria; e.g. setting the daytime limit for specific noise from the development at the lower nominal limit.

Noise criteria should never be applied without due consideration of the practical consequences. Finally, whatever guidelines are followed, it should always be investigated if there is a specific period (daytime or night-time) during a 24-hour cycle during which the noise impact will be at its worst. For constant 24-hour operations, this would normally occur at night-time.

2.18.5 Note on Animal Response to Noise

The author is not qualified to comment or speculate on animal behaviour in response to noise. Moreover, it should be cautioned that any assessment or statement made with regard to the possible impact of project activity noise on animals in the surrounding area should take cognizance of the following:

Assessment in any scientific noise study of the impact of noise on humans is based on well defined scientific criteria. Based on decades of statistic data, international and national standards provide consistent guidelines with respect to noise disturbance and community reaction. If the measured or predicted elevation caused by an intrusive noise exceeds certain reference levels, the response of humans to such noise can be quantified. The noise contours calculated in this study define ranges of acceptable and significant impact noise as perceived by humans.

As for animals, however, not only are human criteria not applicable at all, but there simply are no national or international standards pertaining to animal response to noise - not in terms of audibility or disturbance, let alone the effect of noise on their well-being, health or production. It should be pointed out that not even in the case of humans, can the effect of noise on human health be quantified (except for hearing damage) and no standards or criteria exist in that regard.

It is completely understandable that farmers would be concerned about the effect of intrusive noise on their livestock. But in the lack of standards or criteria, any statements made in the findings and recommendation of a noise study in that regard would be speculative, unscientific and irresponsible. Hence in this report, we refrain from making any such unfounded statements either confirming or rejecting popular views on the matter.

2.18.6 Assessment of Blast Noise

In the assessment of general industrial or community noise, the disturbing noise is measured and averaged over a period considered to be relevant for the source under assessment, which could be a limited period of an on-off operation, or, in the case of an on-going noise, such as road traffic, or mining noise, the relevant sub-interval of a 24-hour day, such as daytime, night-time or the day-night period.

The measurement and assessment of high-energy impulsive noise, as produced by blasting, is much more complicated. There are no regulatory limits and SANS 10103 does not provide any guidelines or criteria in this regard. It only states that advice from a specialist should be obtained. A suggestion in SANS 10103 that the procedures of SANS 10843 may be used is of no help either, since the latter have been specifically developed for, and only apply to, the assessment of risk of hearing damage for persons exposed to gun shots or explosions involving peak levels above 140 dB. These methods and associated criteria have no bearing on, or relevance to noise disturbance assessment.

As in general continuous noise assessment, any test method and criteria employed in noise disturbance assessment of single-event impulsive noise, must take both amplitude and duration into account.

In the lack of any SANS test standards, assessment criteria, or national regulatory limits, the assessment of blast noise disturbance in this assessment is based on calculation techniques developed by the specialist in studies conducted for the SANDF. These techniques adhere to accepted scientific methodology and principles. Blast magnitude is quantified by the determination of impulse energy, by time integration of the amplitude over the duration of the impulse.

The equivalent continuous level of the blast impulse, calculated by spreading the energy over the span of a 12-hour day period, is used to assess the noise disturbance impact against acceptable levels for various districts in terms of SANS 10103 for general noise. This principle is also adopted by international standards currently under development. In the experience of the author, at or below these levels, blast noise is normally hardly noticed by residents and not regarded as disturbing.

2.18.7 Base Line Results and Findings

As is typical of rural farming districts, daytime ambient levels in the proximity of farm residences in the Lusthof study area are elevated by farming and domestic activities. At night, the situation is different. Although the ambient noise character of the region has to some extent been affected by mining and agricultural activities, the study area in the immediate surroundings of the proposed Lusthof development is still very quiet at night.

Mining noise was not audible at any of the locations and there is virtually no traffic on local roads. On the whole, as far as night-time ambient levels are concerned, the area in its current state is still a rural environment.

2.18.7.1 Noise at M1 (Du Hain Residence)

Daytime ambient noise at the Du Hain residence at M1 is determined primarily by domestic and farming activity, such as manual work activities, occasional vehicle movements and speech communication. At night it is very quiet, with only natural sounds, such as wind, birds and insects audible.

Average daytime and night-time ambient levels recorded in a 48-hour survey during the course of this investigation, were 40 dBA (day) and 35 dBA (night), respectively. These levels confirm the Rural District status in accordance with SANS 10103.

2.18.7.2 Noise at M2 (De Jager Residence)

With the two residences at M1 and M2 only about 500 m apart, they are situated in the same external ambient noise surroundings. Due to a larger presence of cattle on the farmyard, higher daytime ambient levels were recorded at M2 (48 dBA). Average night-time levels at 37 dBA were more or less the same as at M1.

2.18.7.3 Noise at M3 (Neethling Residence)

Average daytime levels of 58 dBA at M3 were considerably higher than those measured at M1 and M2, which is ascribed to higher levels of tractor and vehicle movements, as well as more noise made by domestic animals. Night-time levels, however, at an average of 36 dBA, were more or less the same as those measured at M1 and M2.

2.18.7.4 Summary of Base Line Results

The results of the survey are summarised on the map in Figure 2.18.7.4 (a).

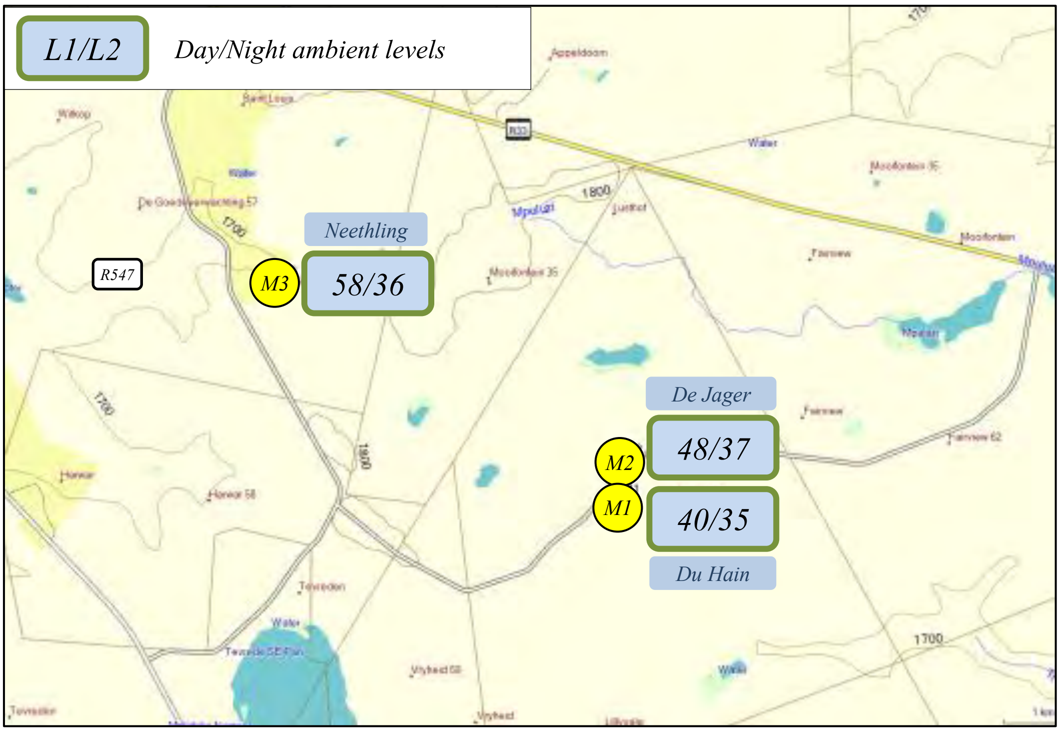


Figure 2.18.7.4 (a): Average daytime (06:00 to 22:00) and night-time (22:00 to 06:00) ambient noise levels

2.18.8 Baseline Ratings

In allocating baseline ambient noise ratings, it should be borne in mind that the levels obtained in any particular survey do not represent absolute values, but samples only of what is a variable parameter. Ambient noise is not fixed and even relatively long-duration averages of day and night levels at any location will vary over time. This is in response to variances in noise source emission levels, as well as unpredictable day, night and seasonal fluctuations in atmospheric conditions.

It should also be noted that for purposes of noise impact assessment, noise contours are calculated at nominal intervals best suited for evaluation of specific locations of concern, as well as for the global study area.

With these considerations in mind, the ratings allocated in the study area were determined by rounding the levels obtained in the survey to the nearest 5 dB day or night interval of typical levels for district categories in accordance with SANS 10103 guidelines. The result is presented in Table 2.18.8 (a). These are realistic best estimates of baseline ambient noise ratings for the area that will be used to define limits in the noise impact assessment to be carried out in terms of the EIA.

Table 2.18.8 (a): Baseline Outdoor Ambient Noise Levels

Area		Baseline Ambient Noise Level L_{Aeq} (dBA)	
		Day-time L_d	Night-time L_n
Specific Locations	M1. Du Hain Residence	40	35
	M2. De Jager Residence	48	37
	M3. Neethling Residence	58	36

2.18.9 Recommended Limits

Daytime intrusive noise levels created by distant industrial noise sources, such as the open-cast mining operation under consideration, are as a general rule substantially lower than the levels created by the same sources at night. The reason is that typical daytime meteorological conditions result in skyward refraction of sound propagation, in contrast with downward diffraction caused by typical night-time temperature profiles (vertical gradients).

During the day, most of the noise emitted by a large source does not reach the ground, while at night, both direct sound and a portion of the energy radiated skywards are focussed back to earth. This contrast between day and night levels is further accentuated by a considerable drop at night in the residual ambient level due to a decline in road traffic and human activity noise. As a consequence, not only are the levels of intrusive noise from distance sources much higher at night, but the sensitivity of the environment increases sharply, as well.

It implies that for continuous noise from a 24-hour operation, such as the mine, maximum impact will occur at night and that for all practical purposes, provided the night-time impact is contained to within acceptable levels, the daytime impact would not be of any consequence or concern at all.

Significant Impact

With reference to the principles explained earlier in this report, a significant impact in this noise study is deemed to occur if the specific level of an intrusive noise exceeds the existing **ambient level (35 dBA at night) by 5 dB or more**.

2.19 VISUAL ASPECTS BASE LINE

Zeli Design was contracted by JMA Consulting (Pty) Ltd to perform a Visual Impact Assessment (VIA) in order to fulfil the requirements of various sets of legislation, regulations and guidelines as applicable to Environmental Authorizations for Lusthof Colliery. The full content of the visuals base line description conducted by them is reproduced in this section.

2.19.1 Contextual Analysis

It is important to provide a contextual description of the study area as it provides the main emphasis for the required visual character of the site and its activities.

2.19.1.1 Macro Context

The site of this project is located in the Mpumalanga Province of South Africa.

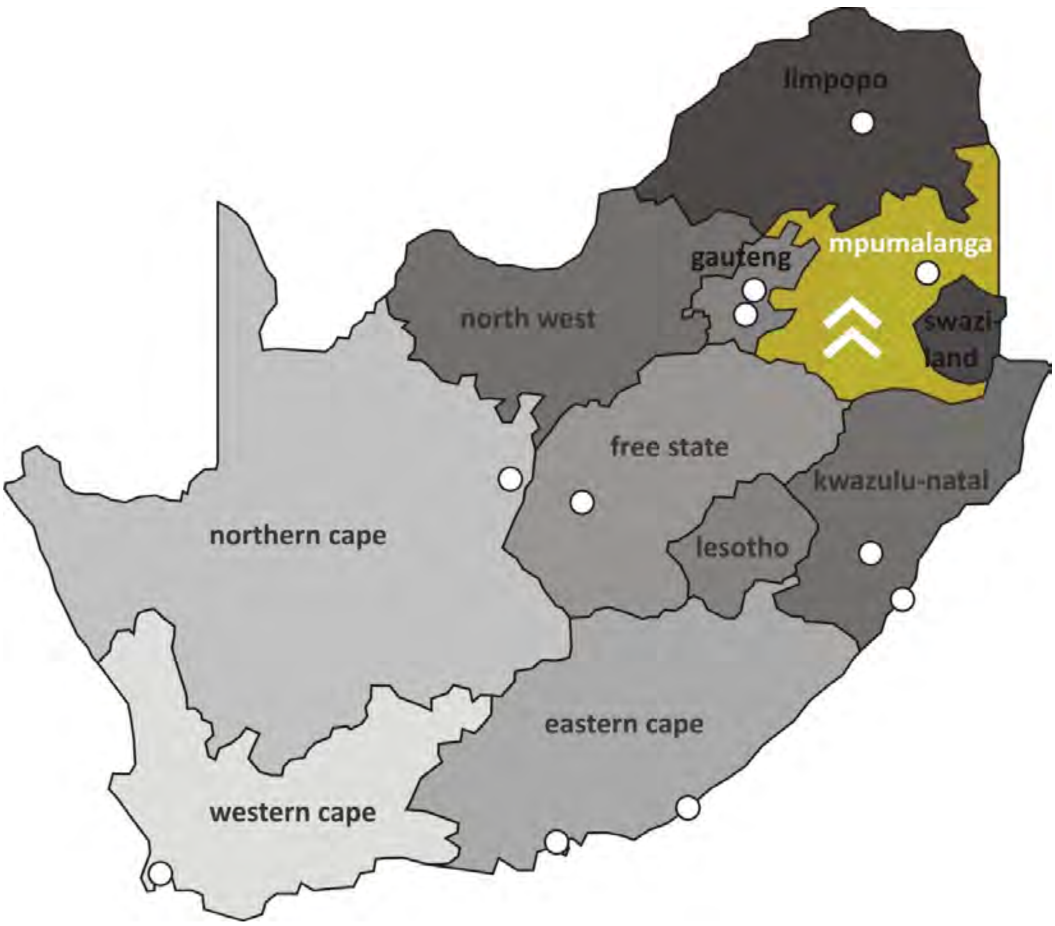


Figure 2.19.1.1 (a): Setting of Site in South Africa (macro context).

The Mpumalanga province lies in eastern South Africa, north of the KwaZulu-Natal province of SA and bordering Swaziland and Mozambique. It constitutes 6.5% of South Africa's land area. In the north it borders on the Limpopo province of SA, to the west the Gauteng province of SA, to the southwest the Free State province of SA and to the south the KwaZulu-Natal province of SA.

2.19.1.2 Regional Context

A discussion on the Regional Context provides the motivation to keep the area visually acceptable.

Mpumalanga Province Profile

Mpumalanga means "Place Where the Sun Rises". Due to the province's spectacular scenic beauty and abundance of wildlife, it is one of South Africa's major tourist destinations.

Whilst visitors flock to Mpumalanga to experience the increasingly globally elusive bush and wildlife experience in the pristine reserves and natural environment, there is far more to be experienced if you just scratch beneath the surface. Mpumalanga's melting pot of history, culture and terrain has created a treasure trove of attractions that are arguably amongst the richest in the world. (www.mpumalanga.com)

Figure 2.19.1.2 (a): Regional Setting of the Site.

Basic Information

LAND AREA:	79 490 km^2
POPULATION:	3.508 million
CAPITAL CITY:	Nelspruit
PRINCIPAL LANGUAGES:	siSwati, isiZulu, isiNdebele
ROADS:	Good to fair, suitable for all vehicles.
CLIMATE:	Extremely varied climate across province.
AIRPORTS:	Nelspruit
RAIL AND BUS SERVICES:	Available throughout the Mpumalanga Province.
DISTRICTS:	The province consists of 3 districts: Ehlanzeni, Gert Sibande, Nkangala Districts (www.mpumalanga.gov.za)

Describing the Mpumalanga Province

Land Area:

With a surface area of only 79 490 km^2, the second-smallest province after Gauteng, it has the fourth-largest economy in South Africa. (www.mpumalanga.gov.za)

Boundaries:

Bordered by Mozambique and Swaziland in the east, and Gauteng in the west, it is situated mainly on the high plateau grasslands of the Middleveld, which roll eastwards for hundreds of kilometres. In the north-east, it rises towards mountain peaks and terminates in an immense escarpment. In some places, this escarpment plunges hundreds of metres down to the low-lying area known as the Lowveld. (www.mpumalanga.gov.za)

Major Cities and Towns:

Nelspruit, Witbank, Standerton, Barberton, Ermelo, Secunda, Middelburg.

Infrastructure:

The area has a network of excellent roads and railway connections, making it highly accessible. Because of its popularity as a tourist destination, Mpumalanga is also served by a number of small airports, such as the Kruger Mpumalanga International Airport. (www.mpumalanga.gov.za)

Economy:

The best-performing sectors in the province include mining, manufacturing and services. Tourism and agro processing are potential growth sectors in the province. (www.mpumalanga.gov.za) Discussed below: the economic areas of agriculture, mining and tourism.

- **Agriculture**

  More than 68% of Mpumalanga is utilised by agriculture. Crops include maize, wheat, sorghum, barley, sunflower seed, soybeans, groundnuts, sugar cane, vegetables, coffee, tea, cotton, tobacco, citrus, subtropical and deciduous fruit.

  Natural grazing covers approximately 14% of Mpumalanga. The main products are beef, mutton, wool, poultry and dairy.

- **Mining**

  Extensive mining is done and the minerals found include: Gold, Platinum Group Metals, Silica, Chromite, Vanadiferous Magnetite, Argentiferous Zinc, Antimony, Cobalt, Copper, Iron, Manganese, Tin, Coal, Andalusite, Chrysotile Asbestos, Kieselguhr, Limestone, Magnesite, Talc and Shale.

  Mpumalanga accounts for 83% of South Africa's coal production. 90% of South Africa's coal consumption is used for electricity generation and the synthetic fuel industry. Coal power stations are in proximity to the coal deposits. A coal liquefaction plant in Secunda (Secunda CTL) is one of the country's two petroleum-from-coal extraction plants, which is operated by the synthetic fuel company Sasol.

- **Tourism**

  Mpumalanga is also a popular tourism destination. Kruger National Park, established in 1898 for the protection of Lowveld wildlife, covering 20,000 square kilometres (7,800 square miles), is a popular destination. The other major tourist attractions include the Sudwala Caves and the Blyde River Canyon.

  Many activities including the big jump, mountain and quad biking, horse trails, river rafting and big game viewing are endemic to the region. This is Big 5 territory.

  In 2008 a Haute Cuisine route was formed, trickling from Mbombela down to Hazyview. The Lowveld Gourmet Route covers the four top fine dining restaurants the area has to offer. The restaurants include Summerfields Kitchen, Oliver's Restaurant, Orange and Salt.

Areas of Importance:

- **Nelspruit** is the capital of the province and the administrative and business centre of the Lowveld. Nelspruit also is the second-largest citrus-producing area in South Africa and is responsible for one third of the country's export in oranges. The Institute for Tropical and Subtropical Crops is situated here.

- **Witbank** is the centre of the local coal-mining industry and the biggest coal producer in Africa. Mpumalanga is very rich in coal reserves. The country's major power stations, three of which are the biggest in the southern hemisphere, are situated here. Unfortunately, these cause the highest levels of air pollution in the country.

- **Secunda**, where South Africa's second petroleum-from-coal installation is situated, is also located in this province.

- **Middelburg** produces steel and vanadium.

- **Standerton**, in the south, is renowned for its large dairy industry.

- **Piet Retief** in the southeast is a production area for tropical fruit and sugar.

- A large sugar industry is also found at **Malelane** in the east.

- **Ermelo** is the district in South Africa that produces the most wool.

- **Barberton** is one of the oldest gold-mining towns in South Africa.

- **Sabie** is situated in the forestry heartland of the country.

- **Groblersdal** is an important irrigation area, which yields a wide variety of products such as citrus fruit, cotton, tobacco, wheat and vegetables.

- **Carolina-Bethal-Ermelo** is mainly a sheep-farming area, but potatoes, sunflowers, maize and peanuts are also produced in this region.

- One of the country's largest paper mills is situated at **Ngodwana**, close to its timber source.

- **The Maputo Corridor**, which links the province with Gauteng and Maputo in Mozambique, heralds a new era in terms of economic development and growth for the region.

  As the first international toll road in Africa, the Maputo Corridor is attracting investment and releasing the local economic potential of the landlocked parts of the country. It will thus generate sustainable economic growth that will lead to sustainable high-quality jobs.
  (www.mpumalanga.gov.za)

Biological Diversity:

Mpumalanga falls mainly within the grassland biome. The escarpment and the Lowveld form a transitional zone between this grassland area and the savanna biome. Long sweeps of undulating grasslands change abruptly into thickly forested ravines and thundering waterfalls of the escarpment, only to change again into the subtropical wildlife splendor of the Lowveld.

Climate:

Mpumalanga's weather is naturally defined by its topography. Mpumalanga is a province of two halves, namely the high-lying grassland savannah of the Highveld escarpment and the subtropical Lowveld plains. The western side of Mpumalanga, on the Highveld escarpment, is like a rise of tropics, an ascent into an uncompromising range of temperatures. The west is drier, hotter and much colder than the rest of the Mpumalanga province.

Middelburg, in the heart of the Highveld, experiences summer rain, and has a summer (October to February) to winter (April to August) range of around 19º C with average temperatures in the contrasting seasons, of 26º C and 8º C. Nelspruit, the capital city of Mpumalanga, lies at the edge of the Lowveld near the Kruger National Park, and enjoys relatively plentiful summer rainfall (an average of around 620 mm falls between September and March) and mild to hot subtropical conditions in the Kruger National Park. (www.sa-venues.com)

Population:

- Total Population: 3,643,435
- Rank: 6th in SouthAfrica
- Density: 45.8/km2 (118.7/sq mi)
- Density rank: 3rd in SouthAfrica

[Community Survey 2007: Basic results". Statistics South Africa. p. 2.]

Literacy Rate:

The Mpumalanga Department of Social Services, Population and Development reported that 29% of the population in the province aged 20 years and older received no schooling or formal education at all, constituting almost a third of the population in this age group (DSSPD, 2001). In addition, it is estimated that only 5% of the population in the province has post-school qualifications. Furthermore, it was reported that only 47% of Grade 12 learners in the province obtained their matriculation in 1996 and that Mpumalanga has a high percentage of over-age learners (HSRC, 1998).

Figure 2.191.2 (b)[a – c]:Visual examples of the typical landscape characteristics of the area in the near vicinity of the Lusthof Colliery Site. Figure 2.19.1.2 (b)[a] Depicts the natural grassland, Figure 2.19.1.2 (b)[b] Depicts the typical Wetlands in the area and Figure 2.19.1.2 (b) [c] shows a typical farmstead

2.19.1.3 District Context

A discussion on the District Context provides a background of the visual nature of the regional attractions and activities, motivating Lusthof Colliery to inhibit development that will change the structure of the visual character of the area.

The Lake District of South Africa

The Lusthof Colliery Site is located in the Lake District of South Africa. This District centres around the town of Chrissiesmeer, where Lake Chrissie, South Africa's largest freshwater lake with a surface area of 1043 ha can be found.

Figure 2.19.1.3 (a): Area Map showing locations of the Lusthof Colliery site and the towns of Carolina, Breyten and Chrissiesmeer

The Lake District of South Africa is a unique network of pans that differs considerably from other pan systems in Southern Africa in that they are perennial, mostly independent of each other despite close proximity and contained within a small high-altitude area.

270 of these small shallow lakes dot the landscape of the Mpumalanga Highveld within a 20 km radius, and are home to thousands upon thousands of birds – particularly in the spring and summer months when the rains fill the pans and the reeds and surrounding grasslands become lush and vibrant. Many of these birds are rare and some critically endangered, among both the endemic/indigenous and the seasonal bird populations.

While the natural heritage value of this lake network is undeniable, the tangible beauty of the area and its abundant bird-life is as important for tourism.

Further interesting and irreplaceable historical aspects to this area include the abundance of San rock art found around the pans – the perennial supply of water supported thriving communities of San hunter gatherers up until fairly recently, a giant's footprint, the history of the Tlou-tle people who lived there 1500 years ago on rafts, and… frogs! There are as many of them as there are birds, if not more, and they and their summer sing-song is well loved. A sign outside the town extolls residents to be aware of frogs crossing the road.

The Chrissiesmeer area is special. It is an absolutely unique eco-system in Southern Africa, and it's biggest hope is eco-tourism. It may be in the pipe line for the near future to declare this area a RAMSAR site, which is The Convention on Wetlands in South Africa which designates Wetlands of International Importance.

Taking into consideration the near vicinity of this special area, this Visual Impact Assessment will carefully assess the visual alterations the Lusthof Colliery Site will have on the environment.

2.19.1.4 Micro Context

A description of the micro context provides the necessary baseline for the assessment of visual impacts and a guideline towards the land use compatibility of Lusthof Colliery when considered in the larger study area.

Describing the Lusthof Colliery Site Near Vicinity Land Use

Currently the land use located in the near vicinity of the site is predominantly agricultural (cultivated lands, hay pastures, grazing lands), very small rural settlements mostly only farm workers and farmsteads. The Dorstbult mine is located about 5 km away from the Lusthof Colliery site, but is the only other mining activity in the near vicinity.

Large portions of natural vegetation and wetland areas are still to be found in the area. The larger area is mostly undeveloped with very little surface infrastructure.

The Lusthof Colliery will be the only mine in the area of its size and type, and not deemed compatible with the land use of the area. Thus this Visual Impact Assessment will assess the mine as such and the visual aspect of the mine will be treated with utmost sensitivity.

2.19.2 Visibility Analysis

The proposed Lusthof Colliery mining area on portions 4 and 6 of the farm Lusthof 60 IT is situated on a local topographical high point. As such, the proposed mining site will be visible from all directions over significant distances. During the topographical assessment of the site, surface contours were generated over 5 meter intervals.

The 5 m surface elevation contour data was then used to create maps representing the surface topography of the study area. The 5 m surface elevation contour data was further used to create a view-shed analysis of the surface topography within the proposed pit boundary.

2.19.2.1 View Shed Analysis

The view shed analysis was performed prior to the site specific photographic analysis in order to determine the visibility of the site from priority access points/routes such as public roads, and also from farms with houses and rural settlements.

The analysis was performed with ARCVIEW, creating 3-dimensional relief (Figure 2.19.2.1 (a) and 2-dimensional view shed maps, using the 1:50000 and 1:10000 published DTM information obtained from the Surveyor General.

The view-shed analysis represented in Figure 2.19.2.1 (b) indicates the visibility of the mine from all areas shown as green, and non-visibility from all areas shown in purple. It is however important to note here that the view-shed analysis is based entirely on the surface elevation data obtained from the 5 m contours and does not take vegetation or surface infrastructure into consideration.

The resulting maps provided a sound basis from which to assess potential vantage points to the site and on which to base planning for the photographic assessment.

The 3-dimensional topographical relief and view shed maps for the Lusthof Colliery site and its surrounds are shown in Figure 2.19.2.1 (a) and Figure 2.19.2.1 (b) respectively.

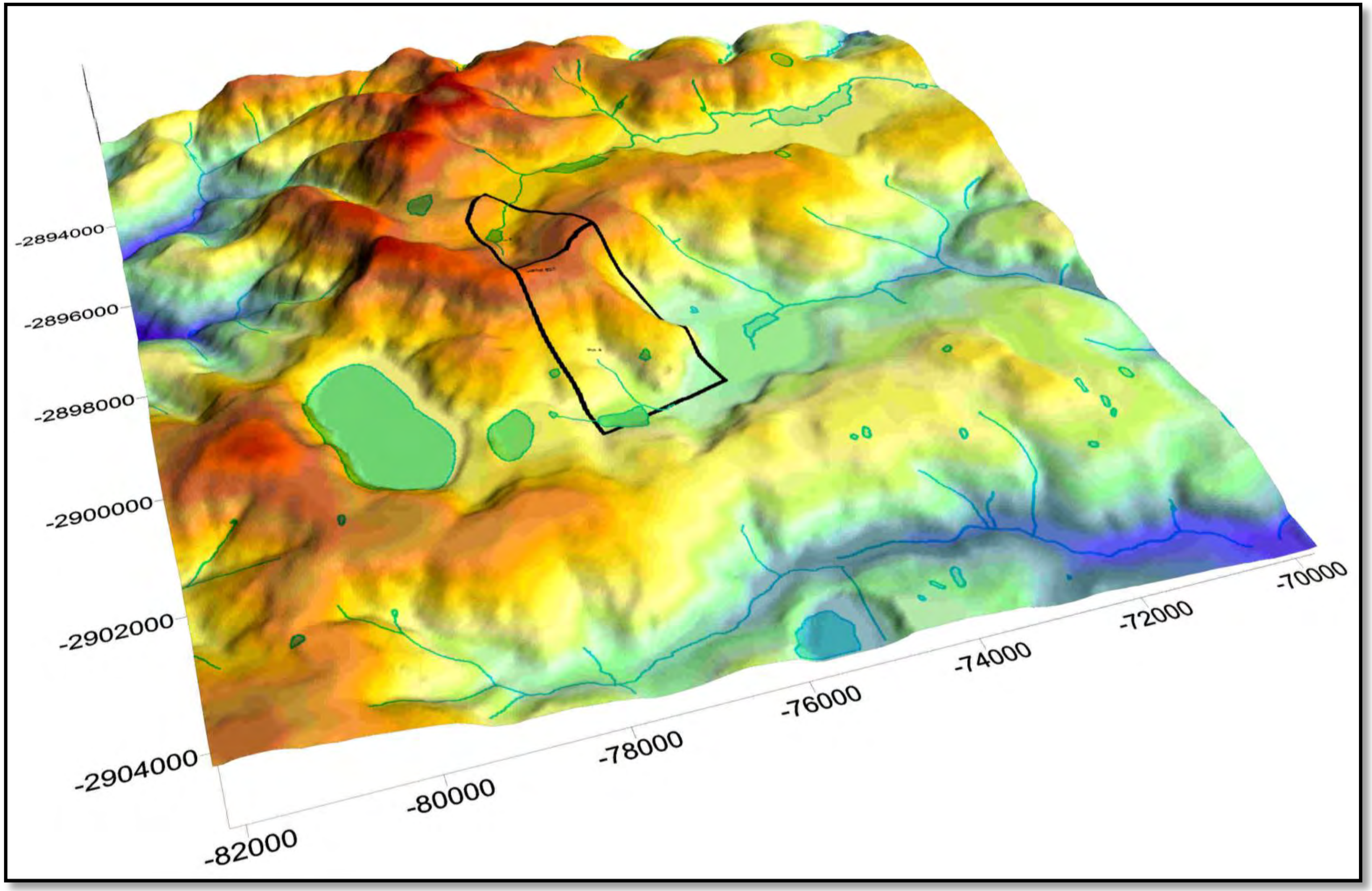


Figure 2.19.2.1 (a): Three Dimensional Relief Map of the Lusthof Colliery Site Area (based on 20 m interval surface topography data)

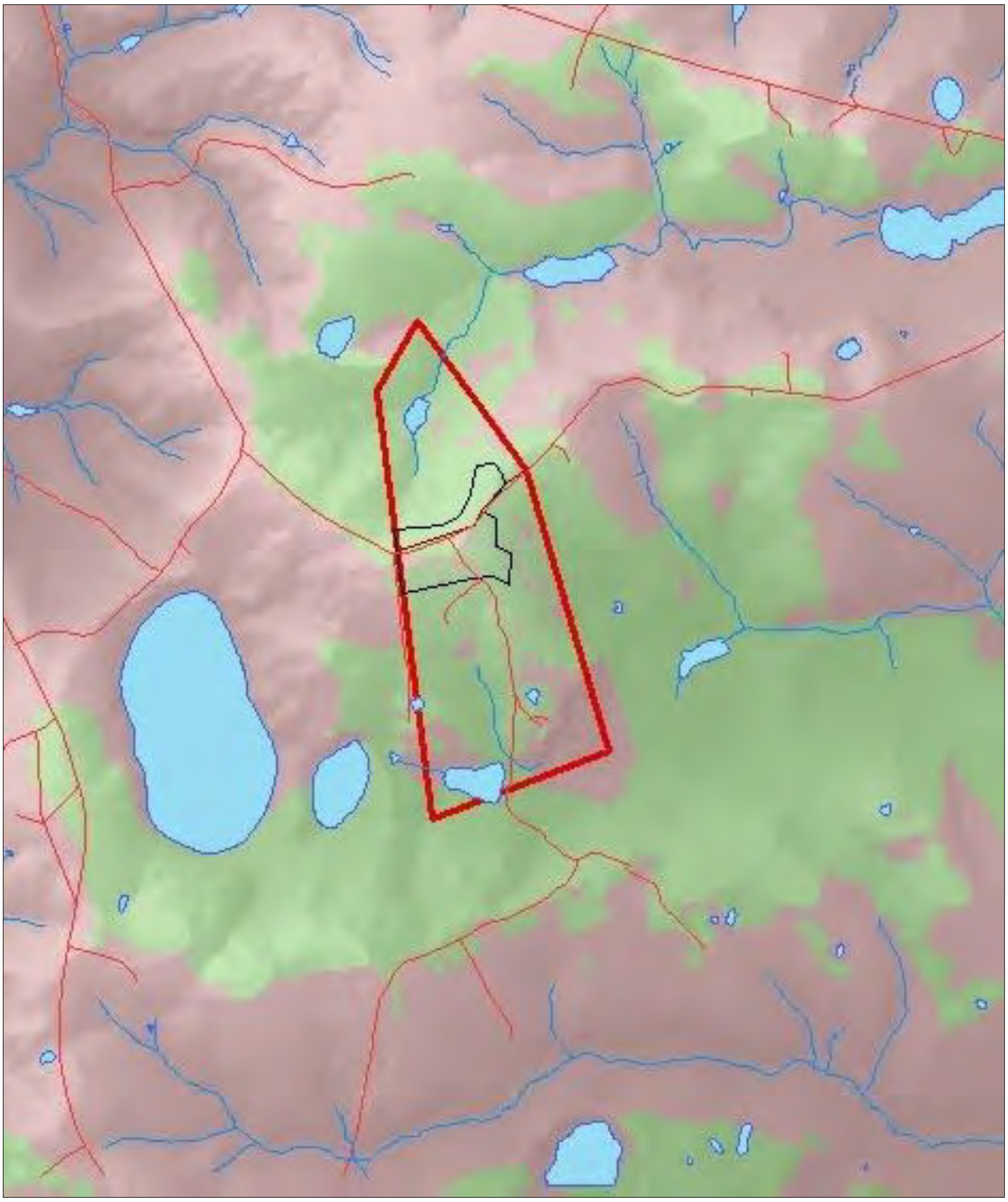


Figure 2.19.2.1 (b): View Shed Map (Lusthof Colliery site visible from within the green areas)

2.19.2.2 Visibility Range of Proposed Sites

The view shed analysis map confirms the visibility of the site from the north, north-east, east, south-east, south and south-west. It is only from the west that visibility of the site is poor. As the mine represents an open-cast operation, the mining activities as such will not be directly visible and will only be noticed as dust generated in the open pit and on the access roads.

From a visual perspective however, visibility is not the only criteria that will determine the visual acceptability. The existence of accessible vantage points is also important. In this respect the view-shed map confirms that the mine will not be visible from views along the two tar access roads as well as the two gravel roads approaching the mine from the west.

The mine will only become visible once the western access road crests the hill immediately west of the mine. The mine will remain visible from here onwards along the northern provincial road diversion, as well as from the home steads of De Jager and Du Hain.

Once past the Du Hain home stead, visibility will once more become insignificant.

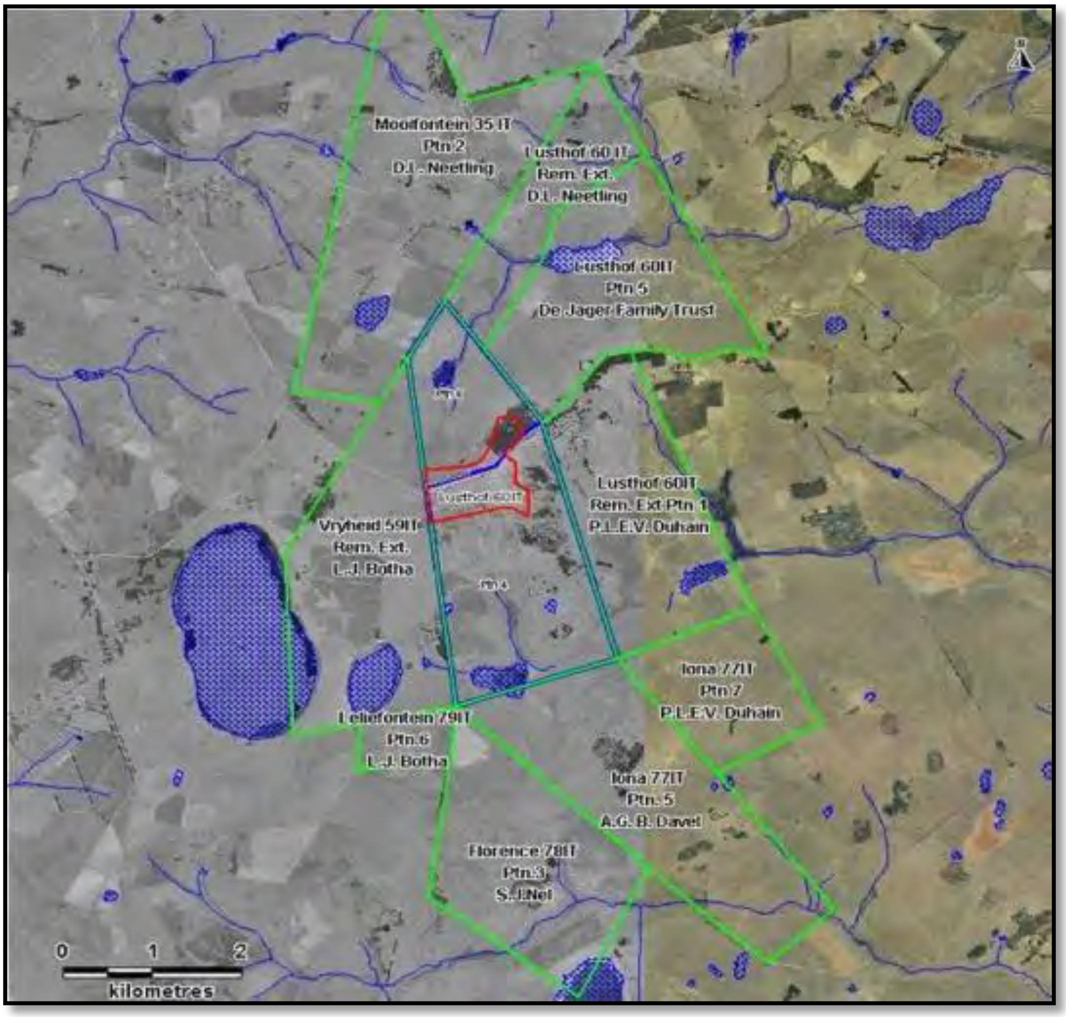


Figure 2.19.2.2 (a): Project and Surrounding Land Owners Property Delineation showing the farms with home steads of De Jager and Du Hain

Although visible from the south, the proposed mine ROM Stockpile and mine infrastructure will only be visible to travellers using the western farm road diversion past the mine towards the low lying areas in the south. These facilities will not be visible from the west, south or east.

The hills cause a restricted visibility range when on lower ground, resulting in short range views of physical objects. But when standing on higher ground though, long range views to the site are the result.

Scattered Black Wattle plantations also block views from certain vantage points, as can be seen in Figure 2.19.2.2 (b) below.

Figure 2.19.2.2 (b): Scattered Black Wattle plantations block views from certain vantage points.

In conclusion: after visiting the site, and selecting the View Points for the photographical survey along public roads surrounding the site, it was observed that although there are long range views to the site, the true visibility of the Lusthof Colliery site are more restricted than indicated on the View Shed Analysis, because of the vegetation, topography and the accessibility of vantage points.

2.19.3 Photographic Assessment

The following photographic assessment will provide support of the above mentioned visibility range of the Lusthof Colliery site.

The points selected for the photographic assessment were chosen along public roads surrounding the Lusthof Colliery Site. The points are shown on the map in Figure 2.19.3 (a).

The assessment distinguishes between long-, medium- and short range views as well as highly-, slightly-, and not-visible views. Also indicated on the maps in Figure 2.19.3 (a) and 2.19.3 (b) are several buffers. Within and on the 300 meter buffer around the Mine Boundary, the vantage points will be Short Range Views. Within and on the 1 km buffer around the Open Pit Boundary, the vantage points will be Medium Range Views. Further than that, all vantage points will be Long Range Views.

When discussing the assessment, the character of the area, one with little to no infrastructure, along with the possibility of some of the surrounding areas to become a RAMSAR site, will be noted. This is the specific character of the site and surrounding regions and should be the point of departure/terms of reference for the Lusthof Colliery visual impact assessment.

To avoid clustering of data and information, the photographic assessment will be presented at the hand of 8 photographic compilations (Figure 2.19.3 (c) – Figure 2.19.3 (j), each representing views to the Lusthof Colliery Site.

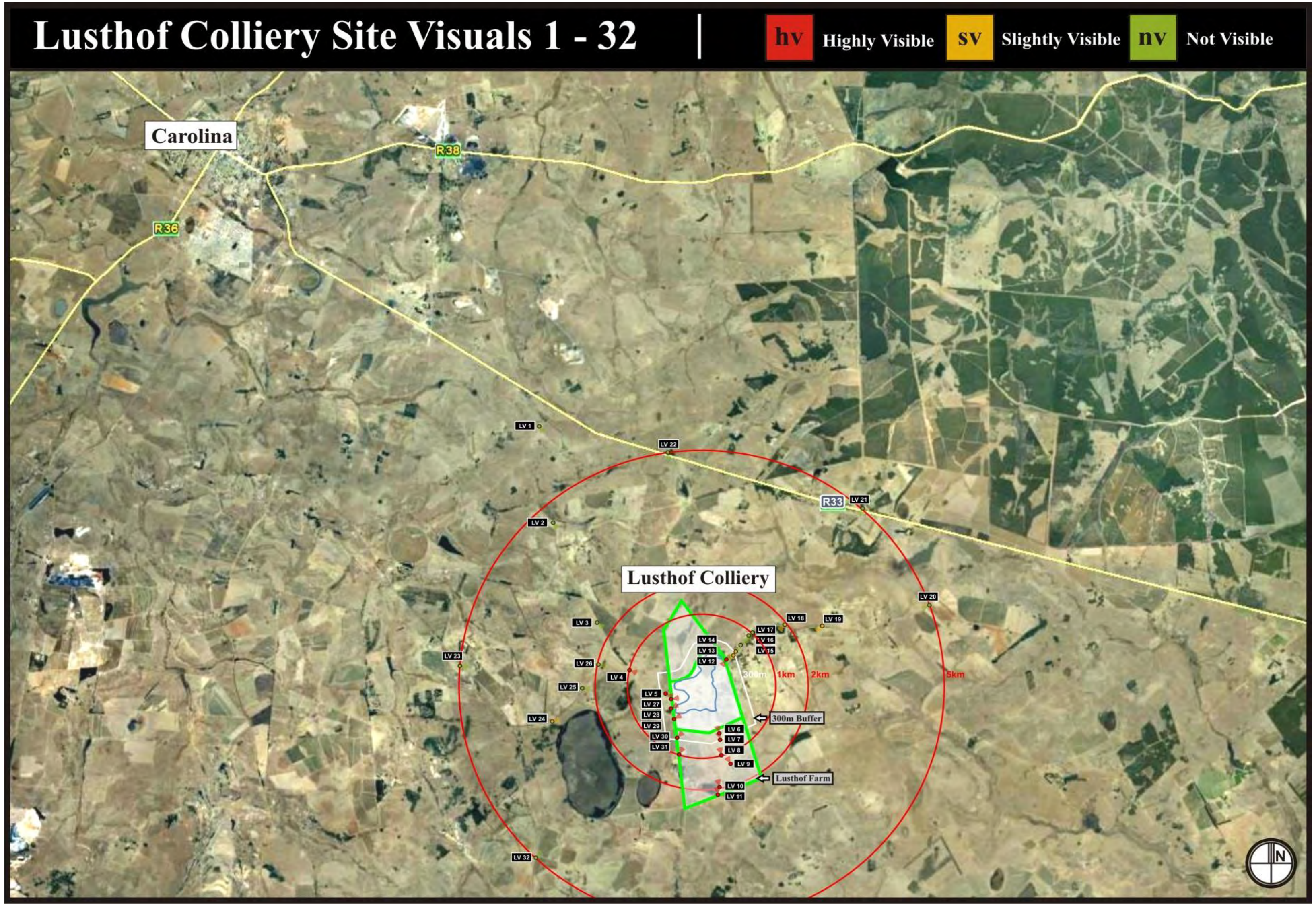


Figure 2.19.3 (a): Map of the Lusthof Colliery Site and View Points from which Photographs were taken.

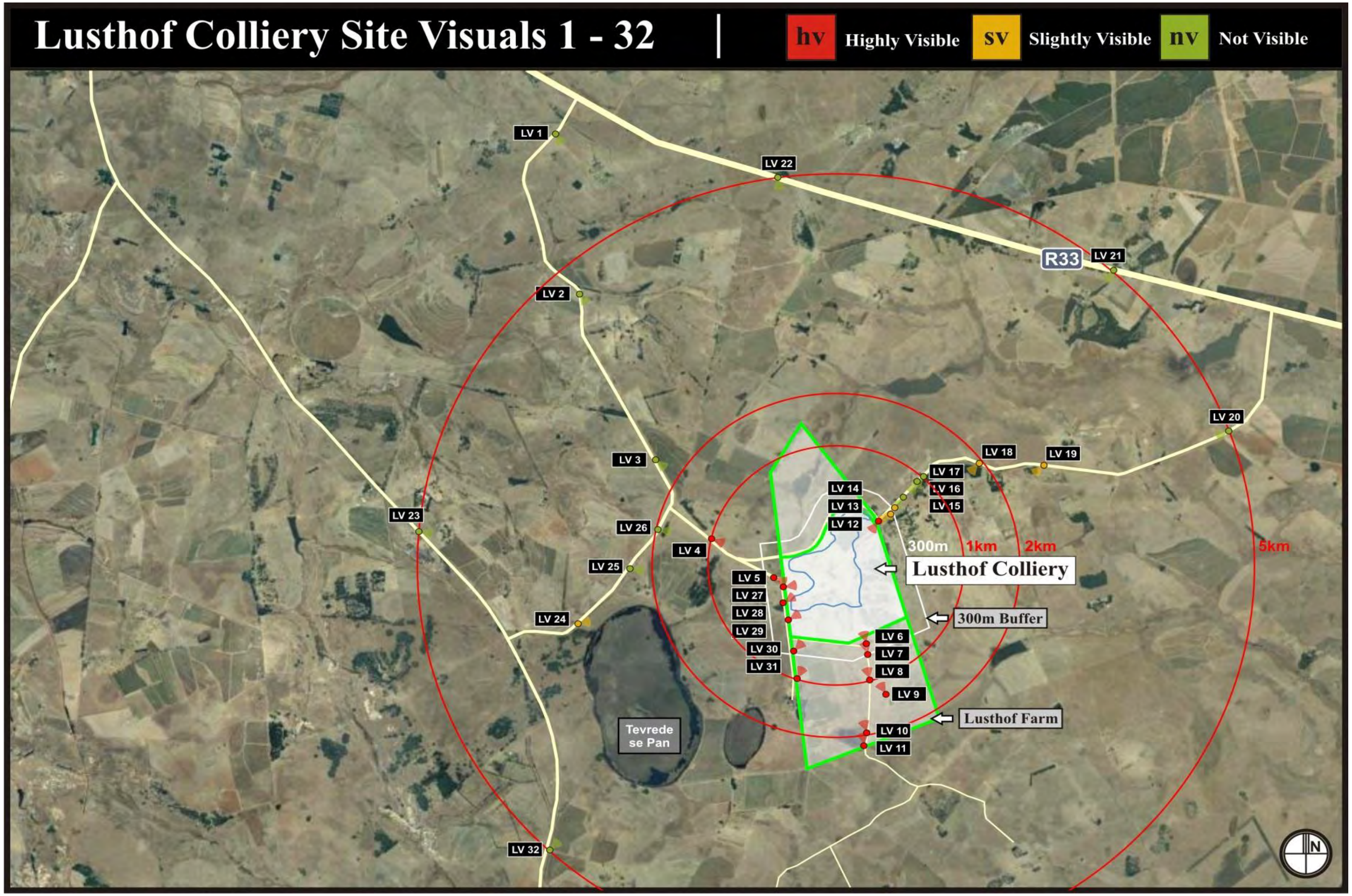


Figure 2.19.3 (b): Map of the Lusthof Colliery Site and View Points from which Photographs were taken.

Figure 2.19.3 (c): Lusthof Colliery Site Visuals 1 – 3.

Figure 2.19.3 (d): Lusthof Colliery Site Visuals 4 – 7.

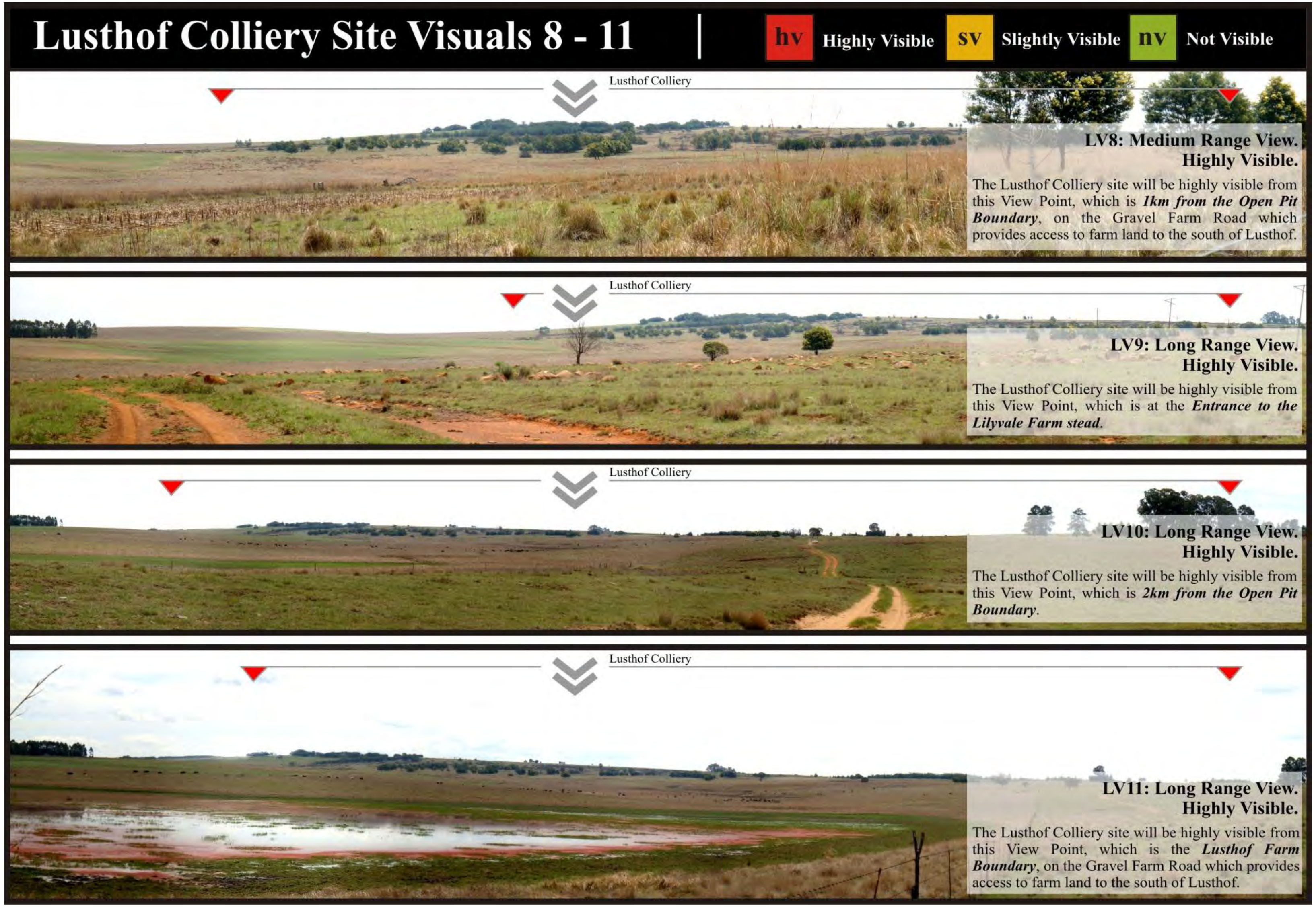


Figure 2.19.3 (e): Lusthof Colliery Site Visuals 8 – 11.

Figure 2.19.3 (f): Lusthof Colliery Site Visuals 12 – 16.

Figure 2.19.3 (g): Lusthof Colliery Site Visuals 17 – 20.

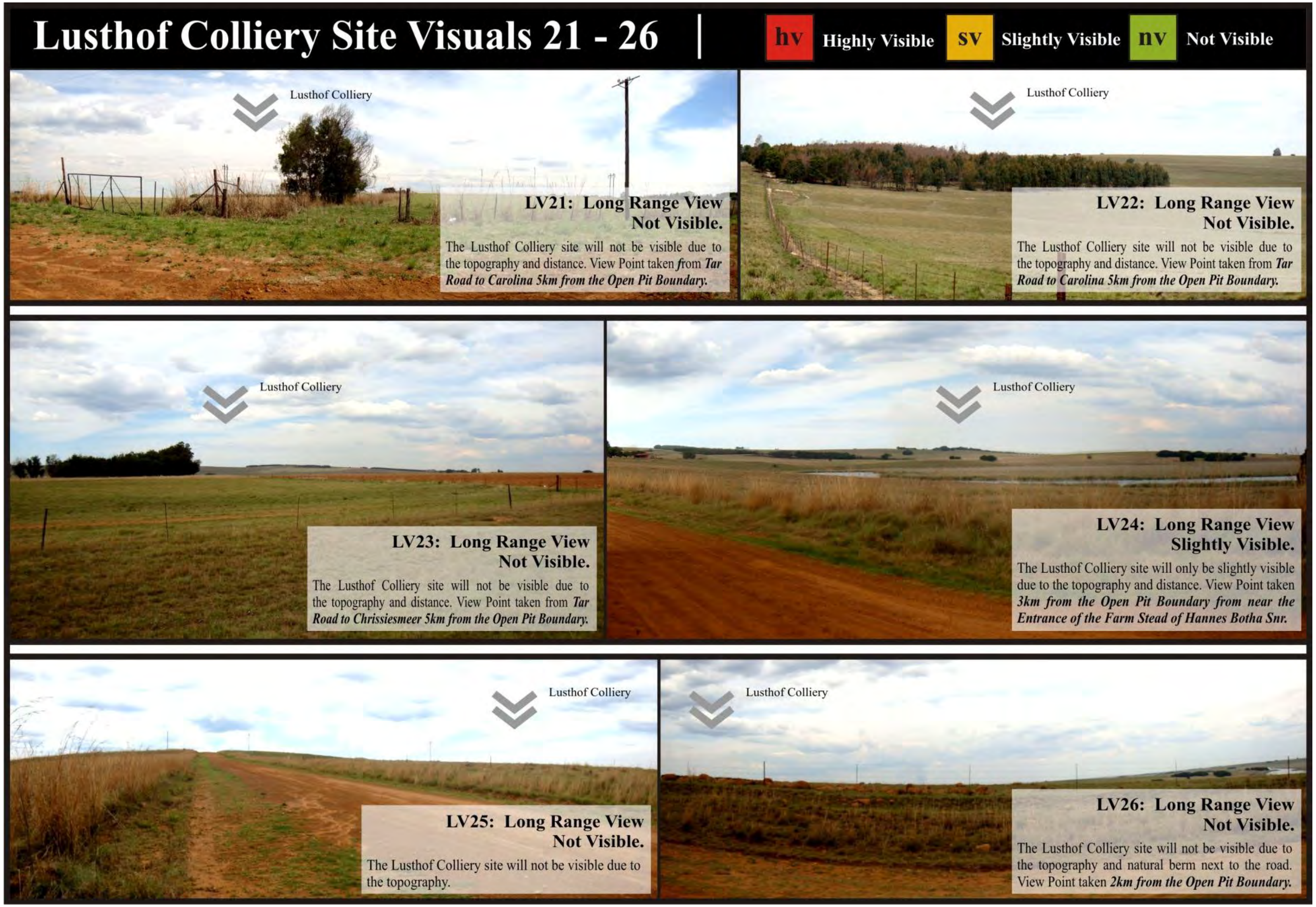


Figure 2.19.3 (h): Lusthof Colliery Site Visuals 21 – 26.

Figure 2.19.3 (i): Lusthof Colliery Site Visuals 27 – 30.

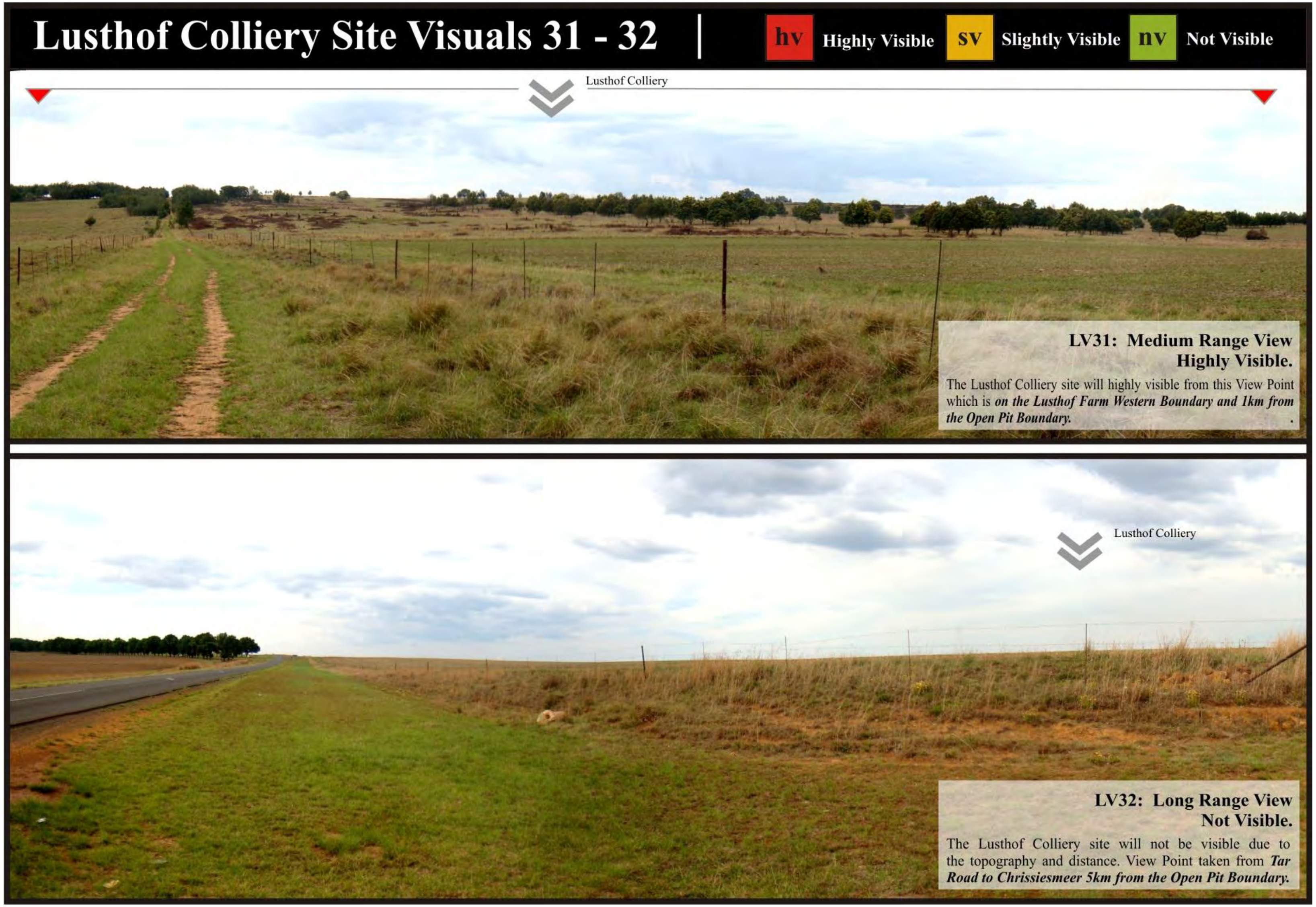


Figure 2.19.3 (j): Lusthof Colliery Site Visuals 31 – 32.

2.19.4 Current Visual Character

2.19.4.1 Regional Visual Character – Long Range Views

Regionally the visual character is three-fold:

The first: is the site being located within the broader Chrissiesmeer Pan Complex, which is generally perceived as a sensitive area out of an ecological view point.

Therefore if the Lusthof Colliery site infrastructure is viewed, against the visual character of the Chrissiesmeer Pan Complex as backdrop, the visual impact will be relatively significant, as the nature of this area contrast greatly with the visual context of mining activities.

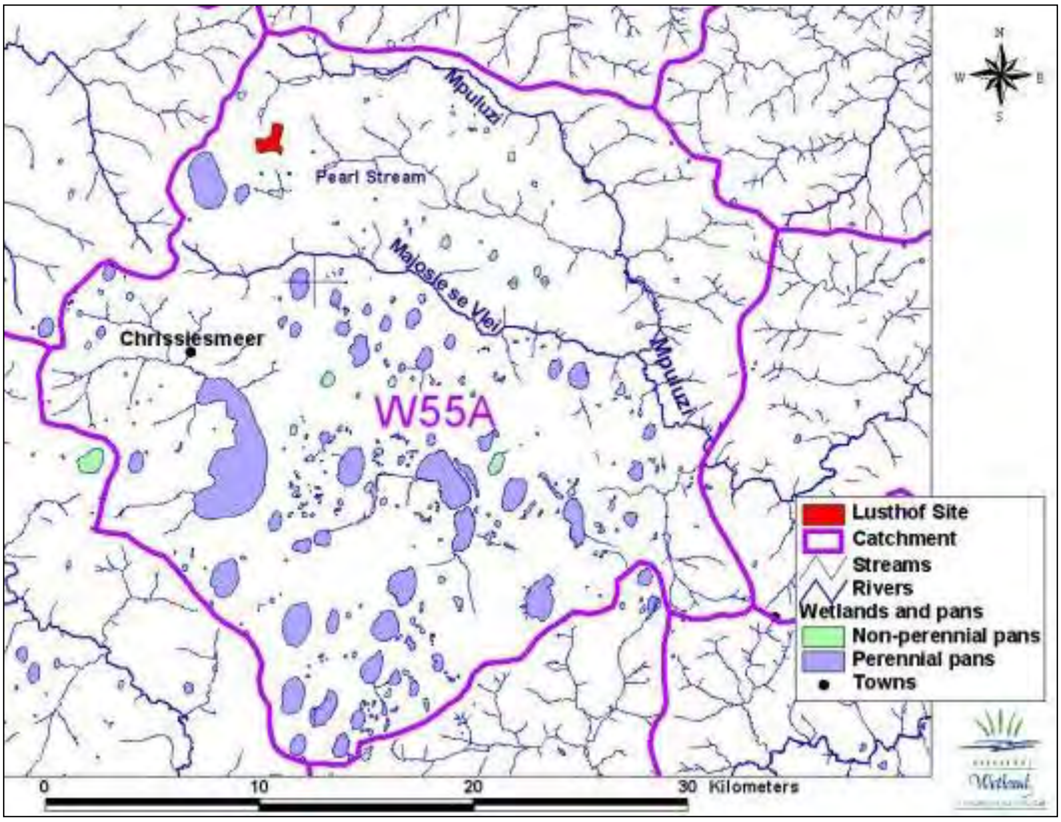


Figure 2.19.4.1 (a): Map Showing the Lusthof Colliery site and Water Bodies in the Area. (Wetland Consulting Services (Pty) Ltd in association with David Hoare Consulting generated the Map)

If the proposed Lusthof Colliery site is analysed in the context of the Chrissiesmeer Pan Complex, also called the South African Lake District, it can be described as one of the few/only mining/industrial complexes in the greater area and thus does present a challenge considering visual intrusion in the current visual character.

The second: The Lusthof study area occurs within Eastern Highveld Grassland (Mucina et al. 2006). This is a short, dense grassland occurring in slightly to moderately undulating plains, including some low hills (Mucina et al. 2006). The perceived degree of human intrusion in the area of the site is moderate with fragmented areas of natural grassland and some wetland.

Large proportions of the site have been previously cultivated or are currently under cultivation. There are significant areas dominated by alien trees, primarily Acacia Mearnsii. Some of these areas are dense stands of alien trees and others are scattered trees within degraded or previously transformed grassland. This type of vegetation can be found in most of the surrounding areas. Due to the absence of indigenous bushes or trees in the Grassland Biome, the site and surrounding area's vegetation does not help with local screening and is no use in camouflage for lower structures.

The topography of the Grassland Biome, which is that of slightly to moderately undulating plains, including some low hills (Mucina et al. 2006), does however lend itself to natural camouflage. Even though the proposed Lusthof Colliery mining area is situated on a topographical high, the hills still create an effective background from long range views, against which the infrastructure can be viewed, or hides the mining activities completely. The visual impact of Lusthof Colliery mining activities in the larger area will be moderate.

Figure 2.19.4.1 (b): The Vegetation and Topography in the Near Vicinity of the Lusthof Colliery Site, showing Natural Grassland and Wetland Vegetation. Also showing: the undulating plains and low hills, lending itself toward natural camouflage.

<u>The third:</u> is that of human settlement.

Farm steads and small informal settlements make out the bulk of human settlement in the near vicinity of the site. Because the proposed Lusthof Colliery site is situated on a topographical high, it will sometimes be visible from some of the farm houses and informal settlements situated in the near vicinity of the site, although views from these points are usually restricted due to local screening because areas are planted by inhabitants. (See Visuals 13, 15 and 16 for example in Photographic Assessment.

The farming population density in this area though is low, with only a few farmers and local workers using the roads running alongside the site. Berms to be built as screens next to the new Northern Provincial Road Diversion, along the Northern Mine Boundary, though will drastically lower visual impact concerning the Lusthof Colliery mining activities.

The Lusthof Colliery site is not visible from the towns of Carolina and Chrissiesmeer, which is the nearest large formal human settlements.

The Lusthof Colliery site's visual impact on the towns of Carolina and Chrissiesmeer and the regional areas could be moderate, as it is relatively unique feature in the area's landscape - few other mining activities can be identified. The site's setting however, in a semi-rural area, away from any prominent, busy roadways cause the visual impact to be less.

In terms of visual character, the proposed Lusthof Colliery facility does to some degree intrude with the surrounding regional visual character.

2.19.4.2 Local Visual Character – Short/Medium Range Views

In this report, short-range views are defined as those views that are closer than 300 meters to a feature, whether the view is not visible, slightly visible or highly visible.

<u>Physical Objects Obscuring Views</u>

When buildings, vegetation or landforms obscure a view, the range of the view is shortened, thus, eliminating the long-range view concerning objects further away. This view can no longer be influenced by the visual intrusion of an object you are no longer able to see.

In instances where physical objects do not dominate short-range views or obscure objects that are further off in the distance, the eye is automatically drawn to any prominent vertical feature, even if these are some distance away.

In this proposed context, there will not be any prominent vertical features in the Lusthof Colliery Mine Boundary as the mining activities will not require this. The highest infrastructure will be that of the Work Shop in the Contractor's Yard, which will be no higher than a typical barn on a farm stead, and the highest mining feature will be that of the ROM Stockpile which will be shaped no higher than the trees currently on the site.

Figure 2.19.4.2 (a): Typical Work Shop in the Contractor's Yard.

Figure 2.19.4.2 (b): Typical ROM Stockpile.

In instances where physical objects do not dominate short-range views or obscure objects that are further off in the distance, the eye will automatically be drawn to these features, but it will not be because they are vertically prominent in the landscape, it will be because Lusthof Colliery is situated on a topographical high.

The phenomenon of physical objects dominating short-range views to obscure objects that are further off in the distance will be illustrated mostly by the presence of areas dominated by alien trees, primarily Acacia Mearnsii. These areas particularly can be found near farm steads in the area, and therefor contributes to the restriction of long range views to the Lusthof Colliery Site.

Short/Medium range views across to the site and its surroundings are generally not restricted. Although some parts along the roads are planted with trees or contain structures closer to the road which can be observed, restricting views to the site, the Lusthof Colliery site will still be visible from several sections along the roads. Furthermore the vegetation found along the road is constantly changing, and as such the visibility of the site and surroundings subtly changes as time and seasons pass. The fact that the site is visible from short-range views does not however suggest a complete negative visual impact, as there are other factors also to consider.

The Setting of the Site

Where views are not obstructed by nearby objects, the proposed Lusthof Colliery site will draw the observer's attention. As the mine will be situated on a topographical high, the activities will be visible from some vantage points. If not for the setting of the site, in a semi-rural area, away from any prominent, busy roadways and towns, the mine would probably have been more of a short/medium-range visual concern. But in this instance, considering the setting of the site, the visual intrusion becomes moderate and acceptable.

The Backdrop against which an Element is Viewed

Another factor that may influence short-range views is the backdrop against which an element is viewed. When viewed from close up, landscape elements are usually seen against the sky and are therefore more visible. When the same elements are viewed against a backdrop, even better if the backdrop is of similar colour, they tend to be "hidden" more. This phenomenon is generally reserved for medium/long-range views, as in this instance, accept in specific cases where an operation is situated close to objects higher than the components of the site.

Figure 2.19.4.2 (c): Close Range View – Illustration of Typical ROM Stockpile, as to be found on the site of the proposed Lusthof Colliery Mining Site, Viewed against the Sky.

Figure 2.19.4.2 (d): Medium Range View – Illustration of Typical ROM Stockpile, as to be found on the site of the proposed Lusthof Colliery Mining Site, Viewed against a Backdrop.

2.19.4.3 Landscape Character

In this document, Landscape Character is a discussion of the nature and occurrence of the physical environment:

Morphology and Topography

The larger study area is located on the Highveld Region of the Mpumalanga Province at an elevation of between 1700 and 1800 meters above mean sea level (mamsl). The area surrounding the Farm Lusthof 60 IT is characterized by an undulating topography consisting of hills and valleys.

The topography of the larger study area is discussed with reference to the information obtained from the 1:50 000 Topographical Maps of South Africa (Sheets 2630AA and 2630AB), depicted as Figure 2.19.4.3 (a). Figure 2.19.4.3 (a) indicates that the Farm Lusthof 60 IT is located some 17 km to the South-East of the town Carolina. The town Carolina, the Lusthof 60 IT farm boundary, arterial roads as well as the secondary roads are indicated on the Figure as well.

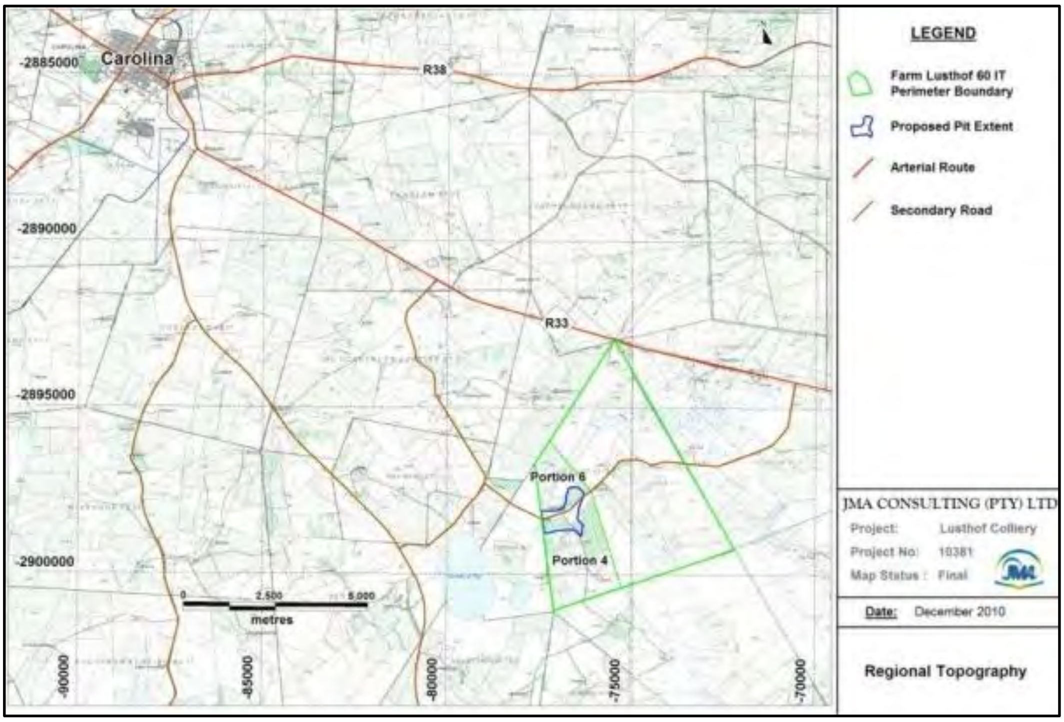


Figure 2.19.4.3 (a): Regional Topography of the larger Study Area.

The proposed extent of the Lusthof mining area is situated on a topographical high, and ranges in elevation between 1770 and 1796 mamsl. The immediate mining right area is flat with gentle to moderate slopes in a western and southern direction, and slightly steep slopes in a northerly and easterly direction.

The proposed pit extent falls on a topographical high as indicated on Figure 2.19.4.3 (b). The secondary gravel road that dissects the proposed pit boundary generally follows this topographical high and forms the boundary between Portions 4 and 6 of Lusthof 60 IT as well.

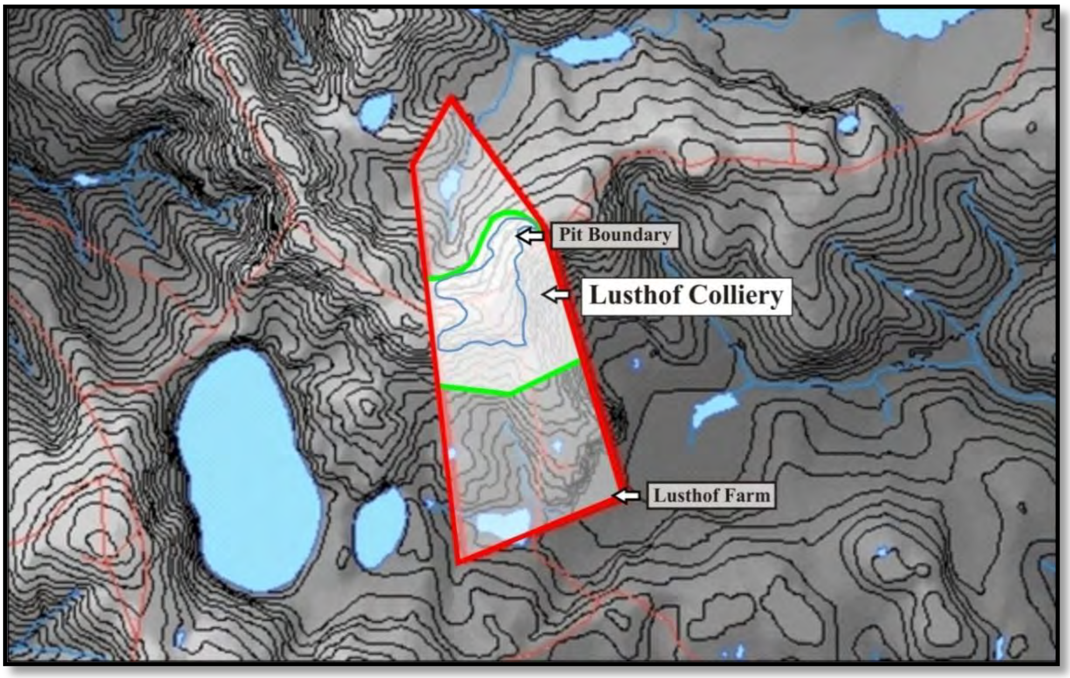


Figure 2.19.4.3 (b): Shaded Relief Map of the Surface Topography

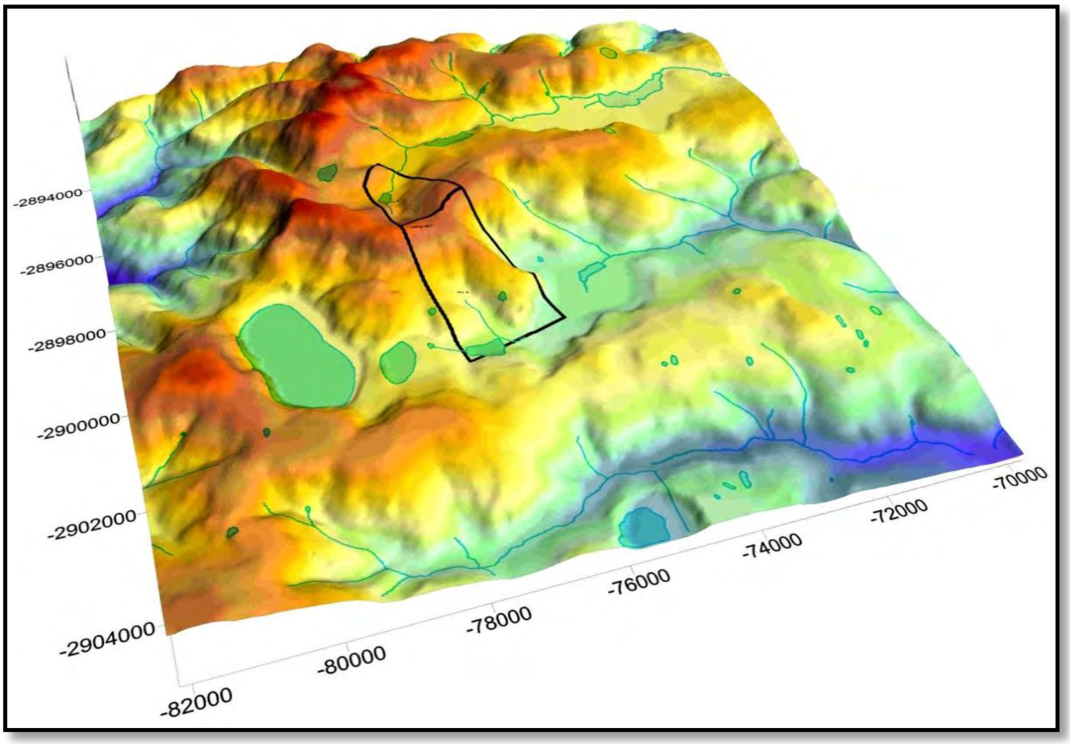


Figure 2.19.4.3 (c): Three Dimensional Relief Map of the Lusthof Colliery Site Area (based on 20 m interval surface topography data).

Figures 2.19.4.3 (b) and (c) clearly indicate that the surface topography on Portion 6 of Lusthof 60 IT becomes lower towards the north and north-west, away from the proposed pit boundary. The surface topography on Portion 4 of Lusthof 60 IT however becomes lower towards the south and south-east, away from the proposed pit boundary. The surface drainage as a result flows away from the proposed pit boundary as well.

As the Lusthof Colliery Site is located in open veld area that does not lie among other mining sites, the site therefore is, from a morphological and topographical point of view, in a pristine condition. The surrounding areas still possess their natural landscape form.

In conclusion: The site and surrounding areas still possess their natural landscape form, and they occur in an area where the local topography and morphology have not been altered in some way due to mining and other activities. The area therefore represents a Greenfields morphological and/or topographical environment.

Surface Vegetative Cover

The Lusthof study area occurs within Eastern Highveld Grassland (Mucina et al. 2006). This is a short, dense grassland occurring in slightly to moderately undulating plains, including some low hills (Mucina et al. 2006).

The vegetation on the Lusthof site consists of some fragmented areas of natural grassland and some wetland vegetation (Figure 2.19.4.3 (d)). Large proportions of the site have been previously cultivated or are currently under cultivation. There are significant areas dominated by alien trees, primarily Acacia Mearnsii. Some of these areas are dense stands of alien trees and others are scattered trees within degraded or previously transformed grassland.

The natural grassland on site is not particularly species-rich. It is dominated by the grasses, Eragrostis curvula, Tristachya leucothrix and Themeda triandra, and the herbs Rumex acetosylla, Lobelia flaccida and Helichrysum aureonitens. This species composition is typical of wet grasslands associated with the boundaries of permanent wetland areas and suggests that most of the grassland on site is within a water seepage area. The site is on a watershed (approximately through the centre of the site where the road passes through the site). This explains the low species richness, which is typical of seasonal to temporary wetlands in comparison to terrestrial grasslands.

Other species often associated with seasonal to temporary wetlands that were found within the grasslands on site are the following: Pseudognaphalium luteo-album, Pelargonium luridum, Fuirena pubescens, Hyparrhenia dregeana, Senecio erubescens subsp. crepidifolia, Hydrocotyl species, Monopsis decipiens, Cirsium vulgare, Agrostis erianthe and Oenothera stricta.

Drainage lines through the grasslands contained species more typical of permanently wet areas, such as Cyperus denudatus, Andropogon appendiculatus, Scirpoides burkei, Kyllinga alata, Juncus lomatophyllous, Juncus oxycarpus, Juncus effusus, Isolepis cernua, Leersia hexandra, Diclis reptans and Eleocharis dregeana.

There are many wet areas, mostly outside of the mapped grassland areas, that have been disturbed or ploughed.

Figure 2.19.4.3 (d): Vegetation patterns within the Lusthof Study site. (Wetland Consulting Services (Pty) Ltd in association with David Hoare Consulting generated the Map)

The transformed grasslands within the proposed mining footprint comprise predominantly the exotic kikuyu, Pennisetum clandistenum and Eragrostis plana. (Wetland Consulting Services (Pty) Ltd in association with David Hoare Consulting generated this information.)

Visually this vegetation community is quite permeable, allowing for long-range views, especially where the viewer is in an elevated position and looks onto lower-lying areas. Small clumps of larger alien trees may however obscure long-range views locally.

Thus at the proposed Lusthof Colliery site significant portions of both, the site itself, as well as parts of the immediate surroundings, farms and small rural settlement areas, have been extensively disturbed and altered by anthropogenic activities already, resulting in only isolated patches of the original vegetation to be present. In the larger area though, the vegetation is still semi-pristine.

It must be realised that vegetation is temporary and that the degree and specific instances of visual screening or obstruction offered by vegetation, constantly changes as the plants grow and die and seasons change.

<u>Current On-Site Land Use</u>

The current land uses identified within the Lusthof farm boundary are indicated on Figure 2.19.4.3 (e) and are listed below:

- Cultivated lands; this includes old lands as well as current maize and soya croplands.
- Wetlands

- Hay pastures; these are predominantly Eragrostis Curvula fields.
- Woodlot; Acacia Mearnsii has been planted as a source of wood for farm inhabitants. These trees have expanded independently into a large portion of the grazing lands to the south of the road.
- Grazing lands; these are grasslands used as extensive grazing for beef cattle.

A very small rural settlement, mostly only farm workers can also be found on the Lusthof Farm.

The area within the opencast pit comprises of land with arable, grazing and wilderness capabilities. Due to the shallow nature of the soil profile, the area is predominately used as grazing land.

The greatest majority of the area is covered by natural vegetation, disused plow ridges occur, indicating a previous crop production use. Limited dry land maize production is also evident on the study area, as a couple of cultivated fields occur. This is however very small in relation to the total area.

A Black Wattle plantation and a couple of isolated patches of Black Wattle also occur within the study area.

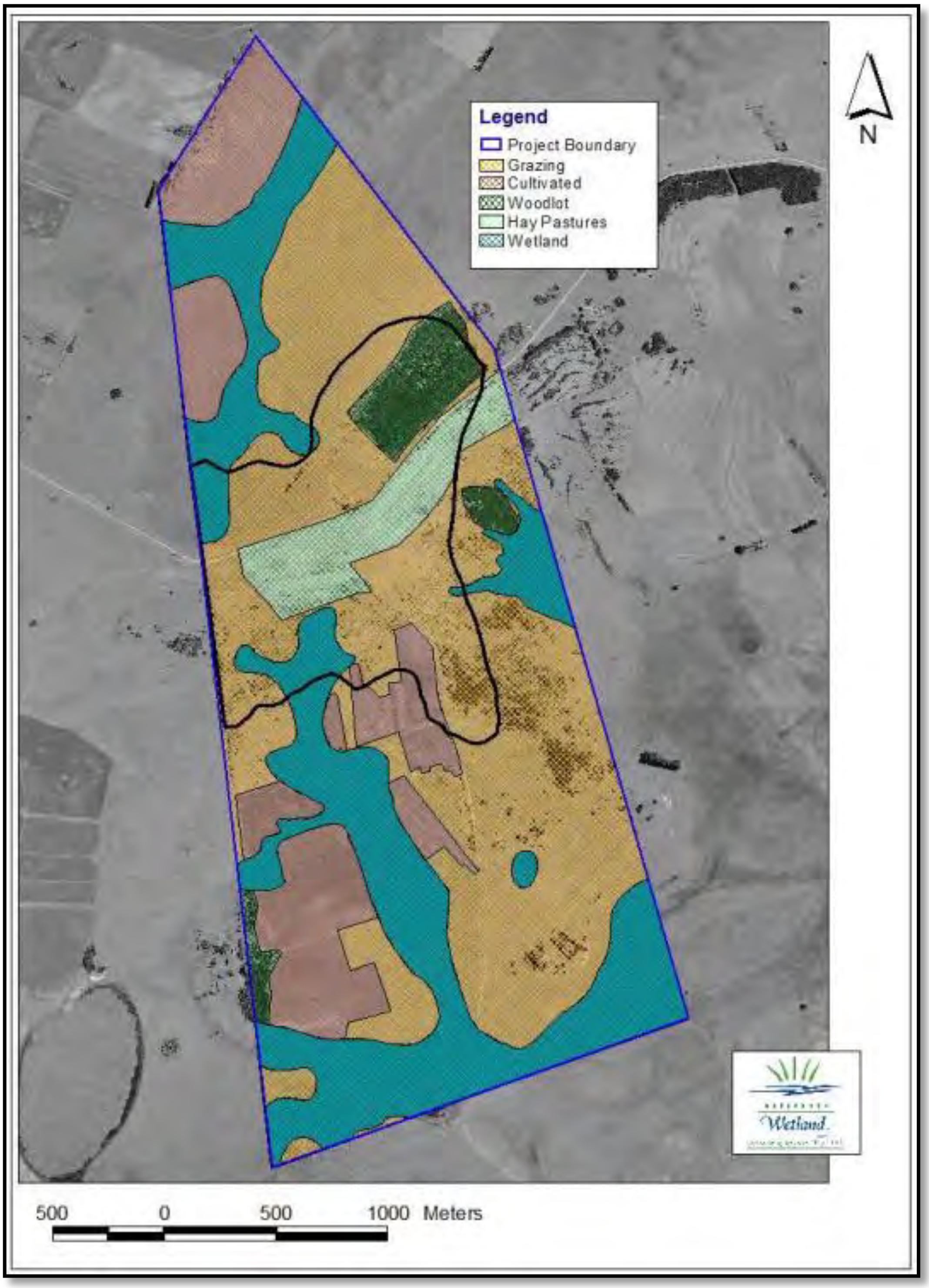


Figure 2.19.4.3 (e): Current Land Uses within the Lusthof Study Area. (Wetland Consulting Services (Pty) Ltd in association with David Hoare Consulting generated the Map)

The current land use attributes, undoubtedly represents the dominant component of the landscape character of the larger study area.

2.19.4.4 Existing Visual Character

The land use on the Lusthof Farm, which is predominantly agricultural (cultivated lands, hay pastures, grazing lands) and very small rural settlements mostly only farm workers, fits into the larger regional character which features exactly these land uses. The vegetation is natural grassland and wetland areas, and the topography consists of small hills and valleys. This is the visual characteristics of the Lusthof Farm and the surrounding areas. Thus the Lusthof Farm area does not visually contrast with the larger area's character context.

The area where the Lusthof Colliery Mine will be located is situated on a topographical high. The site will only be visible from short range views when arriving from the western access road that crests the hill immediately west of the proposed mine area. The mine area will remain visible from here onwards along the northern provincial road diversion, and from the southern side of the site on the new Farm Road Diversion from short, medium and long range views.

The existing visual character of the site and greater region is far from undisturbed and is in fact characterised extensively by agricultural activities. The existing Lusthof Farm site fits into the character of the region and is not uniquely visible and therefore does not visually dominate the area, and do not visually contrast with the area's character context.

Landscape Visual Quality Assessment

In this document, Landscape Quality is a measurement of the union of ecological integrity and aesthetic appeal. Ecological integrity refers to the condition or overall health of the landscape measured in terms of the quality of the physical environment – morphology, topography and vegetation.

Note that air quality and dust pollution is not investigated in this study. It should however be noted that dust from truck traffic can be a most visible feature of mining and industrial activities, when viewed from some distance away. Emissions from mines and other industrial activities are visible from great distances away, more so than the structures or activities themselves that causes it. In this instance, The Lusthof Colliery Mine Activities will not include emissions though.

Aesthetic appeal refers not only to the visual quality of elements of an environment but also to the way in which combinations of elements in an environment appeal to our senses. Studies of perceptual psychology have shown human preferences for landscapes with a higher visual complexity, rather than homogeneous ones. On the basis of contemporary research by Crawford (Crawford, 1994), landscape quality increases when:

- Topographic ruggedness and relative relief increase.
- Where water forms are present.
- Where natural landscapes increase and human-made landscapes decrease.
- Where land use compatibility increases and land use edge diversity decreases.

Using these criteria to analyse the landscape quality of the proposed Lusthof Colliery Site and its immediate surroundings, the following conclusions were subjectively (but in a professional opinion) made. Where the natural/expected condition of the site and immediate surroundings is unaltered, a rating of 1 is given, and where the expected existing condition is not present or has been changed, a rating of 0 is given.

Table 2.19.4.4 (a) - Local Landscape Quality

Ecological Integrity	
Morphology	1
Topography	1
Vegetation	0
Aesthetic Appeal	
Topographical ruggedness	1
Presence of water	1
Natural versus human landscape	0
Land use compatibility	1

As can be seen from the Table above, the ecological integrity of the site and immediate surroundings has not been largely altered. At the Lusthof Colliery Site, localised alteration of the horizon will occur and significant topographical alterations will be made.

The vegetation on the site is already altered by activity adjacent or on the site. Even though the activities are not intrusive, such as other mining activities, the natural state has been altered due to agricultural activities. Therefore, locally, the vegetation can generally no longer be considered to be representative of a pristine natural condition.

The aesthetic appeal of the local setting is relatively high, the greatest landscape altering impact being the extensive presence of agricultural activities.

The land use compatibility of the site with its surroundings is high. The site, at this stage, has no negative effect on the visual character of the local vicinity, but if the proposed mining facilities are built, the activity on site will greatly contrast with the regional character, as there are few other mining activities present locally and regionally. Thus the degree of visual intrusion of the proposed Lusthof Colliery site in the regional setting will be high.

From the above it can be argued that the landscape quality is high, but the development of the new Lusthof Colliery mine will be acceptable, when incorporating clever and effective mine designing methods and visual monitoring methods. Also considering that industry and mining is a major economic booster for the region and the country. The visual impact of the Lusthof Colliery site will have to be carefully monitored to insure that the activities have the smallest possible negative influence on the landscape visual quality.

Visual Character (Sense of Place) Assessment

According to Lynch (Lynch, 1992) sense of place is "the extent to which a person can recognise or recall a place as being distinct from other places, as having a vivid or unique, or at least particular character of its own". Thus sense of place means that a site has a uniqueness or distinctiveness, which distinguishes it from other places. The primary informant of these qualities is the spatial form and character of the natural landscape together with the cultural transformation associated with historic use and habitation. In this analysis the cultural transformation can be seen as the site and regional character, which has been described above. A landscape can be said to have a strong sense of place, regardless of whether it is considered to be scenically beautiful or not. Where high landscape quality and strong sense of place coincides, the visual resource is considered to be high.

Using these criteria to analyse the sense of place of the Lusthof site, the following subjective conclusions are made:

- The Regional "sense of place" is largely linked to three visual characteristics:

    - ❖ The land use, which is predominantly agricultural (cultivated lands, hay pastures, grazing lands), very small rural settlements mostly only farm workers and farmsteads.
    - ❖ The vegetation which is natural grassland and wetland areas, and
    - ❖ The undulating topography consisting of hills and valleys.

    The above three regional characteristics, contribute to a very specific character, with a relatively high visual quality and a unique feeling when viewed from other vantage points.

- The Lusthof site "sense of place" can be attributed to the following characteristics:

    - ❖ Land Use – The site is mainly used for agricultural purposes i.e. grazing and limited crop production. The above-mentioned land uses and associated activities do not require extensive surface infrastructure and hence the area does not have any extensive surface infrastructure.
    - ❖ The vegetation which is natural grassland and wetland areas, and
    - ❖ The undulating topography consisting of hills and valleys.

    Thus the Lusthof Colliery site's character is similar to the regional character and it can therefore not be considered to have a unique genius loci or sense of place in the region, although the region does have a unique sense of place in a larger perspective – areas in South Africa.

- The presence of the Lusthof Colliery site at this stage does not detract from the aesthetic appeal of the area or the visual character, but when the mine is built the visual impact will however be undesirable and visual mitigation should be considered where applicable.

2.20 BLASTING AND VIBRATION BASE LINE

2.20.1 Introduction

Blast Management & Consulting was contracted as part of Environmental Impact Assessment (EIA) to perform an initial base line review and to identify possible impacts with regards to blasting operations in the proposed opencast mining operation. Blast Management & Consulting as a company concentrates on the monitoring, prediction, analysis, audit and consulting on all aspects of blasting operations. Specifically are aspects such as ground vibration, air blast, fly rock, fumes and other influences evaluated.

2.20.2 Legislative and Policy Framework

The protocols applied in this document are based on the author's experience, guidelines from literature research, client requirements and general indicators from the various acts of South Africa. There is no direct reference in the following acts with regards to requirements and limits on the effect of ground vibration and air blast specifically and some of the aspects addressed in this report. The acts consulted are: National Environmental Management Act No. 107 of 1998, Mine Health and Safety Act No. 29 of 1996, Mineral and Petroleum Resources Development Act No. 28 of 2002.

The guidelines and safe blasting criteria are according international accepted standards and specific applied in this document is the United States Bureau of Mines (USBM) criteria for safe blasting for ground vibration and recommendations on air blast. There are no specific South African standard and the USBM is well accepted as standard for South Africa. However it is sure that the protocols and objectives will fall within the broader spectrum as required by the various acts.

2.20.3 Receiving Environment

The source area is located at in Mpumalanga southwest of the town Carolina on the farm Lusthof 60 IT. The receiving environment is considered the area expected to be influenced. This influence is divided into damage causing influence and nuisance or perception type influence. The site will be visited to observe and record typical structures, installations and obtain an understanding of people's perception and tolerance to possible influence. Figure 01 shows area of study with initial aerial identification of potential points of interest (POI's).

The objective is to outline the expected environmental effects that blasting operations could have on the surrounding environment. The study will investigate the related levels and possible influences of expected ground vibration, air blast, fly rock and noxious fumes on the area of 3500m[1] surrounding the blast areas. The more critical receiving environment is indicated as the 0 to 1500m[2] reference area. 1500m is considered range by Blast Management & Consulting as range where influence definitely needs to be monitored in view of the damage causing and nuisance type influence.

[1] Determined by Blast Management & Consulting from Experience

[2] Estimated from experience by Blast Management & Consulting

The possible effects that contribute to damage of structures / installations in the area cannot be determined at this stage. The geology and expected blasting operations to be done needs to be defined. The blasting operations will be the main source contributing to the influences with regards to ground vibration levels, air blast levels and fly rock. These aspects contribute to damage to structures and causing nuisance to humans and animals if levels are too high and not controlled. Apart from levels that causes damage the possible influence with regards to the human perceptions of ground vibration and air blast will also be considered. Humans are sensitive to even very low level effects of ground vibration and air blast. In order to take this into consideration and area of 3500m is identified as area that could observe influence. This is in view that people will experience ground vibration at levels as low as 0.75mm/s[3].

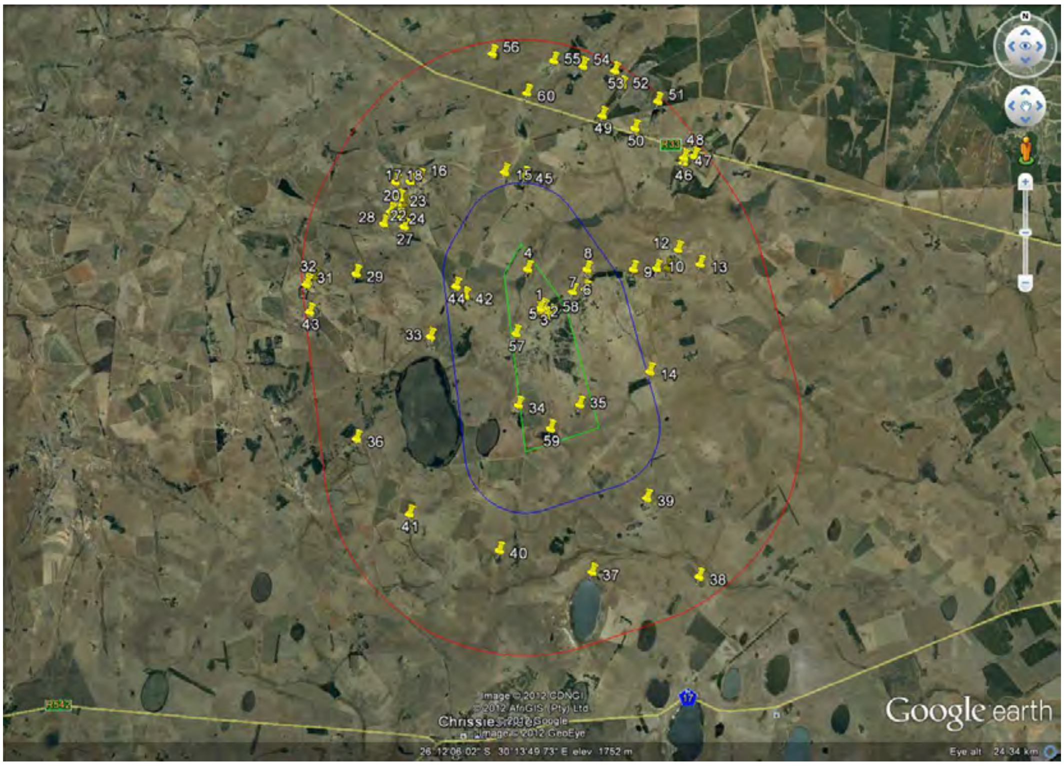


Figure 2.20.3 (a): Study Area

2.20.4 Description of Potential Impacts

The potential impact investigated due to blasting operations is ground vibration, air blast and fly rock. The levels of these aspects are important as it may cause damage to structures, upset people and have influence on animals. The possible levels will be determined and the prediction outcomes will determine the extent and if mitigation will be required. Mitigation will be indicated on two levels:

- what is considered safe blasting criteria with regards to structures and
- what is considered acceptable levels with regards to human perception.

[3] Chiapetta, F., A Van Vreden, 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.

Figure 2.20.4 (a) shows points of interest identified from aerial image (Google Earth). These POI's were identified and classed into four different areas. Structures are found close to the mining area (between 0 and 750m), structures between 750 and 1500m, between 1500m and 3500m and beyond 3500m from the mining area. The distances used are typically considered for possible further action after final investigation by BM&C in this project.

The possible influence on these structures from mine blasting operations will be determined in the full investigation. It is however certain that structures within 750m will be most probably influenced to a certain degree. After 750m the influence is expected to be less with significant greater decrease after 1500m.

The possible environmental or social impacts with regards to blasting operations are then addressed in the final report with the following chapters.

- Ground vibration expected from future blasting operations;
- Ground Vibration and human perception;
- Vibration impacts on productivity of farm animals (cattle, chickens, pigs, etc.);
- Vibration impact on national and provincial roads;
- Vibration to communication towers and equipment in the area sensitive to vibration;
- Vibration that may impact on adjacent communities;
- Damage of houses and consequent devaluation;
- Potential borehole collapse;
- Muddying and pollution of borehole water;
- Air blast expected from future blasting operations;
- Fly-rock expected; and
- Noxious fumes.

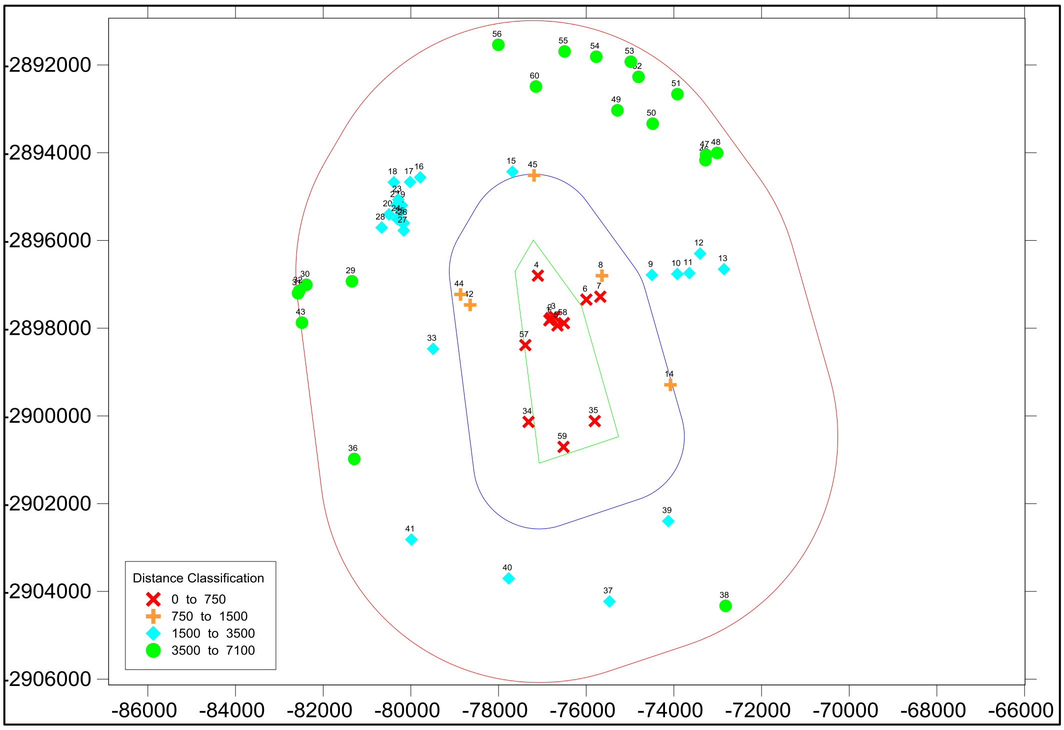


Figure 2.20.4 (a): Map Indicating Potential Influence Zones

2.20.5 Conclusion

The Lusthof project area is located 18km southwest of the town Carolina in Mpumalanga. The area is considered by Blast Management & Consulting as a sensitive area with current POI's present in the surroundings. The area is surrounded by various installations on varying nature that will need to be considered. It is expected that the most critical area is the 1500m around the project area. Depending on the final blasting operations scale the installations in this boundary are expected to be possibly impacted. Installations further away will be impacted to lesser degree but will need consideration as well.

3. ANTICIPATED IMPACTS

3.1 PROJECT DESCRIPTION

The project description provided in this chapter was compiled to the highest possible level of detail and represents the outcome of several iterations as far as the mine design is concerned. This includes alternatives considered for surface infrastructure extent and placement, transport of coal, the extent of mining, the mining method and mining sequence, placement of the ROM Stockpile, calculation of the operational and post closure water balances subject to different mine designs, options for mine water and storm water management and finally the rehabilitation plan.

A discussion of the more important alternatives considered for this project is given in Chapter 4 of this report.

Concerns and comments from I&AP's and authorities, related to *inter alia* water management, rehabilitation and transport of coal were considered throughout the mine design process.

The project description provided, therefore represents the "Planning and Design Phase Management Environmental Management Plan" for Lusthof Colliery. Design features as they relate to mining, transport, water management and rehabilitation were selected and designed to provide a very high level of "Environmental Acceptability" and if implemented as proposed, will result in a coal mine with a very low to insignificant environmental impact. Existing South African Best Practice Guidelines were used throughout the mine design process and the outcome is deemed to represent the **B**est **P**racticable **E**nvironmental **O**ption (**BPEO**) from an Environmental Management perspective.

Project Title
Black Gold Coal Estates – Lusthof Colliery EMPR Addendum, EIA and IWULA

3.1.1 Project Applicant

Project Applicant:	Black Gold Coal Estates (Pty) Ltd
Trading Name:	Lusthof Colliery trading as Black Gold Coal Estates (Pty) Ltd
Business Registration No:	2003/003266/07
Contact Person:	Mr J Ferguson
Physical Address:	34 O R Tambo Street, Model Park, Witbank
Postal Address:	P O Box 3185, Witbank, 1035
Telephone no:	+ 27 (0) 13 690 3131
Fax no:	+ 27 (0) 13 656 4374
E-mail:	ferguson@eastsidecoal.co.za

3.1.2 Project Location

3.1.2.1 Regional/ Local Setting

The site is located in the Mpumalanga Province of South Africa. The site locality, in relation to neighbouring towns/cities, is given in Table 3.1.2.1 (a).

Table 3.1.2.1 (a): Locality of Site in relation to nearest Towns/Cities

Town	Distance from Site (km)	Direction from Site
Carolina	17	North West
Chrissiesmeer	10	South
Breyten	27	West South West
Badplaas	43	North East

The regional setting of the project site is delineated on the map shown in Figure 3.1.2.1 (a) below.

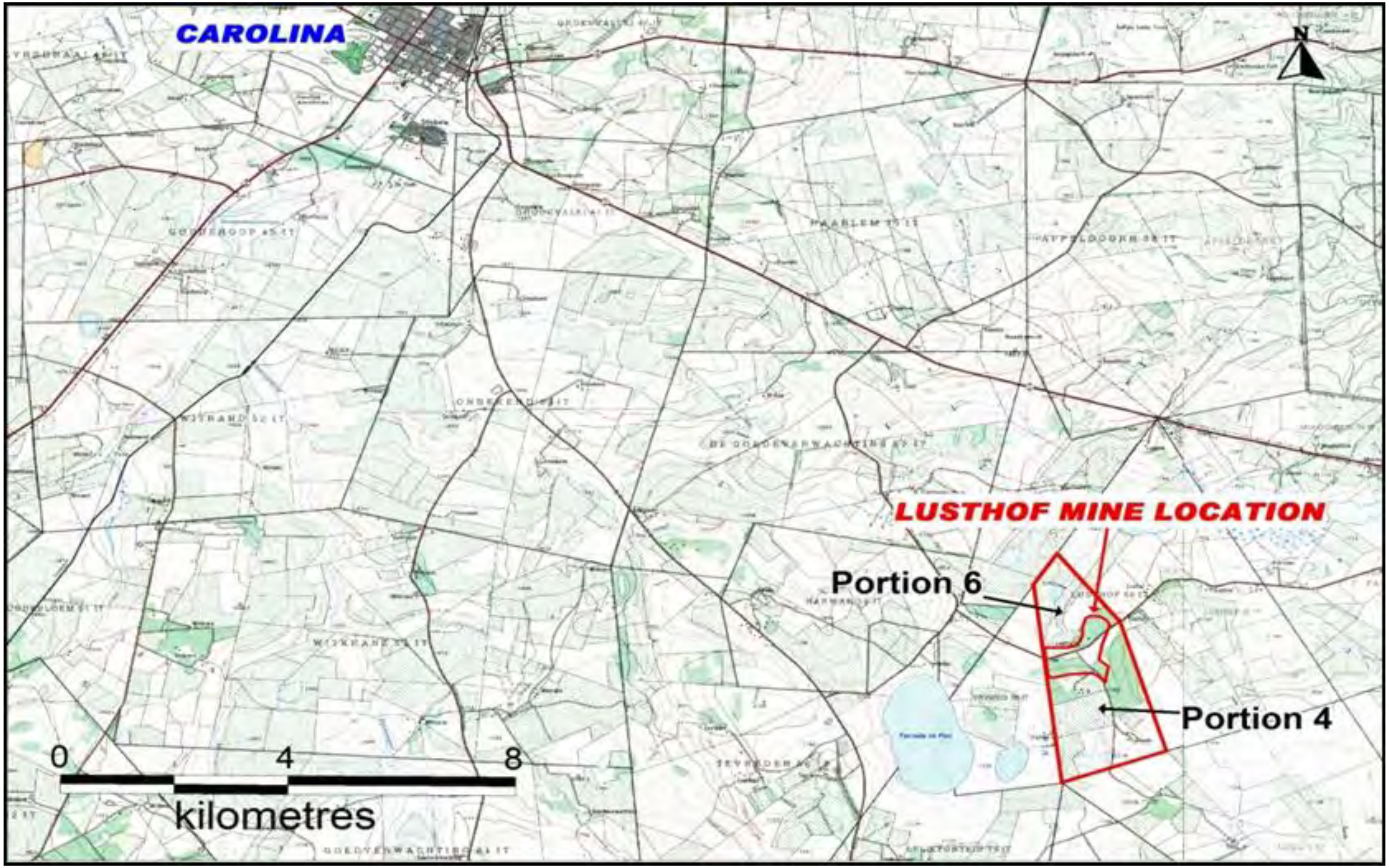


Figure 3.1.2.1 (a): Regional Setting of the Project.

3.1.3 Project Resource Attributes

3.1.3.1 Mineral Deposit

The proposed Lusthof Colliery mining area falls within the eastern portion of the Ermelo Coalfield. The Ermelo Coalfield extends from Carolina in the north to Dirkiesdorp in the south. Selective coal seams will be mined at Lusthof Colliery.

3.1.3.2 Mineable Coal Seams

The coal seams present within the Caroline-Breyten coal sector are alphabetically numbered from the top as follows: A, B, C, D and E coal seams. The A and D seams are generally too thin (<0.6m) to be of economic importance.

The B seam generally attains a thickness of between 2.0 and 3.7 m and consists of alternating layers of poor and good quality coal with generally high ash content.

The C coal seam splits into a C-Upper seam and a C-Lower seam. These seams attain a thickness of 0.6 and 2.0m respectively.

The E seam is generally well developed in the Carolina-Breyten sector of the area and may attain a thickness of 3 m, although this seam will not be mined at Lusthof Colliery.

3.1.3.3 Depth Below Surface and Dip

The 3 distinctive seams that will be mined are the B coal seam, and the Upper and Lower C coal seam. The depth of mining for the B seam (most upper of the economical reserve) ranges between sub-outcrop depths (covered by 5m of soft overburden) to a maximum depth of 31 m.

The Upper C coal seam is below the B coal seam and separated by a medium-grained, horizontally laminated sandstone. The average thickness of this parting is 5.7 m. The range in depth of the Upper C seam is therefore 10 m – 36 m below surface.

The Lower C coal seam is separated from the Upper C coal seam by a characteristic “dirty grey” carbonaceous sandstone. This parting is very thin and the depth distribution of the Lower C coal seam is merely a function of the added thickness of this seam. The range in depth of the Lower C seam is therefore 12 m – 38 m below surface.

3.1.3.4 Coal Reserves

The estimated (Y2010) reserve within the B, Upper C and Lower C coal seams of the proposed Lusthof Colliery project area is in the order of 3.78 Million ROM tons. This is in the total given reserve area of 82 ha.

3.1.3.5 Coal Quality

Three distinct qualities of coal are available:

- An A-grade export quality coal. A 27.5Mj/kg CV (Calorific Value) export quality product is achieved at a washability of 70%.
- An inland high-quality product of 26 Mj/kg CV. This type of high quality inland product is typically used by paper mills and sugar refineries.
- An Eskom quality coal is blended to an approximate quality of 20 Mj/kg CV.

3.1.3.6 Coal Market

The sale of all export coal products depend on short term market conditions. Contracts are negotiated on a short term (6-12 month) basis, the latter being the most likely of contract schedule.

Eskom contracts will be negotiated on a longer term, 3-5 year basis. Currently no fixed contract is in place.

Export quality inland use will be considered if the opportunity arises during the Life of Mine.

3.1.3.7 Coal Price

The coal price for export will be fixed to pre-negotiated fixed prices, or as a ratio to prevailing spot prices. Export spot prices can vary between $70-$100/ton at the given CV's.

The inland prices for Eskom delivery fluctuates less and is currently (March 2010) in the region of R515/ton. Inland export quality will be delivered at pre-negotiated prices (contract-specific).

3.1.3.8 Planned Production Rates

The planned production rate is in the order of 50 000 – 60 000 t/month. However, this production rate can vary between 30 000 – 120 000 t/month, depending on prevailing market conditions and shorter term contracts.

3.1.3.9 Planned Life of Mine/Facility

The total Life of Mine is a function of the production rate, as given above. Given the size of the total reserve and the average production rate, a total Life of Mine of 8 years is envisaged.

3.1.4 Project Motivation (Need and desirability)

3.1.4.1 Legal Standing

Lusthof Colliery is owned in full by Black Gold Coal Estates (Pty) Ltd. (Reg. No: 2003/003266/07). It has been granted a mining right in terms of section 23(1) of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002).

3.1.4.2 Need for Product

The end use for the three different coal products is well known. Export quality coal is used in metallurgical processes, while the Eskom quality steam coal is used for electricity production in the Republic of South Africa. No alternative source for coal-fired power stations currently exists.

3.1.4.3 Strategic Importance of the Resource/Product

The strategic importance of a continuous supply of steam coal to South-Africa's coal fired power stations cannot be over-emphasised. All power stations (current and newly commissioned) need a constant supply of coal to keep operational.

3.1.4.4 Contribution to Gross Domestic Product

The contribution of the total mining operation to the Gross Domestic Product was calculated as follows:

- Total reserve: 3.78 Million tons.
- Total export earnings: Approximately R1.3 Billion, based on an export price of $80/t and a ZAR exchange rate of R7.30/$.
- Total domestic earnings: Approximately R800 Million, based on a domestic rate of R515/ton.
- Total earnings: Approximately R2.3 Billion in total.

3.1.4.5 Contribution to Foreign Earnings

Using the figures quoted above, the total foreign earnings will exceed R1.3 Billion, at current commodity prices.

3.1.4.6 Socio-Economic Benefits

Lusthof Colliery has an approved Social and Labour Plan (S&LP) which addresses aspects related to BEE (51% BEE Shareholding), Human Resources Development and Local Economic Development which addresses Infrastructure Development and Poverty Eradication projects in line with the East-Vaal District Municipality and the Albert Luthuli Local Municipality's Integrated Development Plans.

3.1.5 Project Infrastructure

3.1.5.1 General Infrastructure

The general infrastructure will be discussed with reference to the proposed mine design and layout plan indicated on Figure 3.1.5.1 (a). A large scale version of this map is attached as APPENDIX 3.1.5.1 (A) to this report.

3.1.5.1.1 Access Roads

Two of the original gravel roads dissecting the Lusthof reserve area will be diverted around the mining activities via two road diversions, namely a northern road diversion and a southern road diversion. The northern road diversion will divert the provincial secondary gravel road to the north of the mining operations at Lusthof Colliery as indicated on Figure 3.1.5.1 (a). The proposed northern road diversion will extend across a distance of approximately 2.2 km.

The southern road diversion extends to the south of the mining operations as shown in Figure 3.1.5.1 (a). The western section of the road diversion will consist of the upgrading of the existing farm road along the boundary fence over a length of 1.6 km, whereas the southern section of the road diversion will extend from the upgraded farm road along (outside) the southern perimeter fence and connect to the two private farm roads used by local farmers. The proposed western/southern road diversion section will extend across a length of 2.1 km.

An internal access road of some 10 meters wide will be developed along the western perimeter, inside the mine boundary fence from the main security entrance to the ROM stockpile and beyond to the contractor's yard as indicated on Figure 3.1.5.1 (a). This road will carry all traffic entering and leaving the mine including the coal transport trucks to and from the ROM Stockpiles as well as all mine personnel and visitors to the contractor's yard.

A 4 m wide access road will be developed to provide access to dust suppression water bowsers to the Existing Lusthof Northern Surface Water Dam, as well as to the Water Treatment Plant located south of the Contractor's Yard.

3.1.5.1.2 Fencing

During the initial construction phase, a 5 strand barbed wire perimeter fence will be erected around the total perimeter of the mining operations. The extent of the perimeter fence is delineated on Figure 3.1.5.1 (a) and will extend along the inside shoulder of the two road diversions and along the eastern property boundary to the east of the mining operations.

Access to the mine will be controlled by a security gate, located on the western side of the mining area where the entrance road crosses the perimeter fence as shown on Figure 3.1.5.1 (a).

The contractor's yard will be protected by a 400 m long, 1.8 m high security fence along the perimeter of the yard and will be constructed during the initial construction phase. The contractor's yard will be equipped with a single security gate at the south-western corner of the yard, whereby access to the yard can be obtained from the haul roads passing on the southern side of the yard. The location of the contractor's yard (W/S) is shown on Figure 3.1.5.1 (a).

The Water Treatment Plant and its temporary brine storage facility will be fenced with a 1.8 m high security fence along their perimeters and will be constructed during the initial construction phase. Access to these facilities will be through a single security gate at an appropriate location. The locations of these facilities are shown on Figure 3.1.5.1 (a).

3.1.5.1.3 Haul Roads

There are two proposed haul roads entering the pit area. Both haul roads will enter the pit from the south and will progressively extend to the north as mining progresses. The first haul road will access the ROM stockpile on the northern side whereas the second haul road will have access to the ROM stockpile from the southern side.

The haul roads within the mining area will take the form of high wall ramps with an incline angle of 8°.

3.1.5.1.4 Parking Areas

Parking areas will be provided for in the designated areas around the offices for:

- Heavy machines
- Light delivery vehicles
- Cars/Light motor vehicles

3.1.5.1.5 Railway Lines

No railway lines will be constructed in or around the mining operations as rail transport is not a viable option for this project. Also, no existing railway lines need to be taken into consideration during mining operations.

3.1.5.1.6 Power Lines

The existing overhead power line will be diverted to the east of the mining area as indicated on Figure 3.1.5.1 (a). Electricity supply for the Water Treatment Plant and Contractors Yard will be reticulated from this eastern extension of the ESKOM line – see Figure 3.1.5.1 (a). Power supply within the open pit and at the ROM stockpile will either be sourced from the ESKOM supply or else from diesel powered generator sets.

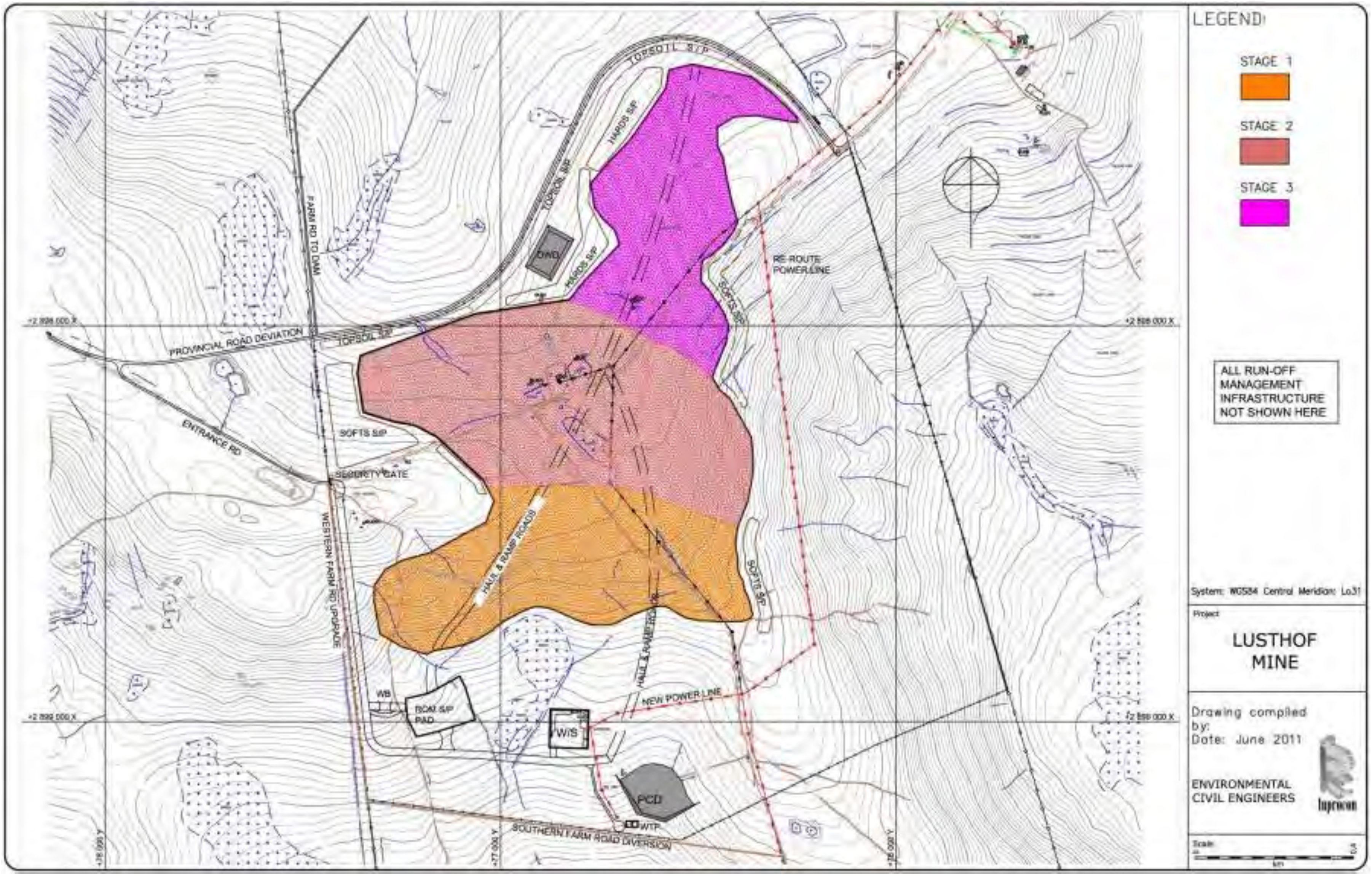


Figure 3.1.5.1 (a): General Infrastructure Layout Plan.

3.1.5.1.7 Pipe Lines

No existing pipe lines cross the reserve area. A series of pipe lines will be constructed to reticulate potable water from the potable supply borehole to the contractor's yard and in the event that mine Water needs to be abstracted from the open pit or spoils, it will be reticulated along a pipe line to the Water Treatment Plant.

3.1.5.1.8 Servitudes

No registered servitudes exist on the two farm portions. However, two gravel roads crosses the mining area and which have to be diverted. Overhead power lines to the local farmers' homesteads also need to be moved. Both the roads as well as the power line will be diverted. The existing and proposed new road and power line alignments are shown on Figure 3.1.5.1 (a).

3.1.5.2 Contractor's Yard

The proposed contractor's yard at Lusthof Colliery covers an area of 1 ha and is located to the south of the mining pit boundary. The infrastructure to be provided in the yard is discussed with reference to the layout of the contractor's yard indicated as Figure 3.1.5.1 (b). Photos of similar surface infrastructure at other collieries have been incorporated into the body of the text, to provide a visual indication of the infrastructure to be expected at Lusthof Colliery.

3.1.5.2.1 Housing

No housing will be provided on site. Personnel will travel to the mine from neighbouring towns and settlements. There will be a maximum of 42 personnel on site at any given time.

3.1.5.2.2 Site Offices

The site offices will be located along the north-eastern perimeter of the contractor's yard. The site offices will be in the form of mobile prefabricated park homes.

Figure 3.1.5.2.2 (a): Typical Site Office in the Contractor's Yard.

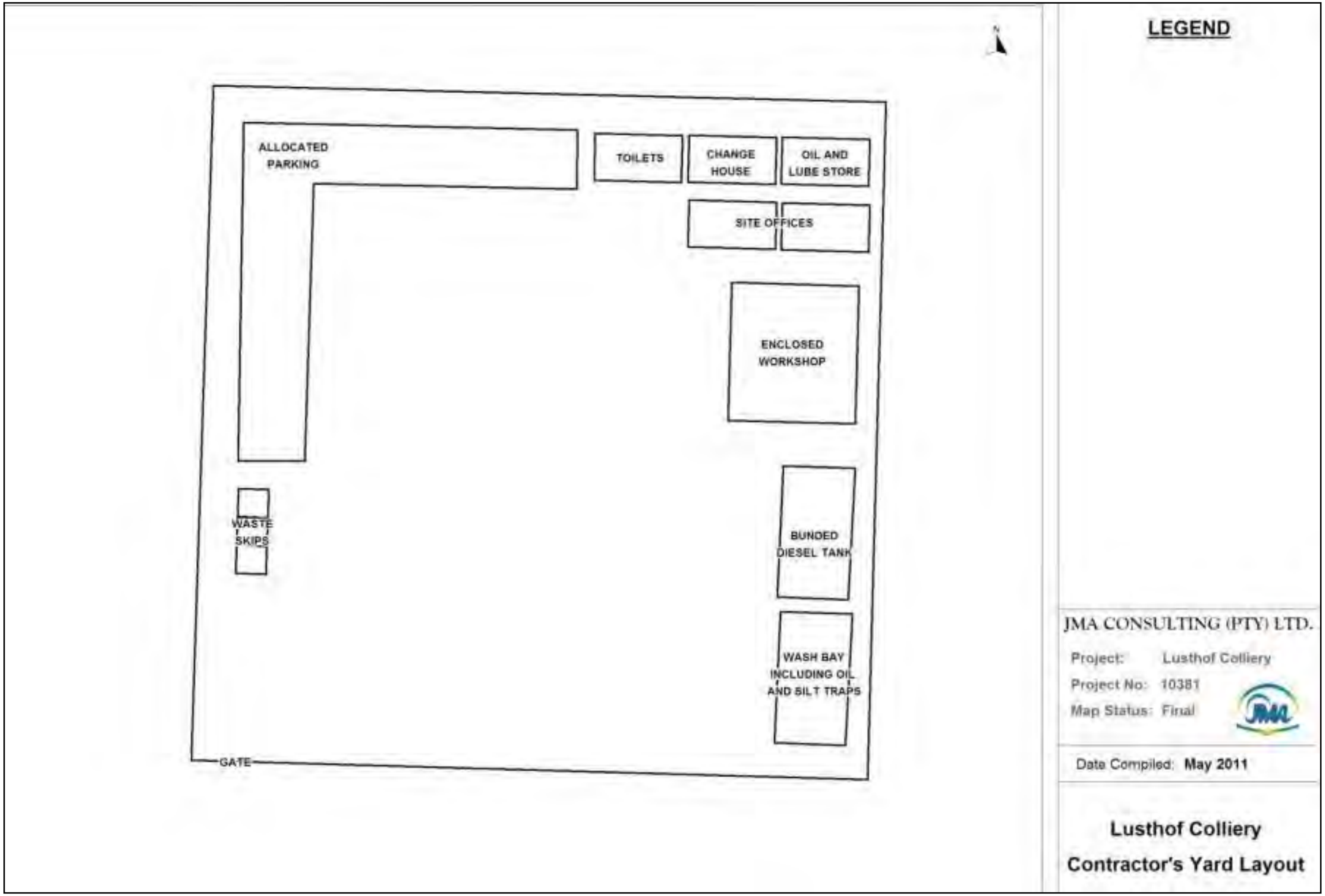


Figure 3.1.5.1 (b): Contractors Yard Layout Plan.

3.1.5.2.3 Oil and Lube Store

An oil and lube store will be provided in the north-eastern corner of the contractor's yard. The store will be located on a concrete slab, will be bunded and equipped with an oil trap/sump.

3.1.5.2.4 Change Houses

One change house will be situated within the contractor's yard. The change house will be a mobile prefabricated park home. Due to the small volume of effluent water from the change house, it will go into a French drain constructed on site.

Figure 3.1.5.2.4 (a): Typical Change House in the Contractor's Yard.

3.1.5.2.5 Toilets

One toilet unit will be erected. It will be a mobile park home sanitation container. The small volume of sewage effluent will go into a French drain.

Figure 3.1.5.2.5 (a): Typical Toilet in the Contractor's Yard.

3.1.5.2.6 Work Shops

There will be one enclosed workshop situated along the eastern perimeter of the contractor’s yard. The workshop will be erected with a 1 meter high brick bund wall at the four sides and a concrete floor. The walls and roof of the workshop will be constructed with corrugated galvanized sheeting.

Figure 3.1.5.2.6 (a): Typical Work Shop in the Contractor’s Yard.

3.1.5.2.7 Fuel Storage

Diesel fuel storage will be provided by a competent supplier. No contract has been awarded to any major fuel supplier to date. The diesel will be stored in 2 x 23000 *l* tanks within a bunded area on a concrete floor with a spillage sump. The diesel storage area is located along the eastern perimeter of the contractor’s yard, adjacent to the wash bay and workshop.

Figure 3.1.5.2.7 (a): Typical Diesel Storage Tank – note the Spillage Bowl.

3.1.5.2.8 Wash Bays

A single wash bay will be provided along the south-eastern perimeter of the contractor's yard. The wash bay will have a concrete floor, will be bunded and will include oil and silt traps to intercept any potential spillages.

3.1.5.2.9 Waste Skips

Two waste skip bins will be provided on the south-western perimeter within the contractor's yard. Each of the bins will be designated to contain a specific waste stream – general waste and hazardous waste. The designated waste streams will thus be disposed of in the appropriate waste skip bins, which will be serviced regularly by an external waste disposal service provider.

Figure 3.1.5.2.9 (a): Typical Waste Skip.

3.1.5.2.10 Parking

Allocated parking areas are demarcated within the contractor's yard. The allocated parking area extends across the western and southern perimeter of the contractor's yard. The vehicles will park directly on the ground surface and no paving is envisaged.

Figure 3.1.5.2.10 (a): Typical Parking Area.

3.1.5.2.11 Explosives Storage

Explosives will be used during the blasting operations which will take place once a week. No explosives magazine will be present on-site. Explosives will be delivered to site for immediate use – bench delivery. A same day charge and blast process will be applied. Designated temporay storge areas will be used according to legal prescriptions. All unused explosive material will be destroyed as per legal requirement. The necessary use and transport permits as required will be acquired by the drilling and blasting company responsible.

3.1.5.2.12 Recreational Facilities

No recreational facilities will be provided at Lusthof Colliery.

3.1.5.2.13 Electrical Substation

A formal electrical substation will not be required at Lusthof. The total power demand for the contractor's yard, the water treatment plant, as well as for borehole pumps to be used for potable water and mine water abstraction, is estimated not to exceed 200 kVA, which can be supplied with overhead power lines to pole mounted transformers. Lighting in the Open Pit and at the ROM Stockpile will be provided with diesel powered generator sets.

3.1.5.3 Mining Infrastructure

3.1.5.3.1 Open Pit Perimeter(s)

The total mining area at Lusthof Colliery extends across an area of some 82 *ha*. The extent of the pit boundary overlays a watershed in the upper reaches of quaternary W55A and is delineated on Figure 3.1.5.1 (a). The coal will be mined using the standard box cut roll over method. Mining will begin in the south and progress in a northerly direction.

The actual delineation of the open pit perimeter was determined through an iterative mine planning process during which optimization of the operational phase and post closure phase mine water management, was used as the main design criterion.

It should be mentioned that the available coal reserve that could be mined at Lusthof is some 97 *ha* but in support of the mine water management plan, the pit extent was truncated to a surface elevation of 1770 mamsl, which resulted in the 82 *ha* open pit. This implies a 15% sacrifice in coal reserve in support of effective mine water management.

3.1.5.3.2 Haul Roads

The haul roads will enter the pit from the south and will gradually extend to the north as mining progresses in a northerly direction. Two haul roads will initially enter the pit in the south in order to optimize the removal of coal during the mining operations. The two haul roads will connect in the centre of the pit and will continue to progressively extend towards the north.

The original mine design provided for the mining to commence in the north (shallowest coal) and progress towards the south. However, in order to optimize operational phase in-pit mine water management, the mining sequence was reversed to now commence in the south, thereby providing in-pit storage capacity for affected mine water right from the outset of mining.

The haul roads will culminate at the run of mine (ROM) stockpile in the south and the final blocks to be mined in the northern section of the mining area.

3.1.5.3.3 Sequential Open Cast Mining Plan

Mining will take place in the form of a standard open cast box cut roll over method, starting in the south and progressively extending in a northerly direction. The mining rate is expected to fluctuate between 50 000 and 60 000 t/month. The expected life of mine thus estimated to be 8 years. The most recent planned mining schedule is shown on Figures 3.1.5.3.3 (a) and 3.1.5.3.3 (b) respectively. The mining operation is classified as small, with no deviation from the opencast pit perimeter boundary. The mining operations will run 24 hours a day, for a 5.5 days a week. There will be two 10.5 hour shifts a day, with 1.5 hours allocated to the change of shifts. There will be a maximum of 42 personnel on site at any given time per shift during the operation of the mine.

Figure 3.1.5.3.3 (a): Sequential Open Cast Mining Block Plan.

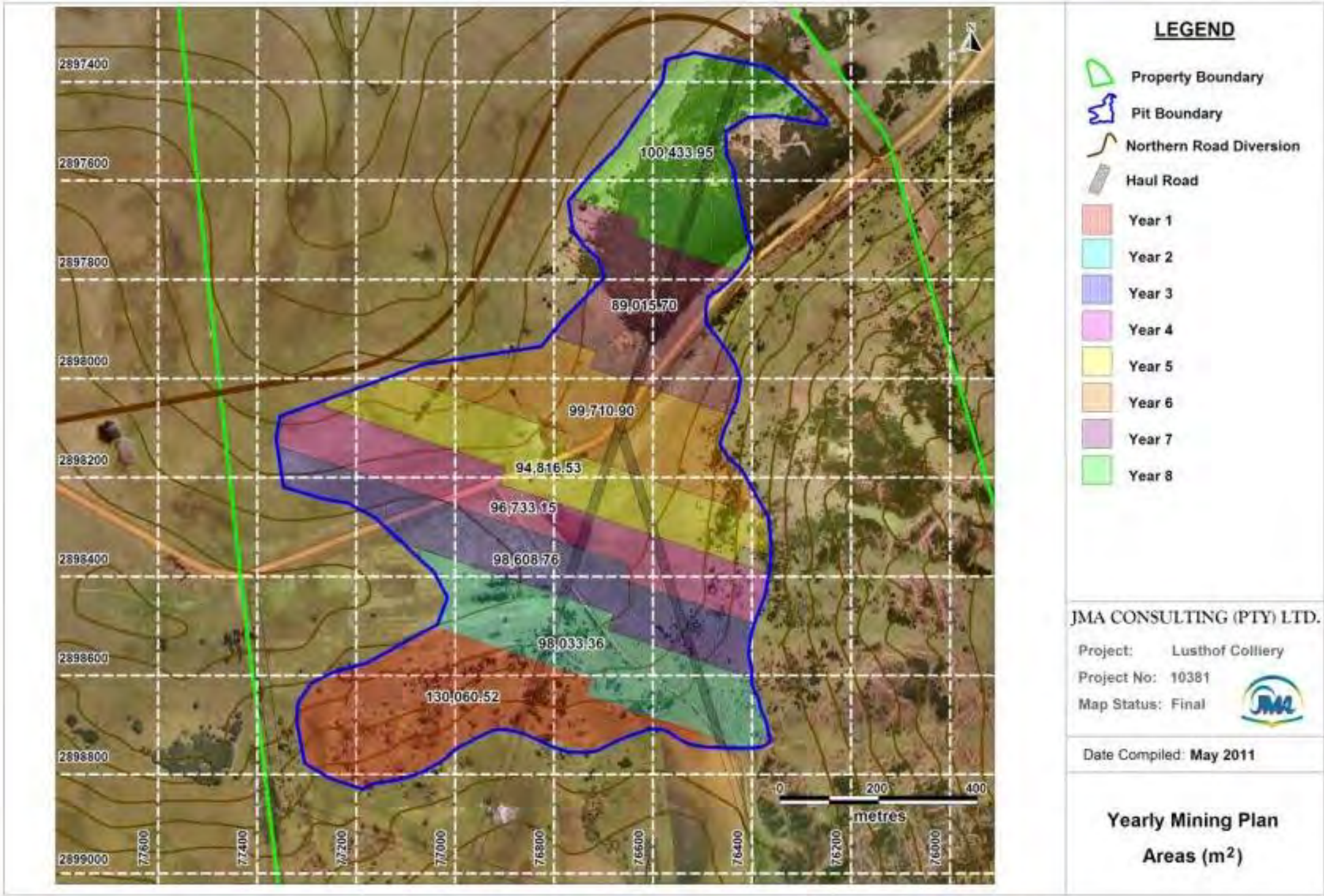


Figure 3.1.5.3.3 (b): Sequential Open Cast Mining Annual Progress Plan.

3.1.5.4 Mineral Processing Plant

No mineral processing (crushing, screening or washing) will take place at Lusthof Colliery. The ROM coal will be transported by road to the existing wash plant at BGCE's East Side Colliery just outside Carolina.

3.1.5.5 Run of Mine (ROM) Stockpile

The ROM stockpile (maximum volume of 25 000 tons) will be placed to the south of the pit boundary with access from both haul roads. The ROM stockpile will be located more than 120 m from the marshy area to the east as delineated on the topographical maps – see Figure 3.1.5.1 (a) for the ROM Stockpile locality.

The ROM stockpile will be placed on an engineered platform with a drainage channel on its perimeter to isolate the stockpile area and capture all surface water run-off and discharge it via an open lined drain and silt trap into the Pollution Control Dam. The platform will also be designed to minimize the potential for seepage of water into the sub-surface. A dirty storm water diversion berm/drain will be constructed along the lower side of the haul road on the northern side of the ROM stockpile platform in order to isolate and divert contaminated upslope surface water generated from the haul road and mining area into the perimeter drain of the ROM stockpile.

The coal that is mined from the pit will be hauled and deposited by means of articulated dump (haul) trucks on the ROM stockpile via the northern and southern entrances of the two haul roads. A truck loading the coal will enter the stockpile from the south and leave via the weighbridge on the west. Once the truck has been loaded with the allocated tonnage of coal, a tarpaulin will be fitted to cover the coal and to prevent dust losses or spillages during transport. All loaded trucks leaving the site will be fitted with tarpaulins.

Figure 3.1.5.5 (a): Typical ROM Stockpile – note the sequential operation as well as the water management berms.

3.1.5.5.1 Conceptual Civil Design of ROM Stockpile Platform

A conceptual civil design was performed for the ROM Stockpile Area. The design was influenced by the requirements for the surface/storm water manage system, as well as by the outcome of the ground water impact assessment related to possible contamination of the underlying ground water system as a result of possible AMD generation and subsequent infiltration into the sub-surface.

From a surface water management perspective the entire ROM Stockpile Area is deemed as a dirty water area.

The ground water impact assessment indicated that provided that the effective roll over protocol of the coal footprint areas on the ROM Stockpile platform is adhered to, a footprint permeability design specification of 1×10^{-6} cm/sec will be adequate to protect the sub-surface from being contaminated.

The conceptual civil design for the ROM Stockpile Platform and its associated water management features, is discussed together with the designs for the other surface water management infrastructure in section 3.1.5.13.10 of this report.

3.1.5.6 Overburden Stockpiles

Overburden will be classified as soft overburden and hard overburden and will comprise siltstone, shale and sandstone. The soft overburden contain negligible percentages of carbonaceous material whilst the hard overburden has been verified to contain between 0.1 % and 0.25 % S, which in terms of EPA Standards are considered as **moderate to non acid forming**.

Provision has been made for the placement of the overburden along the western and north-western perimeter of the pit boundary during the initial stage of mining operations as indicated on Figure 3.1.5.1 (a). Additional areas for the stockpiling of soft materials are provided adjacent to the pit perimeter on the eastern side. The overburden is stockpiled as close as possible to where it will be required for the final backfill and rehabilitation of the open pit.

Geochemical assessment of the Lusthof overburden material indicated the hard material to be **moderate to non acid generating** and when considered in conjunction with factors such as resident times and limited saturation profiles, are deemed not to require protective lining systems for their footprints – see Geology Specialist Report .

Provision is made for total soft overburden stockpiling of 25 000 m^3 and hard overburden stockpiling of 30 000 m^3 with a maximum stacking height of 4 m. The volumes have been determined from the detailed materials balance as based on the mining plan and as detailed in the Geology Specialist Report.

Figure 3.1.5.6 (a): Typical Overburden Stockpile – note the low carbonaceous content.

3.1.5.7 Soil Stockpiles

Soil from stripping the initial box cut will be used for the construction of a 2.5 m high berm adjacent to the northern road diversion. The berm will aid the overall storm water management system of the mine and will also act as a perimeter barrier for dust control, noise abatement and visual impact management.

Sufficient drainage structures will be provided at local low points along the soil stockpile to allow clean surface water run-off to pass through into the natural environment.

The soil stockpiles will be planted with grass as well. Any remaining soil will be stockpiled adjacent to the hard and soft stockpiles to the north-west of the pit boundary. Soils are inert and don't require lined footprints during storage.

The soil stockpiles at Lusthof will not be as high as the one shown in Figure 3.1.5.7 (a) below. A decision has been taken to restrict soil stockpiling at Lusthof to a height of 2.5 m in order to optimize soil fertility preservation.

Figure 3.1.5.7 (a): Typical re-vegetated Soil Stockpile.

3.1.5.8 Spoils Piles

The selected method of mining is that of continuous opencast roll-over, so apart from the soft and hard stock piles from the initial box cut, no additional out-of-pit spoiling will take place. All spoils will thus be retained within the open pit as mining progresses.

Additional areas for the stockpiling of soft materials are provided adjacent to the pit perimeter on the eastern side. Additional areas for the stockpiling of soft materials are provided adjacent to the pit perimeter on the eastern side.

3.1.5.9 Water Supply System

Water supply at Lusthof Colliery relates to the following components:

- Potable water supply for the Contractors Yard – offices, change house, toilets, wash bay.
- Clean water supply for dust suppression on gravel roads outside dirty areas – access roads to mine and haul roads outside open pit.
- Dirty water supply for in-pit dust suppression on haul roads.

As no coal washing will occur at Lusthof, no process water is required.

3.1.5.9.1 Potable Water Supply and Storage at Contractors Yard

Potable Water Demand

The potable water demand for the uses identified above was calculated based on the presence of 42 people per 24 hour cycle, each using 100 *l/day*, which comes to 4 200 *l/day*, as well as an estimated demand of 5 000 *l/day* for the wash bay. The total daily potable water demand is rounded to 10 000 *l/day*.

Potable Water Source

Potable water will be sourced from a single borehole. The required yield for such a borehole if operated over a 10 *hour/day* period, is only 0.28 *l/s*. The borehole drilling performed for the ground water study at Lusthof has confirmed the availability of ground water for this purpose. The quality of ground water in the area has been confirmed to be complaint with the SANS 241:2006 Drinking Water Standard. The borehole will be sited to be in close proximity to the contractor's yard and power supply and will be equipped with a small submersible pump.

Potable Water Storage

The borehole will be reticulated to discharge into a 10 000 *l* JoJo type plastic tank located within the contractor's yard, from where the water will be reticulated via black PVC pipes to the various points of use.

3.1.5.9.2 Clean Water Supply for Dust Suppression

Clean Water Demand

The clean water demand has been calculated based on the length and width of gravel roads in clean areas that require dust suppression. Provision is made for continuous daily dust suppression with two bowsers, each with a water capacity of 12 000 *l*. Each truck will complete three trips per day during daylight hours only, implying a total available dust suppression capacity of 72 m^3/day.

The maximum number of coal trucks per hour past any given point along the access route will be 4/*hour*. This low traffic volume will require the minimum dust suppression and therefore a dosage of 1 *mm* of water per cycle is applicable. The water requirement for the clean gravel roads to be dust suppressed calculates to 61 m^3/day or 16 775 $m^3/year$ for 275 dust suppression days. This volume can effectively be deposited with the two water bowsers.

Clean Water Source

Four potential sources exist for the clean water demand of 16 775 $m^3/year$:

- Proposed new Lusthof Colliery Clean Water Dam in the mine area – see section 3.1.5.10 for a discussion of this dam – its estimated annual yielding capacity was calculated as 6 500 $m^3/year$. This volume would supply 38% of the required dust suppression demand.
- Existing Lusthof Northern Surface Water Dam on Lusthof Portion 6 - its estimated annual yielding capacity was calculated as 144 200 $m^3/year$ which is more than sufficient to supply the dust suppression demand.
- Ground water from boreholes – an estimated 10 000 *l/day* (10 m^3/day) can be sourced per individual borehole – 6 boreholes would be required.
- Treated mine water from the proposed Mine Water Treatment Plant – see section 3.1.5.11.2 – the estimated capacity of the plant is 300 m^3/day = more than sufficient to supply the dust suppression demand.

The preferred source for the construction phase clean dust suppression water is the Existing Lusthof Northern Surface Water Dam.

The preferred source for the operational phase clean dust suppression water is initially also the Existing Lusthof Northern Surface Water Dam until Water Treatment plant comes into operation.

Clean Water Storage

Clean water for dust suppression can be stored in the two surface water dams.

- The proposed Lusthof Colliery Clean Water Diversion Pond has a storage capacity of 4 000 m^3 Dam has a capacity of 8 000 m^3.
- The existing Lusthof Colliery Northern Surface Water Dam has a current storage capacity of 33 750 m^3.

Should borehole water or water treatment plant water be used to augment the natural clean water supply for dust suppression, it will be pumped directly from these sources into suitably designed storage vessels that can be used to fill the water bowsers under gravitation. A typical setup would be 6 * 5000 *l* JoJo tanks on 4 *m* high tank stands with two valve controlled discharge points into the water bowsers.

3.1.5.9.3 Dirty Water Supply for Dust Suppression

Dirty Water Demand

The mine water demand for in-pit dust suppression has been calculated based on the length of in-pit haul roads and the surface areas of possible dust generating surfaces within the open pit. Provision is made for continuous daily dust suppression with one bowser with a water capacity of 12 000 *l*.

The truck will complete three trips per day during daylight hours only, implying a total available dust suppression capacity of 36 m^3/day.

The haulage activities in the pit will require the minimum dust suppression and therefore a dosage of 1 *mm* of water per cycle is applicable. The water requirement for the in-pit haul roads to be dust suppressed calculates to 30 m^3/day or 8 250 $m^3/year$ for 275 dust suppression days. This volume can effectively be deposited with the one water bowser.

Dirty Water Source

Four sources exist for dirty water for in-pit dust suppression.

- The first most obvious source for dirty water is the rain water accruing to the current active cut.
- The second most obvious source for dirty water is the actual mine water make from rainfall and ground water seepage into the pit and stored in the mined out sections. A detailed water balance has been compiled for this component – see section 3.1.5.15 for details on the mine/ground water balance. It is quite

obvious that this source will be more than capable to supply in the dirty water dust suppression demand.

- The third potential source is the proposed Dirty Water Dam located to the north of the pit.
- The fourth potential source is the proposed Pollution Control Dam located to the south of the pit.

The preferred source for in-pit dust suppression is the water contained in the PCD. The water used for dust suppression from this dam makes a big difference to the evaporation capacity required from the PCD which means that the size of the dam can be limited.

<u>Dirty Water Storage</u>

The dirty water used for in-pit dust suppression will be stored within the Storm Water PCD. The bowser will be filled with a pump powered by a diesel generator set.

3.1.5.10 Water Management Systems

Water management at Lusthof Colliery comprises the following two components:

- Storm water management
- Mine water & ground water management – storm water and ground water accruing to the open pit

The overall water management system for Lusthof Colliery was designed to give full compliance with the requirements of GN 704 as it applies to water management at mines. Designs for infrastructure and calculations for water and salt balances were conducted in accordance with the DWA Guidelines for Water Management at Mines.

3.1.5.11 Storm Water Management System

The provision of storm water management infrastructure will be a continuous operation that will be implemented mainly during the construction phase and then in three incremental stages as the mining operations progress. The details of the water management infrastructure are discussed with reference to Figures 3.1.5.11 (a), 3.1.5.11 (b) and 3.1.5.11 (c) and will cater for the following components:

- Separation of clean water and dirty water. Because the mining area straddles a watershed, the construction of a number of localized earth berms at selected areas near to the mining perimeter will ensure that all water outside of the berms can be diverted as clean water run-off around the mine. All water falling into the open pit, as well as water falling in the sub-catchment areas between the pit perimeter and the earth berms and along the external haul roads will be considered as dirty water. The area that might be contaminated by the operations of the mine has been minimised by implementing surface water control infrastructure continuously in three stages of mining development and by placing potential pollution sources, including haul roads, in the area south of the opencast mine.

- The generation of dirty surface water will be minimised by implementing surface water control infrastructure during the construction phase and thereafter continuously in three stages of mining development and by placing potential pollution sources, including haul roads, in a concentrated area south of the opencast mine.

- All dirty surface water is to be captured, contained and treated before it can be either re-used or released back into the environment. No dirty surface water will be allowed to progress beyond the isolating or diversion berms or the extent of the rehabilitated mine spoils.

- All water classified as dirty water will be contained either in the pit spoils as in pit-storage or in suitably-sized dirty water or pollution control dams which will be lined and sized according to DWA guidelines. A dedicated Pollution Control Dam will be provided on the southern side of the mine for the storage of dirty water run-off. The PCD will be provided with a suitable liner system. Provision has been made for the in-pit storage and the volumes have been calculated on a quarterly basis. The environmentally safe volume of water that can be stored within the spoils is calculated to be 604 084 m^3. A Dirty Water Dam, which will only be lined if water quality requirements indicate a liner, will be provided for the northern catchment to capture possible contaminated surface water which may be generated from the overburden stockpiles – mainly silt and possibly low salinity water.

- Clean surface water run-off will be maximised by diverting surface run-off past the mining area on the western boundary of the mine and through the area between the ROM stockpile and Contractor's yard.

3.1.5.11.1 Bunds, Berms, Canals and Outlets

As indicated previously, the mining area will be isolated by a series of berms and/or drainage canals to prevent surface water inflows into the mining area and outflows into the natural environment. All clean water and dirty water will be separated by means of diversion berms, drainage canals, bund walls and culverts, where applicable.

The storm water management infrastructure will be implemented in four distinct stages, the first during the construction phase and then during the operational phase to ensure containment of polluted water and the optimal release of clean surface water into the receiving water bodies.

All rainwater and seepage emanating from inside the mining area will be treated as polluted water and contained in the pit area below the decant level as discussed in previous sections. Rainwater falling on the southern areas where the haul roads, ROM stockpile and Contractor's Yard are located will be intercepted by diversion berms, channels and bund walls and routed to the Pollution Control Dam (PCD) via lined drainage canals and a silt trap to the west of the dam.

Clean surface water emanating from rainfall in the saddle area to the west of the mining area will be diverted via berms and a Clean Water Diversion Pond and discharged into the environment via a culvert on the western side.

The marshy area between the ROM stockpile and the Contractor's yard will be isolated by a berm along the perimeter of the mining area to prevent inflow of contaminated water. All surface water falling in this area will be clean and routed through the marshy area via a culvert underneath the haul road into the natural environment. The catchment area of the PCD will be minimised by the provision of diversion berms on the upslope side of the dam. As the mining operations develop and rehabilitation has been completed more clean water will be routed through the marshy area as indicated for stages 2 and 3 (Figure 3.1.5.11 (b) and Figure 3.1.5.11 (c) respectively). During the mining operations isolating or diversion berms will be placed on a continuous basis on the northern side of operations in order to divert clean surface water either to the west or east into the natural environment as shown in Figure 3.1.5.11 (a).

Clean surface water will be allowed to drain into the natural environment through two low level culverts installed underneath the topsoil stockpile along the road diversion and culverts underneath the haul roads on the western and southern sides of the site.

A Dirty Water Dam and appropriate diversion berms will be constructed on the northern side of the watershed, adjacent to the soft material stockpiles, to intercept and store dirty water emanating from these stockpiles during the construction phase. Clean surface water will be allowed to drain into the natural environment through two low level culverts installed underneath the topsoil stockpile along the road diversion.

As the mine develops, a storm water diversion/isolating berm will be provided along the eastern perimeter of the mining area on a continuous basis to prevent the outflow of dirty water from the mining area as shown in Figure 3.1.5.11 (b) and Figure 3.1.5.11 (c). All rainfall falling on the eastern side of this berm will be clean water and allowed to flow into the natural environment. The diversion berm will be removed where required or culverts installed to allow clean water passage as the rehabilitation from the southern side progresses towards the final cut.

3.1.5.11.2 Clean Water Diversion Pond (CWDP)

Clean surface water emanating from rainfall in the saddle area to the west of the mining area will be diverted via berms and a Clean Water Diversion Pond past the mine on the western side and by means of a storm water diversion berm on the northern side of the advancing pit area. The estimated storage capacity of the CWDP is about 4 000 m^3. The mean annual run-off generated in the catchment area of the CWDP is about 6 500 m^3 of which most will be used for dust suppression. Excess run-off will be released into the natural environment.

3.1.5.11.3 Dirty Water Dam (DWD)

The Dirty Water Dam located in the northern catchment as shown in Figure 3.1.5.11 (b) will be required during Stage 1 to intercept and capture possible contaminated surface water which may be generated from the overburden stockpiles – mainly silt and possibly low salinity water. The dam will only be lined if water quality tests indicate that a liner will be required. The size of the dam will be optimized subject to the water balance calculations and will be discussed in the conceptual design.

3.1.5.11.4 Pollution Control Dam (PCD)

A Pollution Control Dam will be required in the southern catchment for the control of contaminated surface and mine water during the operation of the mine. The Pollution Control Dam at Lusthof Colliery will be situated to the south of the pit boundary, as indicated on Figure 3.1.5.11 (a). The dam wall will be lined and sized for optimal storage and evaporation of dirty water. Dirty water from the haul roads and ROM stockpile will first flow through a silt trap before being discharged into the PCD. The silt trap will have two compartments to allow for cleaning out of one compartment while the other is in operation.

Allowance will be made in the PCD for the storage of dirty mine water generated during the first year of operations and contaminated flows from the washing bay. The storage volume of the pollution control dam and its surface area will be optimized based on the water balance for average monthly rainfall and evaporation conditions as will be determined in the conceptual design.

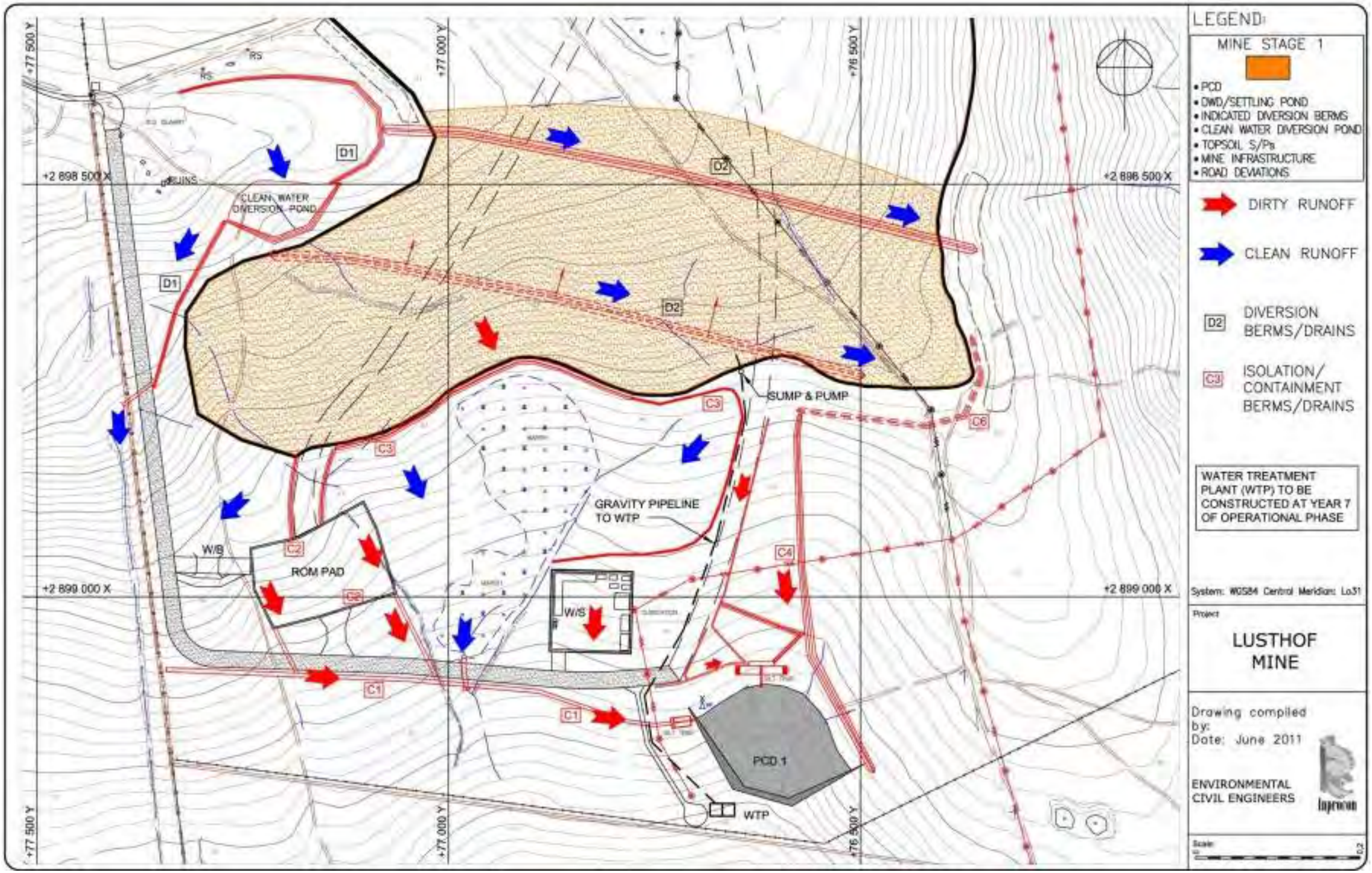


Figure 3.1.5.11 (a): Storm Water Management Infrastructure – Construction and Operational Phase Stage 1.

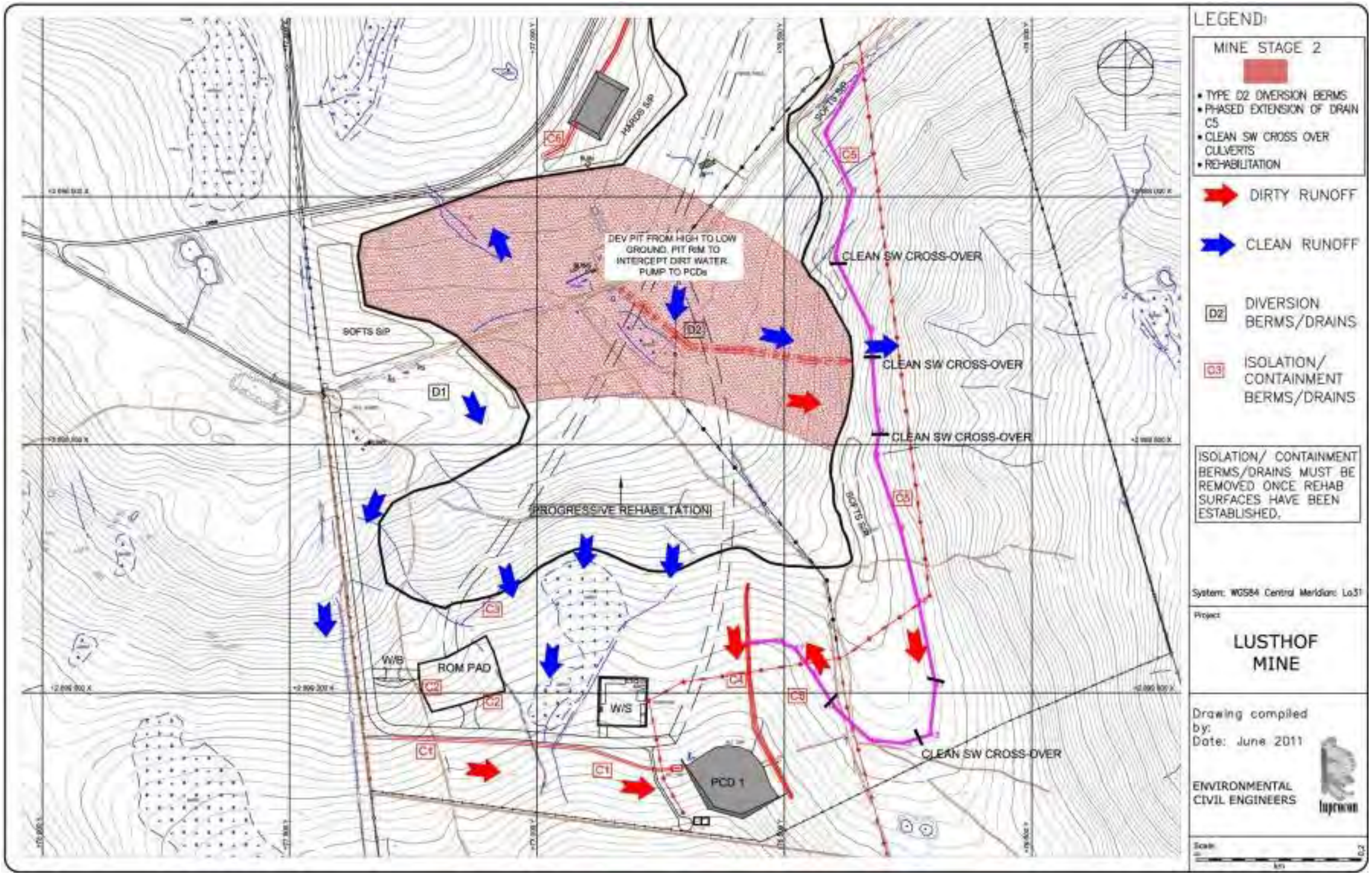


Figure 3.1.5.11 (b): Storm Water Management Infrastructure – Operational Phase Stage 2.

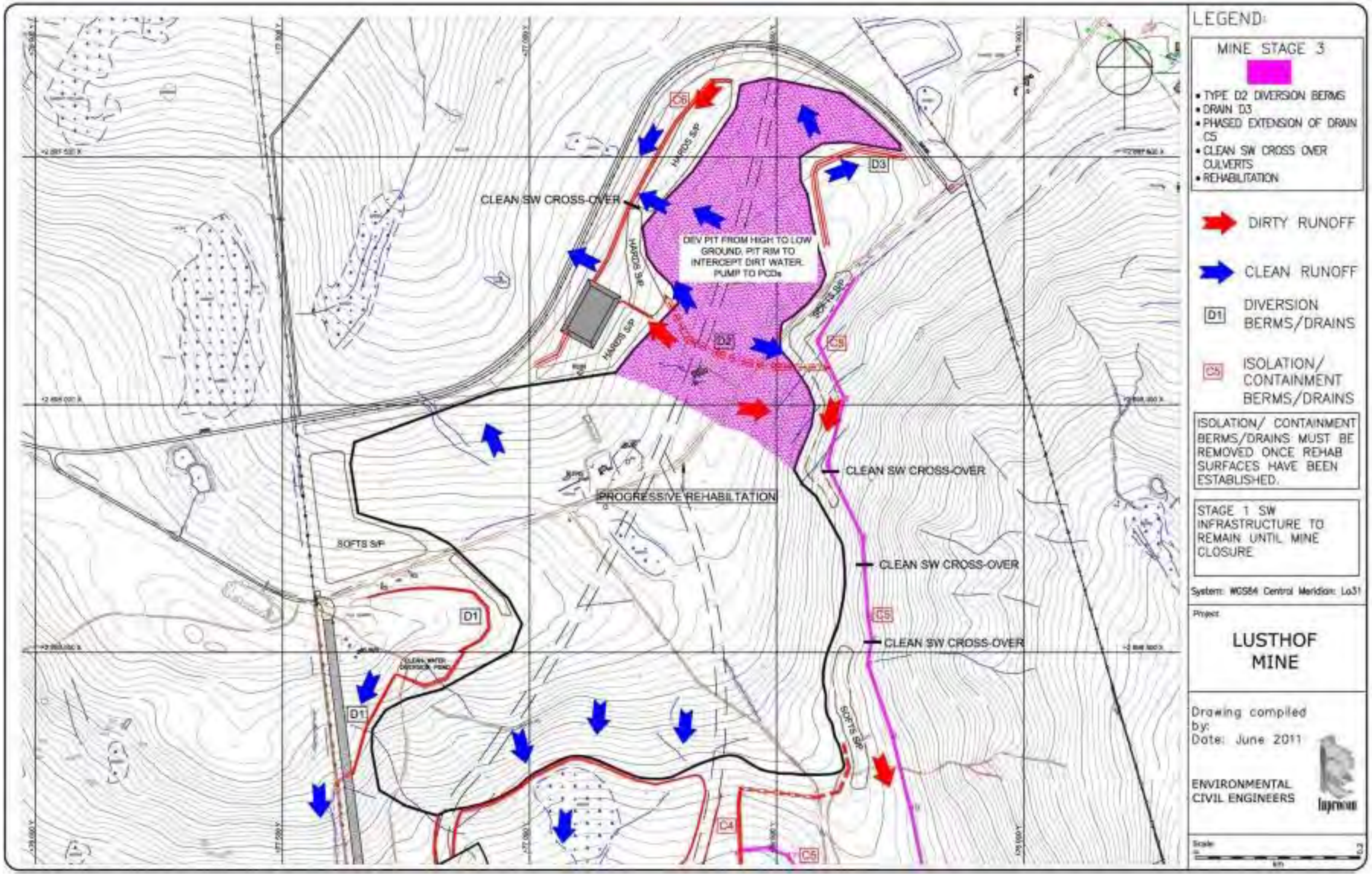


Figure 3.1.5.11 (c): Water Management Infrastructure – Operational Phase Stage 3.

3.1.5.12 Surface/Storm Water Balance

In order to provide the required design inputs for the conceptual design of the storm/surface water management systems, detailed surface/storm water balance calculations were performed for the sizing of the dirty water storage dams and also the Lusthof Colliery Mining area for both the operational and post closure phases. The water balances for the dams are discussed in this section while the water balances for the whole mining area, including flow diagrams, are discussed in section 3.1.5.18 of the report.

3.1.5.12.1 Water Balance for the Pollution Control Dam (PCD)

The following areas generating dirty water need to be catered for when sizing the Pollution Control Dam:

- The upslope area not part of the mining area = 21.2 *ha*
- The Contractor's Yard = 1.00 *ha*
- The ROM stockpile platform = 1.44 *ha*
- The disturbed portion of mining area during construction = 5.00 *ha*
- The disturbed portion of mining area during operations = 20.0 *ha*

In addition to the rainfall run-off a further 5 m^3/day from the washing bay and 15 000 m^3 (82 m^3/day) for the first and fourth quarters (6 months worst case scenario) of mining operations need to be provided for. It is expected that the initial surface water storage in the PCD will be clean and could be used as clean water for dust suppression for at least the first quarter of operations or it can be released into the natural environment in a controlled manner. Releases from the PCD will only be possible during the construction phase (maximum 6 months) and will not exceed 30 m^3/day if dust suppression of 24 m^3/day is applied or 54 m^3/day if no dust suppression is applied.

Dust suppression on the external hauls roads for two applications of 1 mm each in the mornings and mid-afternoons with clean water will be about 24 m^3/day during the construction phase. However, during the operational phase all water in the PCD will be considered dirty and dust suppression of 30 m^3/day from the PCD can be applied on the in-pit haul roads.

The water balances for the PCD during the construction and operational (with and without dust suppression) phases are shown in Tables 3.1.5.12.1 (a), 3.1.5.12.1 (b) and 3.1.5.12.1 (c) respectively. From the calculation results it is clear that a minimum storage volume of 23 800 m^3 is required during the construction phase and 34 600 m^3 six months later during the operational phase.

The PCD will be redundant after the closure of the mine and will not be required for the storage or evaporation of surface water run-off. This is confirmed by the post closure water balance shown in Table 3.1.5.12.1 (d)

TABLE 1: Lusthof Opencast PCD: Construction Phase Water Balance

Lusthof: Run-Off Volumes m^3 per month

Dam Evaporation Area (m^2) — Calculated: 12800

MAP= 776 mm	In spoils area m^2	0	Upslope Area m^2	262000	Run-off Factor 8%
Symons pan MAE = 1583 mm	In Spoils Evap Factor	0.2	ROM Area m^2	14400	20%
			Contractor's yard m^2	10000	30%

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
(days)		31	30	31	31	28	31	30	31	30	31	31	30	365
Symons pan(%MAE)		9.79	10.19	10.91	10.98	9.39	9.09	7.07	5.88	4.94	5.54	7.15	9.07	100
Symons pan (mm)		155	161	173	174	149	144	112	93	78	88	113	144	1583
pan factor		0.81	0.82	0.83	0.84	0.88	0.88	0.88	0.87	0.85	0.83	0.81	0.81	0.84
Gross Lake Evapor.(mm)		**126**	**132**	**143**	**146**	**131**	**127**	**98**	**81**	**66**	**73**	**92**	**116**	**1331**
Rainfall (% MAP)		10.08	15.62	15.77	17.74	13.4	11.79	6.42	2.73	1.16	1.05	1.00	3.24	100
Ave Rainfall (mm)		78.2	121.2	122.4	137.7	104.0	91.5	49.8	21.2	9.0	8.1	7.8	25.1	776

Interception Dam [Inflow-Outflow = Delta Storage]

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Inflow (m3)		**3256**	**4955**	**5006**	**5612**	**4262**	**3782**	**2125**	**995**	**507**	**478**	**463**	**1147**	**32586**
Direct Rain		1001	1552	1566	1762	1231	1171	638	271	115	104	99	322	9933
Monthly upslope run-off		1640	2541	2565	2885	2180	1918	1044	444	189	171	163	527	16265
Washing bay (m^3/day)	5	155	150	155	155	140	155	150	155	150	155	155	150	1825
ROM & Contractor's yard		460	713	720	809	611	538	293	125	53	48	46	148	4563
From in-pit stripped area	82	2542	2460	2542	2542	2296	2542	0	0	0	0	0	0	14924
Outflow (m3)		**3281**	**3313**	**3509**	**3543**	**3186**	**3295**	**1981**	**1781**	**1571**	**1676**	**1917**	**2209**	**31261**
Total Evaporation		1607	1693	1835	1869	1674	1621	1261	1037	851	932	1173	1489	17041
Outflow discharge (m^3/day)	30	930	900	930	930	840	930	0	0	0	0	0	0	5460
Export ROM 2000t/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dust Suppression (m3/day)	24	744	720	744	744	672	744	720	744	720	744	744	720	8760
Inflow-Outflow (m3)		(25)	1642	1497	2069	1076	487	144	(786)	(1064)	(1198)	(1455)	(1062)	1325
Delta Storage		0	1642	3139	5208	6284	6770	6915	6129	5065	3867	2412	1350	
Maximum month end capacity (m3)		8265												
		1350	2992	4489	6558	7634	8121	8265	7479	6415	5217	3762	2700	

1 in 50 Year 24 hour storm event:

1:50 Year storm (mm)	122
Direct Rain (m3)	1561.6
1:50 volume (m3)	13976
Storm capacity required (m3)	15538

Run-off factor estimated: 0.4

Capacity required for interception	23803 m^3

Inprocon

Table 3.1.5.12.1 (a): Construction Phase Water Balance for PCD.

TABLE 2: Lusthof Opencast PCD: Operational Phase Water Balance

Lusthof: Run-Off Volumes m³ per month

Dam Evaporation Area (m²)								Calculated		12800				
					In spoils area m²		0	Upslope Area m²		412000		Run-off Factor		8%
MAP=	776	mm			In Spoils Evap Factor		0.2	ROM Area m²		14400				20%
Symons pan MAE =	1583	mm						Contractor's yard m²		10000				30%
		31	30	31	31	28	31	30	31	30	31	31	30	365
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Symons pan(%MAE)		9.79	10.19	10.91	10.98	9.39	9.09	7.07	5.88	4.94	5.54	7.15	9.07	100
Symons pan (mm)		155	161	173	174	149	144	112	93	78	88	113	144	1583
pan factor		0.81	0.82	0.83	0.84	0.88	0.88	0.88	0.87	0.85	0.83	0.81	0.81	0.84
Gross Lake Evapor.(mm)		**126**	**132**	**143**	**146**	**131**	**127**	**98**	**81**	**66**	**73**	**92**	**116**	**1331**
Rainfall (% MAP)		11.92	16.94	16.74	16.33	12.32	9.76	6.23	1.87	1.08	0.80	1.59	4.41	100
Ave Rainfall (mm)		92.5	131.4	129.9	126.7	95.6	75.7	48.4	14.5	8.4	6.2	12.4	34.2	776
Interception Dam		[Inflow-Outflow = Delta Storage]												
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Inflow (m3)		**4932**	**6938**	**6863**	**6696**	**5078**	**4066**	**2647**	**903**	**583**	**474**	**793**	**1917**	**41890**
Direct Rain		1184	1682	1663	1621	1224	969	619	185	107	79	158	438	9931
Monthly upslope run-off		3049	4332	4281	4175	3152	2496	1594	477	276	203	407	1128	25572
Washing bay (m³/day)	5	155	150	155	155	140	155	150	155	150	155	155	150	1825
ROM & Contractor's yard		544	773	764	745	562	445	284	85	49	36	73	201	4562
Outflow (m3)		**3777**	**3793**	**4005**	**4039**	**3634**	**3791**	**3361**	**3207**	**2951**	**3102**	**3343**	**3589**	**42591**
Total Evaporation		1607	1693	1835	1869	1674	1621	1261	1037	851	932	1173	1489	17041
Seepage	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Export ROM 2000t/d	0.02	1240	1200	1240	1240	1120	1240	1200	1240	1200	1240	1240	1200	14600
Dust Suppression (m3/day)	30	930	900	930	930	840	930	900	930	900	930	930	900	10950
Inflow-Outflow (m3)		1156	3145	2858	2657	1444	275	(713)	(2304)	(2368)	(2628)	(2550)	(1671)	(701)
Delta Storage		1156	4300	7158	9816	11259	11534	10821	8517	6149	3521	971	0	
Maximum month end capacity (m3)		**11534**												
		1156	4300	7158	9816	11259	11534	10821	8517	6149	3521	971	(701)	

1 in 50 Year 24 hour storm event:

1:50 Year storm (mm)	122		
Direct Rain (m3)	1561.6		
1:50 volume (m3)	21296	Run-off factor estimated:	0.4
Storm capacity required (m3)	**22858**		
Capacity required for Interception	**34392** m³		

Inprocon

Table 3.1.5.12.1 (b): Operational Phase Water Balance for PCD – with Dust Suppression.

TABLE 2A: Lusthof Opencast PCD: Operational Phase Water Balance - no dust suppression

Lusthof: Run-Off Volumes m³ per month

Dam Evaporation Area (m²)				Calculated	32000	
		In spoils area m²	0	Upslope Area m²	412000	Run-off Factor 6%
MAP=	776 mm	In Spoils Evap Factor	0.2	ROM Area m²	14400	20%
Symons pan MAE =	1583 mm			Contractor's yard m²	10000	30%

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
(days)		31	30	31	31	28	31	30	31	30	31	31	30	365
Symons pan(%MAE)		9.79	10.19	10.91	10.98	9.39	9.09	7.07	5.88	4.94	5.54	7.15	9.07	100
Symons pan (mm)		155	161	173	174	149	144	112	93	78	88	113	144	1583
pan factor		0.81	0.82	0.83	0.84	0.88	0.88	0.88	0.87	0.85	0.83	0.81	0.81	0.84
Gross Lake Evapor.(mm)		**126**	**132**	**143**	**146**	**131**	**127**	**98**	**81**	**66**	**73**	**92**	**116**	**1331**
Rainfall (% MAP)		11.92	16.94	16.74	16.33	12.32	9.76	6.23	1.87	1.08	0.80	1.59	4.41	100
Ave Rainfall (mm)		92.5	131.4	129.9	126.7	95.6	75.7	48.4	14.5	8.4	6.2	12.4	34.2	776

Interception Dam [Inflow-Outflow = Delta Storage]

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Inflow (m3)		**6709**	**9461**	**9357**	**9128**	**6914**	**5520**	**3576**	**1181**	**744**	**592**	**1031**	**2575**	**56786**
Direct Rain		2960	4206	4157	4053	3060	2423	1548	463	266	197	395	1085	24827
Monthly upslope run-off		3049	4332	4281	4175	3152	2496	1594	477	276	203	407	1128	25572
Washing bay (m³/day)	5	155	150	155	155	140	155	150	155	150	155	155	150	1825
ROM & Contractor's yard		544	773	764	745	562	445	284	85	49	36	73	201	4562
Outflow (m3)		**5257**	**5433**	**5827**	**5912**	**5306**	**5292**	**4352**	**3831**	**3327**	**3569**	**4174**	**4922**	**57201**
Total Evaporation		4017	4233	4587	4672	4186	4052	3152	2591	2127	2329	2934	3722	42601
Seepage	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Export ROM 2000t/d	0.02	1240	1200	1240	1240	1120	1240	1200	1240	1200	1240	1240	1200	14600
Dust Suppression (m3/day)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inflow-Outflow (m3)		1452	4029	3530	3216	1608	228	(776)	(2651)	(2583)	(2977)	(3143)	(2347)	(415)
Delta Storage		1452	5480	9010	12226	13834	14062	13286	10635	8053	5075	1932	0	
Maximum month end capacity (m3)		**14062**												
		1452	5480	9010	12226	13834	14062	13286	10635	8053	5075	1932	(416)	

1 in 50 Year 24 hour storm event:

1:50 Year storm (mm)	122
Direct Rain (m3)	3904
1:50 volume (m3)	21296
Storm capacity required (m3)	**25200**

Run-off factor estimated 0.4

Capacity required for Interception	**39262** m³

Improcon

Table 3.1.5.12.1 (c): Operational Phase Water Balance for PCD – without Dust Suppression.

TABLE 3: Lusthof Opencast PCD: Post Closure Water Balance

Lusthof: Run-Off Volumes m³ per month

Dam Evaporation Area (m²)				Calculated	12800	
		In spoils area m²	0	Upslope Area m²	0	Run-off Factor 8%
MAP= 776 mm		In Spoils Evap Factor	0.2	ROM Area m²	0	20%
Symons pan MAE = 1583 mm				Contractor's yard m²	0	30%

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
(days)	31	30	31	31	28	31	30	31	30	31	31	30	365
Symons pan(%MAE)	9.79	10.19	10.91	10.98	9.39	9.09	7.07	5.88	4.94	5.54	7.15	9.07	100
Symons pan (mm)	155	161	173	174	149	144	112	93	78	88	113	144	1583
pan factor	0.81	0.82	0.83	0.84	0.88	0.88	0.88	0.87	0.85	0.83	0.81	0.81	0.84
Gross Lake Evapor.(mm)	**126**	**132**	**143**	**146**	**131**	**127**	**98**	**81**	**66**	**73**	**92**	**116**	**1331**
Rainfall (% MAP)	10.08	15.62	15.77	17.74	13.4	11.79	6.42	2.73	1.16	1.05	1.00	3.24	100
Ave Rainfall (mm)	78.2	121.2	122.4	137.7	104.0	91.5	49.8	21.2	9.0	8.1	7.8	25.1	776

Interception Dam [Inflow-Outflow = Delta Storage]

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Inflow (m3)		**1001**	**1552**	**1566**	**1762**	**1331**	**1171**	**638**	**271**	**115**	**104**	**99**	**322**	**9933**
Direct Rain		1001	1552	1566	1762	1331	1171	638	271	115	104	99	322	9933
Monthly upslope run-off		0	0	0	0	0	0	0	0	0	0	0	0	0
Washing bay (m³/day)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROM & Contractor's yard		0	0	0	0	0	0	0	0	0	0	0	0	0
Outflow (m3)		**1607**	**1693**	**1835**	**1869**	**1674**	**1621**	**1261**	**1037**	**851**	**932**	**1173**	**1489**	**17041**
Total Evaporation		1607	1693	1835	1869	1674	1621	1261	1037	851	932	1173	1489	17041
Seepage	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Export ROM 2000t/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dust Suppression (m3/day)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inflow-Outflow (m3)		(606)	(142)	(268)	(107)	(343)	(450)	(623)	(765)	(736)	(827)	(1074)	(1167)	(7108)
Delta Storage		0	0	0	0	0	0	0	0	0	0	0	0	
Maximum month end capacity (m3)		**0**												
		0	(142)	(410)	(517)	(860)	(1310)	(1933)	(2698)	(3434)	(4261)	(5335)	(6502)	

1 in 50 Year 24 hour storm event:

1:50 Year storm (mm)	122
Direct Rain (m3)	1561.6
1:50 volume (m3)	0
Storm capacity required (m3)	**1562**

Run-off factor estimated: 0.4

Capacity required for Interception	**1562** m³

Inprocon

Table 3.1.5.12.1 (d): Post Closure Phase Water Balance for PCD.

3.1.5.12.2 Water Balance for the Dirty Water Dam (DWD)

The Dirty Water Dam mainly needs to provide for surface water run-off and silt generated from the areas where the hards stockpiles will be placed, next to the north-western pit perimeter. During stage three of the operational phase the DWD will also be used for the containment of dirty water run-off from the advancing mining area on the northern side of the watershed. The surface run-off area to be provided for is 22.3 *ha* in total.

From the water balance results shown in Table 3.1.5.12.2 (a) it is clear that allowance need to be made for a storage capacity of 16 800 m^3 of potentially contaminated water, with the usage of 30 m^3/day for dust suppression. With no dust suppression the storage to be provided in the DWD is doubled to about 25 000 m^3. Dust suppression of clean areas can be done with this water provided that the water is of acceptable quality.

3.1.5.12.3 Water Balance for the Clean Water Diversion Pond (CWDP)

The catchment area for the Clean Water Diversion Pond is only 3.48 *ha* with the result that a storage capacity of 3 850 m^3 is required to accommodate the surface water run-off and 1:50 year 24 hr rainfall event. The average annual inflow into the CWDP is about 6 500 m^3, which will all be evaporated if the water is not used for operational purposes. Excess surface water run-off will flow through the CWDP into the natural environment. The water balance calculations are shown in Table 3.1.5.12.3 (a).

TABLE 4: Lusthof Opencast Dirty Water Dam: Operational Phase Stage 2 Water Balance

Lusthof: Run-Off Volumes m^3 per month

Dam Evaporation Area (m^2)		Calculated	6000	L = 100	W =	60
	Mine area m^2: 50000	Upslope Area m^2	222600		Run-off Factor	8%
MAP=	776 mm	ROM Area m^2	0			30%
Symons pan MAE =	1583 mm	Contractor's yard m^2	0			30%

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
(days)		31	30	31	31	28	31	30	31	30	31	31	30	365
Symons pan(%MAE)		9.79	10.19	10.91	10.98	9.39	9.09	7.07	5.88	4.94	5.54	7.15	9.07	100
Symons pan (mm)		155	161	173	174	149	144	112	93	79	88	113	144	1583
pan factor		0.81	0.82	0.83	0.84	0.88	0.88	0.88	0.87	0.85	0.83	0.81	0.81	0.84
Gross Lake Evapor.(mm)		**126**	**132**	**143**	**146**	**131**	**127**	**98**	**81**	**66**	**73**	**92**	**116**	**1331**
Rainfall (% MAP)		11.92	16.94	16.74	16.33	12.32	9.76	6.23	1.87	1.08	0.80	1.59	4.41	100
Ave Rainfall (mm)		92.5	131.4	129.9	126.7	95.6	75.7	48.4	14.5	8.4	6.2	12.4	34.2	776
Interception Dam	[Inflow-Outflow = Delta Storage]													
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Inflow (m3)		**2203**	**3129**	**3093**	**3016**	**2277**	**1803**	**1151**	**345**	**200**	**147**	**294**	**815**	**18471**
Direct Rain		555	789	779	760	574	454	290	87	50	37	74	206	4655
Monthly upslope run-off		1648	2341	2313	2256	1703	1349	861	258	149	110	220	609	13816
Total Recharge		0	0	0	0	0	0	0	0	0	0	0	0	0
ROM & Contractor's yard		0	0	0	0	0	0	0	0	0	0	0	0	0
Outflow (m3)		**1683**	**1694**	**1790**	**1806**	**1625**	**1690**	**1491**	**1416**	**1299**	**1367**	**1480**	**1598**	**18938**
Total Evaporation		753	794	860	876	785	760	591	486	399	437	550	698	7988
Water Treatment m^3/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Export ROM 2000t/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dust Suppression m^3/d	30	930	900	930	930	840	930	900	930	900	930	930	900	10950
Inflow-Outflow (m3)		519	1436	1302	1210	652	113	(340)	(1071)	(1099)	(1220)	(1186)	(783)	(466)
Delta Storage		519	1955	3258	4467	5119	5232	4893	3822	2722	1503	317	0	
Maximum month end capacity (m3)		**5232**												
		519	1955	3258	4467	5119	5232	4893	3822	2722	1503	317	(466)	

1 in 50 Year 24 hour storm event:

1:50 Year storm (mm)	122	
Direct Rain (m3)	732	
1:50 volume (m3)	10863	Run-off factor estimated: 0.4
Storm capacity required (m3)	**11595**	
Capacity required for Interception	**16827** m^3	
Average depth	**2.8**	

Inprocon

Table 3.1.5.12.3 (a): Operational Phase Water Balance for DWD..

TABLE 5: Lusthof Opencast Clean Water Diversion Pond: Operational Phase - Water Balance

Lusthof: Run-Off Volumes m^3 per month

Dam Evaporation Area (m^2)				Calculated	5000	
		In spoils area m^2	0	Upslope Area m^2	34800	Run-off Factor 10%
MAP=	776 mm	In Spoils Evap Factor	0.2	ROM Area m^2	0	30%
Symons pan MAE =	1583 mm			Contractor's yard m^2	0	30%

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
(days)	31	30	31	31	28	31	30	31	30	31	31	30	365
Symons pan(%MAE)	9.79	10.19	10.91	10.98	9.39	9.09	7.07	5.88	4.94	5.54	7.15	9.07	100
Symons pan (mm)	155	161	173	174	149	144	112	93	78	88	113	144	1583
pan factor	0.81	0.82	0.83	0.84	0.88	0.88	0.88	0.87	0.85	0.83	0.81	0.81	0.84
Gross Lake Evapor.(mm)	**126**	**132**	**143**	**146**	**131**	**127**	**98**	**81**	**66**	**73**	**92**	**116**	**1331**
Rainfall (% MAP)	11.92	16.94	16.74	16.33	12.32	9.76	6.23	1.87	1.08	0.80	1.59	4.41	100
Ave Rainfall (mm)	92.5	131.4	129.9	126.7	95.6	75.7	48.4	14.5	8.4	6.2	12.4	34.2	776

Interception Dam [Inflow-Outflow = Delta Storage]

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Inflow (m3)		**785**	**1115**	**1102**	**1074**	**811**	**642**	**410**	**123**	**71**	**52**	**105**	**290**	**6579**
Direct Rain		463	657	649	633	478	379	242	72	42	31	62	171	3879
Monthly upslope run-off		322	457	452	441	333	264	168	50	29	21	43	119	2700
Total Recharge		0	0	0	0	0	0	0	0	0	0	0	0	0
ROM & Contractor's yard		0	0	0	0	0	0	0	0	0	0	0	0	0
Outflow (m3)		**628**	**661**	**717**	**730**	**654**	**633**	**492**	**405**	**332**	**364**	**458**	**581**	**6656**
Total Evaporation		628	661	717	730	654	633	492	405	332	364	458	581	6656
Water Treatment m^3/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Export ROM 2000t/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dust Suppression m^3/d	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inflow-Outflow (m3)		157	453	385	344	157	9	(82)	(282)	(261)	(312)	(354)	(291)	(77)
Delta Storage		157	610	995	1339	1496	1505	1423	1140	879	568	214	0	
Maximum month end capacity (m3)		**1505**												
		157	610	995	1339	1496	1505	1423	1140	879	568	214	(77)	

1 in 50 Year 24 hour storm event:

1:50 Year storm (mm)	122
Direct Rain (m3)	610
1:50 volume (m3)	1698
Storm capacity required (m3)	**2308**

Run-off factor estimated: 0.4

Capacity required for interception	**3813** m^3

Inprocon

Table 3.1.5.12.3 (b): Operational Phase Water Balance for CWDP.

3.1.5.13 Conceptual Civil Designs – Storm Water Management

A Conceptual/Preliminary Civil Engineering Design Report was compiled by Inprocon Civil Engineers. The sections describing the designs of the Storm Water Management Infrastructure have been incorporated verbatim (complete with the design drawings) into this report in order to provide a fully comprehensive project description for review and approval by the relevant competent authorities.

3.1.5.13.1 Clean/Dirty Water Diversion Berms

Several storm water diversion berms of sandy/clayey gravel will be constructed along the western and southern sides of the opencast mining area to divert clean water run-off into the natural environment and to intercept dirty water run-off and route it to the Strom water PCD via settling ponds / silt traps. The dirty water interception berms on the south and south-eastern sections will be constructed progressively along the perimeter as the mine develops in a northerly direction.

The design parameters for the storm water diversion berms are as follows:

- Maximum berm height = 1.0 m
- Length of clean SW diversion berm = 650 m
- Length of dirty SW diversion berm = ± 1 400 m
- Crest width = 1.0 m
- Side slopes = 1V:1.5H

The location of the diversion and interception berms are shown in the layout drawings for the various stages of mining development attached in Figures 3.1.5.13.1 (a) through 3.1.5.13.1 (d).

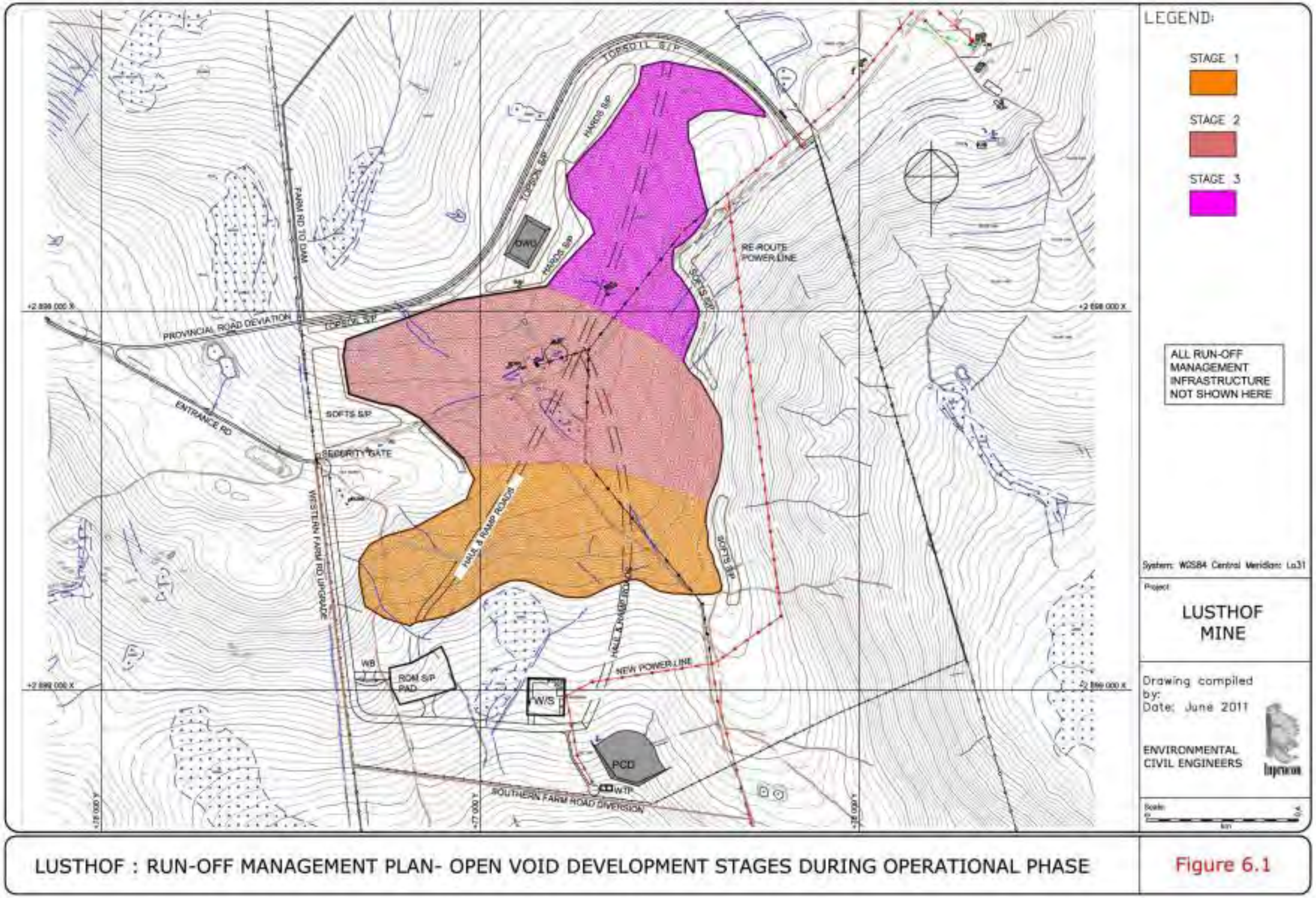


Figure 3.1.5.13.1 (a): Run-off Management Plan – Open Void Development Stages During Operational Phase.

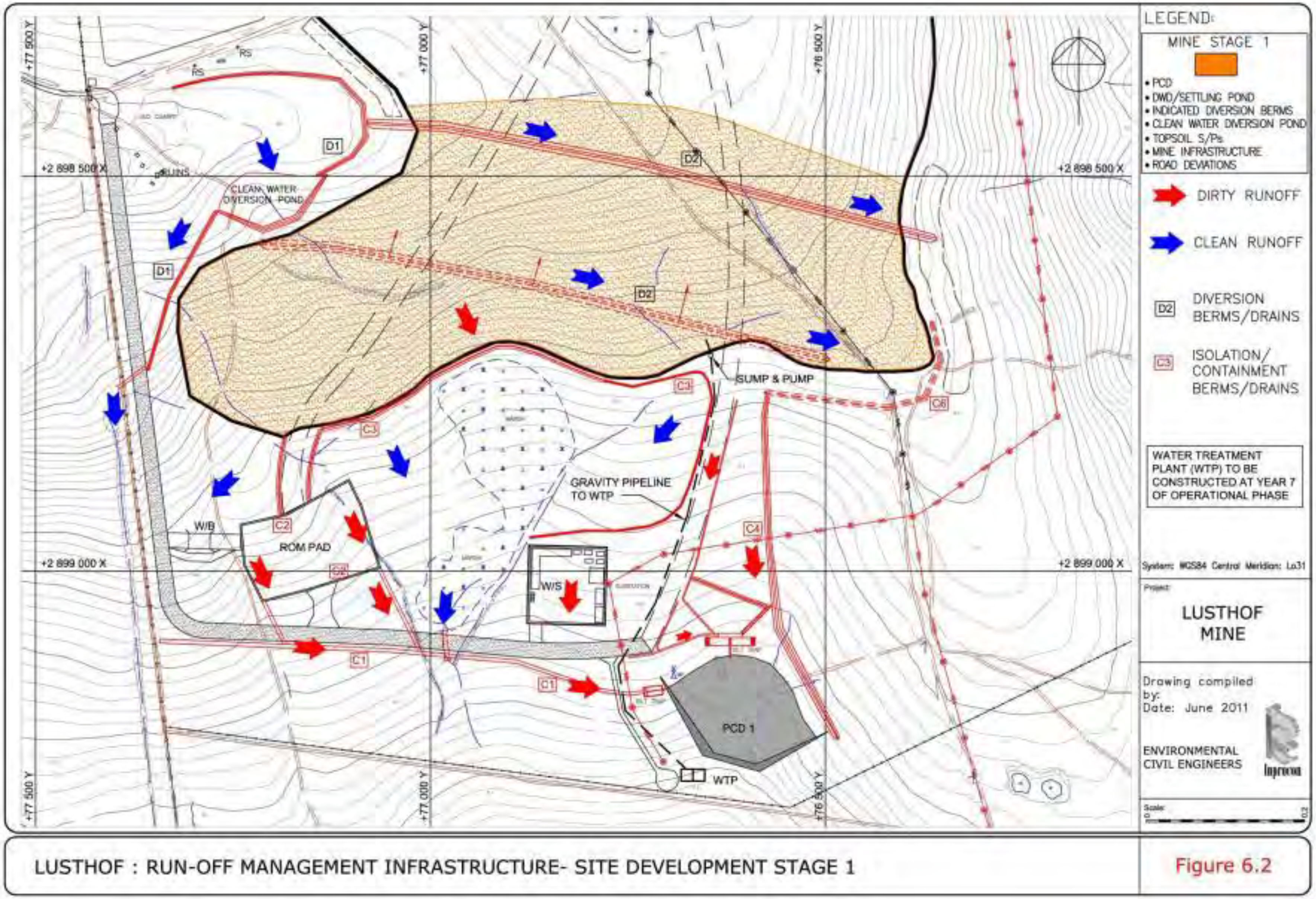


Figure 3.1.5.13.1 (b): Run-off Management Infrastructure – Mine Development Stage 1.

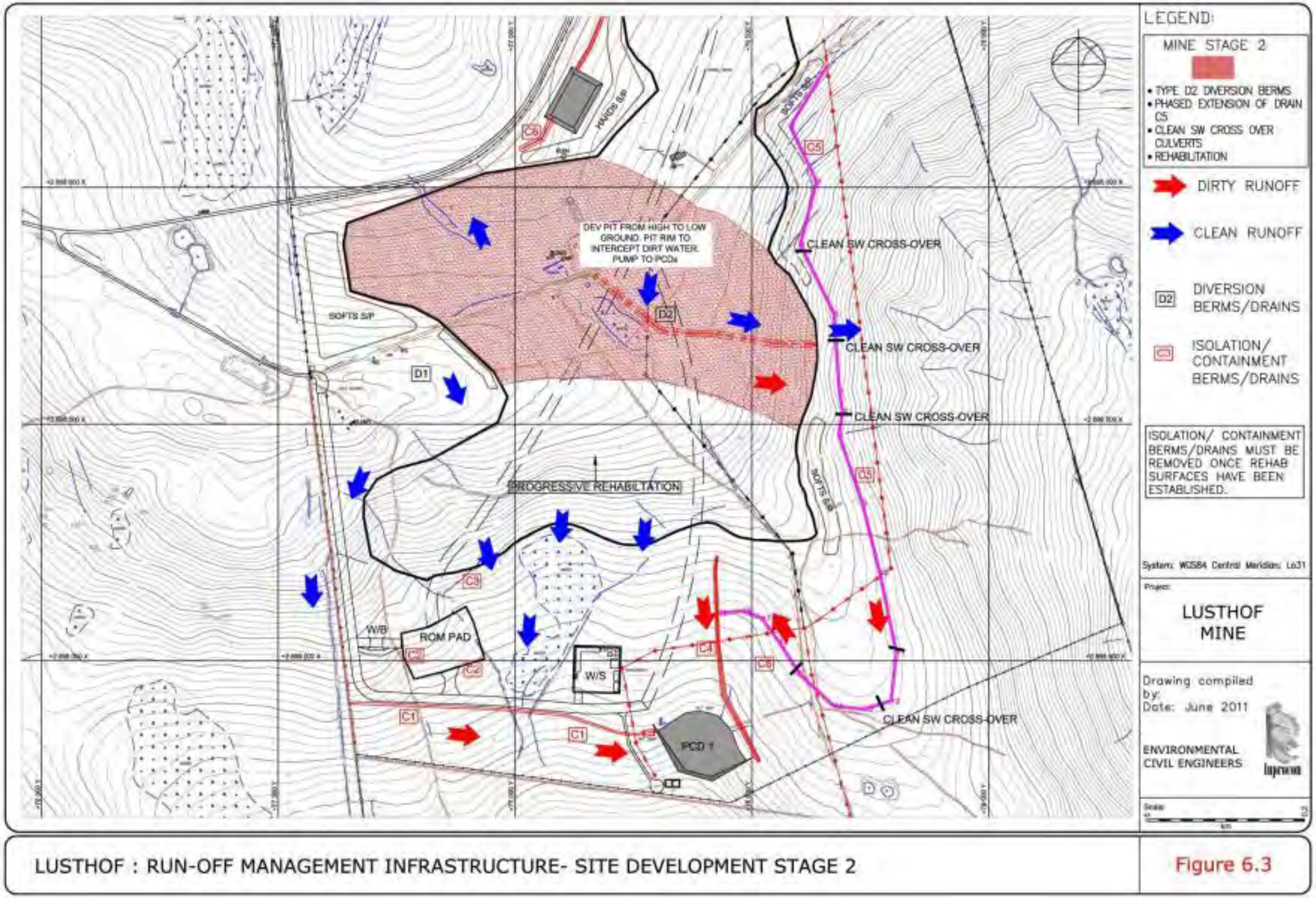


Figure 3.1.5.13.1 (c): Run-off Management Infrastructure – Mine Development Stage 2.

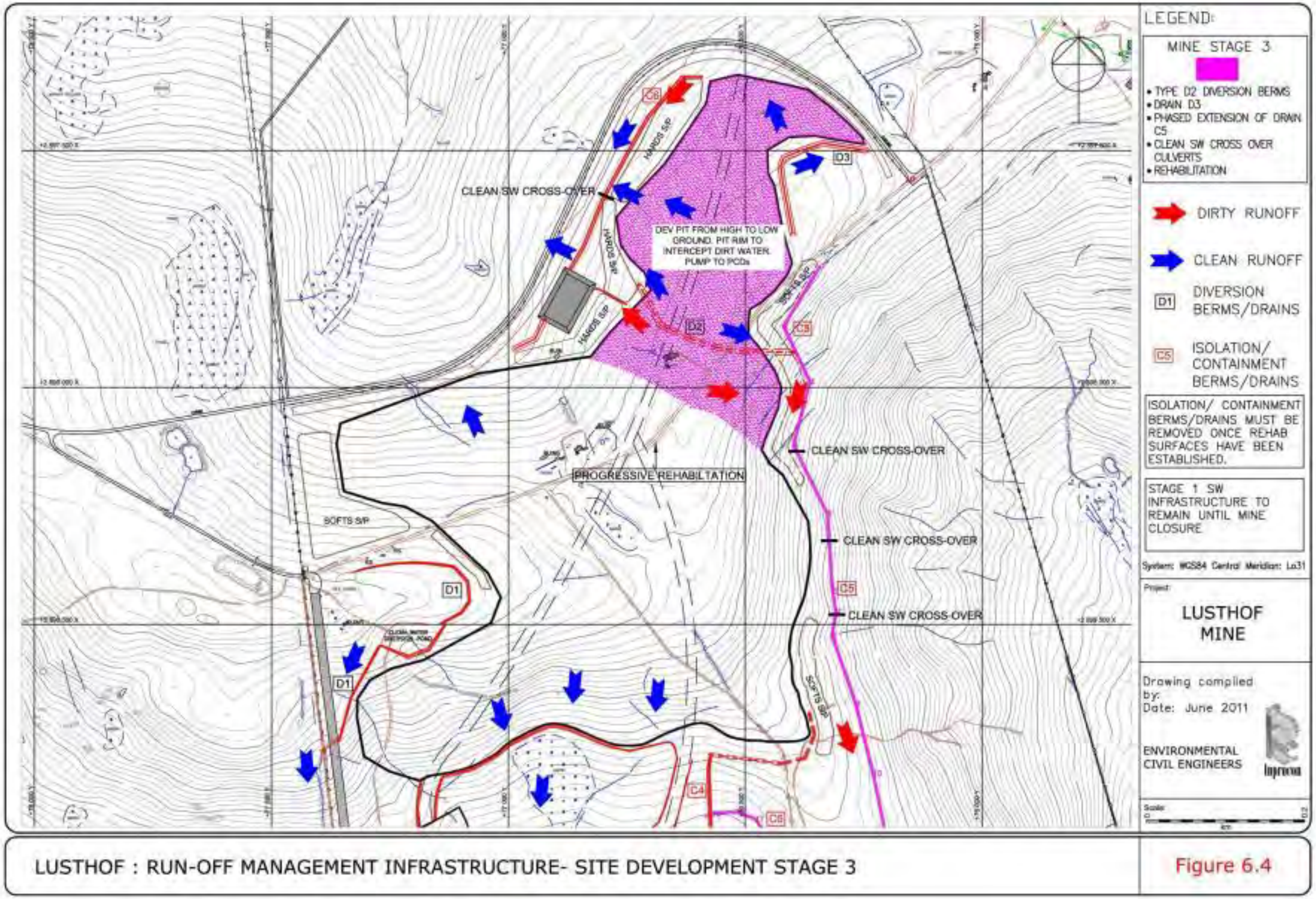


Figure 3.1.5.13.1 (d): Run-off Management Infrastructure – Mine Development Stage 3.

3.1.5.13.2 Southern Dirty Water Interception Drain

A major concrete lined interception drain will be constructed along the haul road on the southern side of the opencast mining area to intercept and collect dirty water run-off from the upslope mining area, including the ROM pad and Contractor's yard area and route it to the PCD via a settling pond / silt trap. Two discharge structures (pipe culverts) as indicated on the drawings will be constructed under the haul road to allow the discharge of dirty water from the upslope areas into the drain.

The design parameters for the interception drain and settling pond are as follows:

- Type of drain = lined trapezoidal
- 1: 50 year design flood = 1 100 ℓ/s
- Lined depth of drain (ch0 to ch446) = 500 mm
- Bottom width of drain (ch0 to ch446) = 300 mm
- Longitudinal slope of drain (ch0 to ch446) = 1:50
- Lined depth of drain (ch446 to ch604) = 600 mm
- Bottom width of drain (ch446 to ch604) = 900 mm
- Longitudinal slope of drain (ch446 to ch604) = 1:300
- Side slopes of drain = 1V:1.5H
- Inlet pipe culvert structure = 600 mm
- Type of settling pond = excavated open pit
- Lining of settling pond = clay material
- Storage volume = 1 230 m^3
- Surface area = 2 000 m^2
- Storage depth = 1.0 m
- Outlet capacity of spillway to PCD = 4.0 m^3/s

The layout, long section and typical details for the dirty water interception drain and settling pond are shown in drawings IPC/LF/100/106/01 and 02 shown in Figures 3.1.5.13.2 (a) and 3.1.5.13.2 (b).

The area between the ROM platform and Contractor's yard is a wet marshy area which will be maintained as a clean water run-off area. A culvert structure will be provided at the natural drainage path in this area underneath the haul road and across the dirty water drain. Details of the culvert structure are included in the sections below.

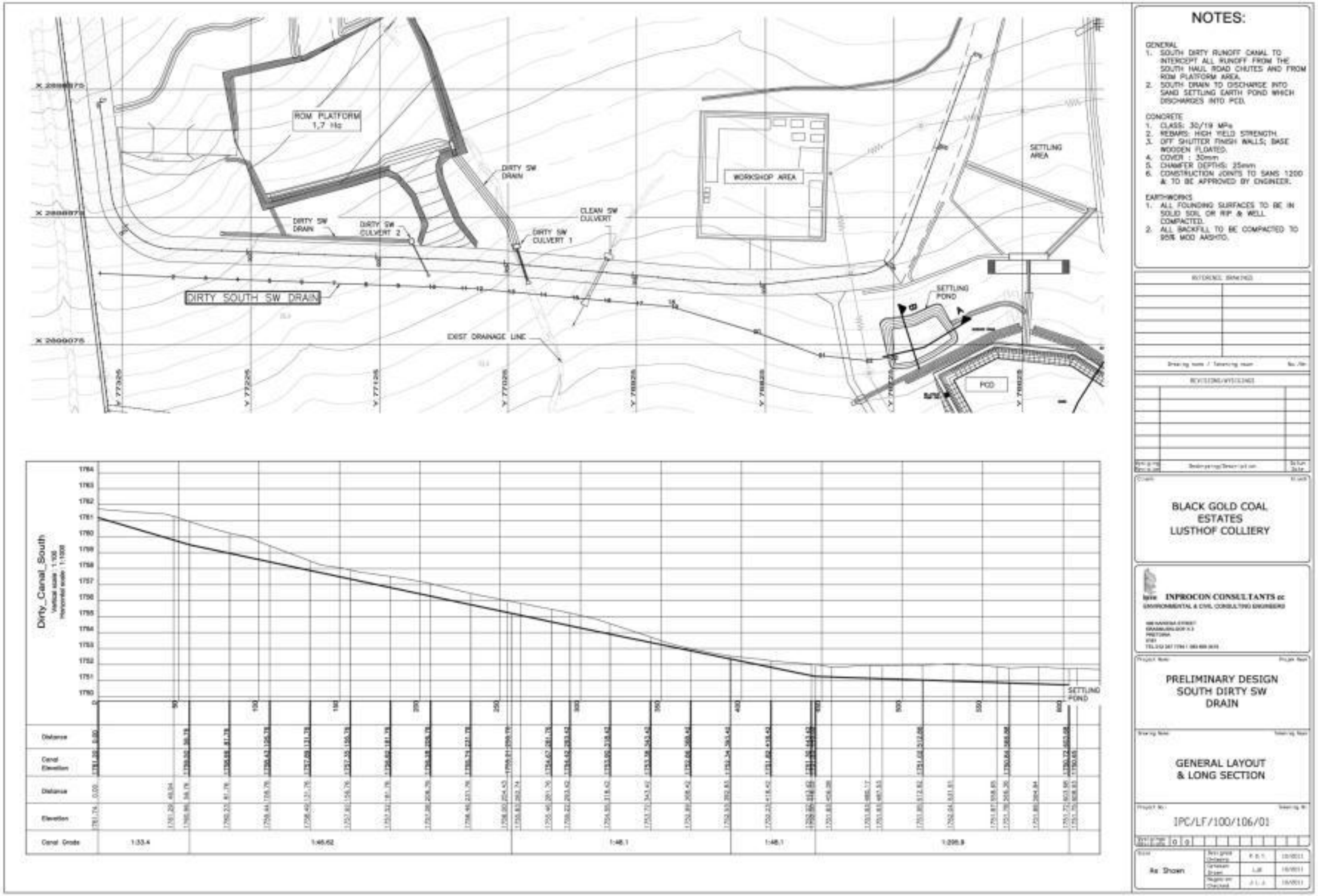


Figure 3.1.5.13.2 (a): Southern Dirty Water Interception Drain – General Layout and Long Section.

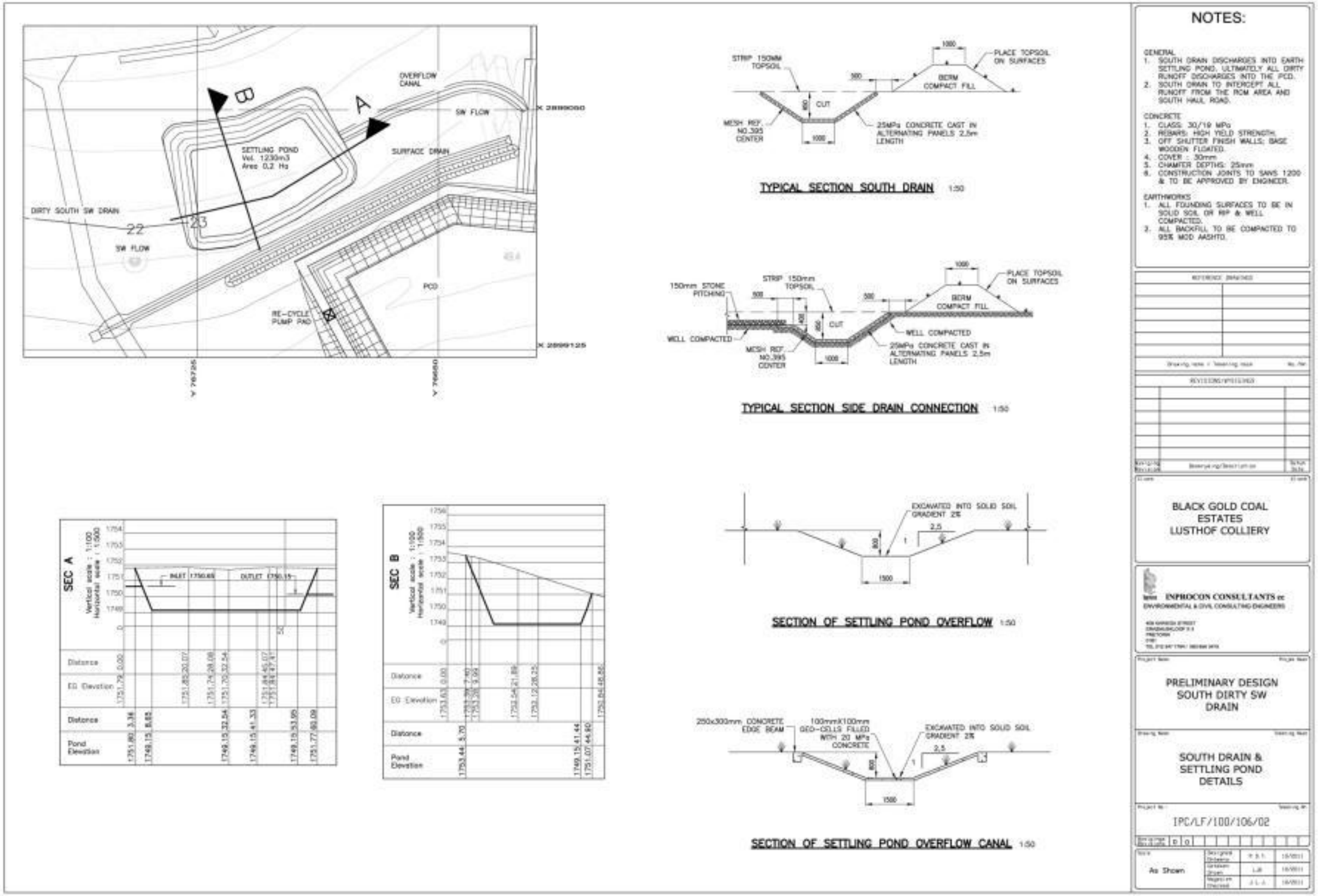


Figure 3.1.5.13.2 (b): South Drain and Settling Pond Details.

3.1.5.13.3 Dirty Storm Water Intercept East Canal

A major unlined interception drain will be constructed along the pit perimeter on the eastern side of the opencast mining area to intercept and collect dirty water run-off from the upslope mining area and route it to the PCD via a silt trap. Clean water cross-over structures will be provided at regular intervals along the interception drain to allow the discharge of clean surface water from the rehabilitated upslope areas into the natural environment.

Gabion drop structures or steps will be installed at defined locations in order to reduce the gradient and to prevent super-critical flow conditions. The flow velocity in the drain will thus be reduced to below 1.0 m/s in order to prevent erosion of the channel.

The design parameters for the dirty water interception drain are as follows:

- Type of drain = unlined trapezoidal
- 1: 50 year design flood (ch0 to ch385) = 600 ℓ/s
- Minimum depth of drain (ch0 to ch385) = 500 mm
- Bottom width of drain (ch0 to ch385) = 1 000 to 2 000 mm
- Longitudinal slope of drain (ch0 to ch385) = varies (1:175 ave)
- 1: 50 year design flood (ch385 to ch540) = 1 220 ℓ/s
- Minimum depth of drain (ch385 to ch540) = 600 mm
- Bottom width of drain (ch385 to ch540) = 2 000 to 3000 mm
- Longitudinal slope of drain (ch385 to ch540) = varies (1:265 ave)
- 1: 50 year design flood (ch540 to ch1875) = 1 530 ℓ/s
- Minimum depth of drain (ch540 to ch1875) = 600 mm
- Bottom width of drain (ch540 to ch1875) = 3000 mm
- Longitudinal slope of drain (ch540 to ch1875) = varies (1:300 ave)
- Side slopes of drain = 1V:2H
- Cross-over pipe culvert structure = 2 x 600 mm dia

The layout, long section and typical details for the dirty water drain and cross-over structure are shown in drawings no. IPC/LF/100/104/01 to 03 in Figures 3.1.5.13.3 (a) through 3.1.5.13.3 (c).

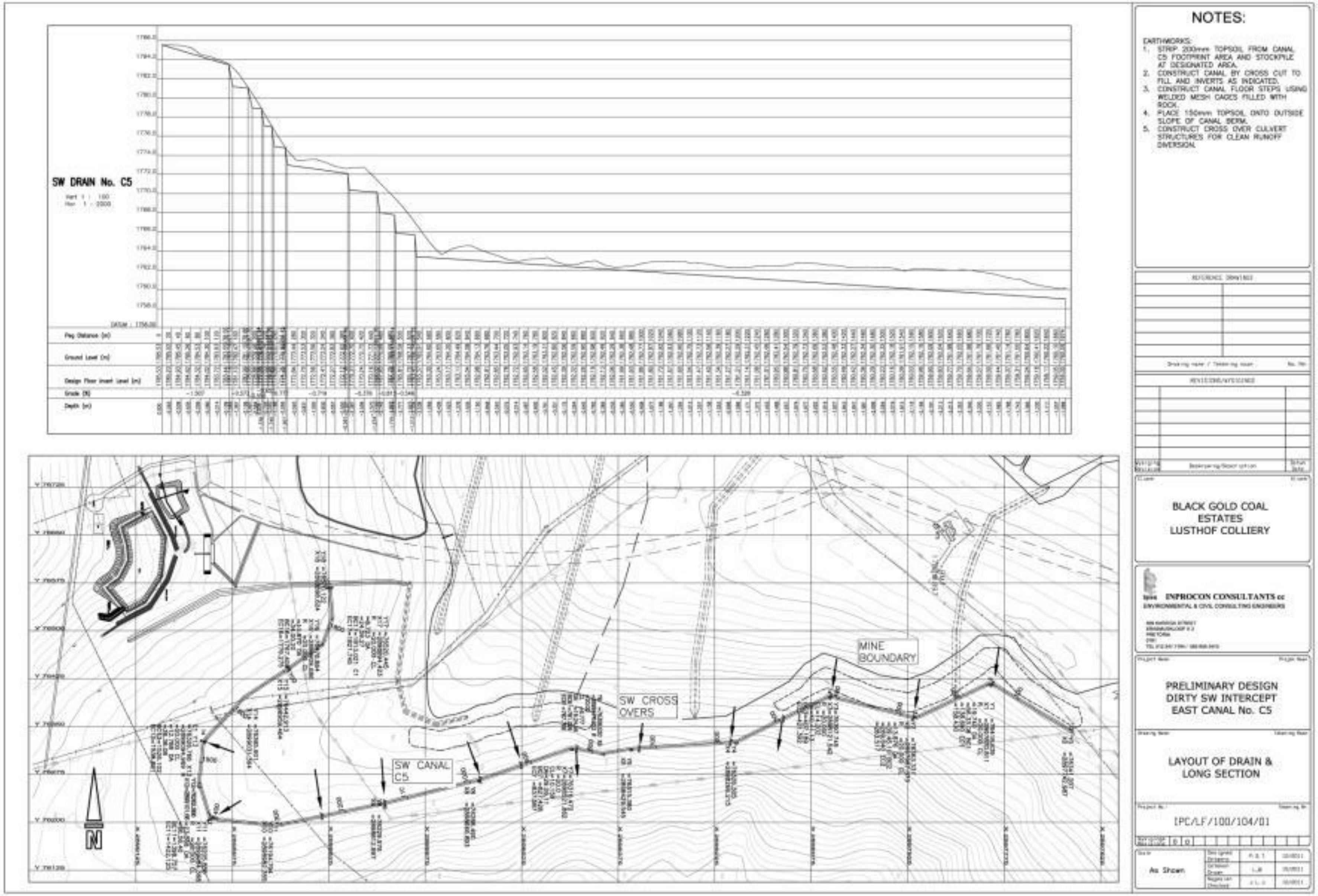


Figure 3.1.5.13.3 (a): Dirty Storm Water Intercept East Canal - Layout of Drain and Long Section.

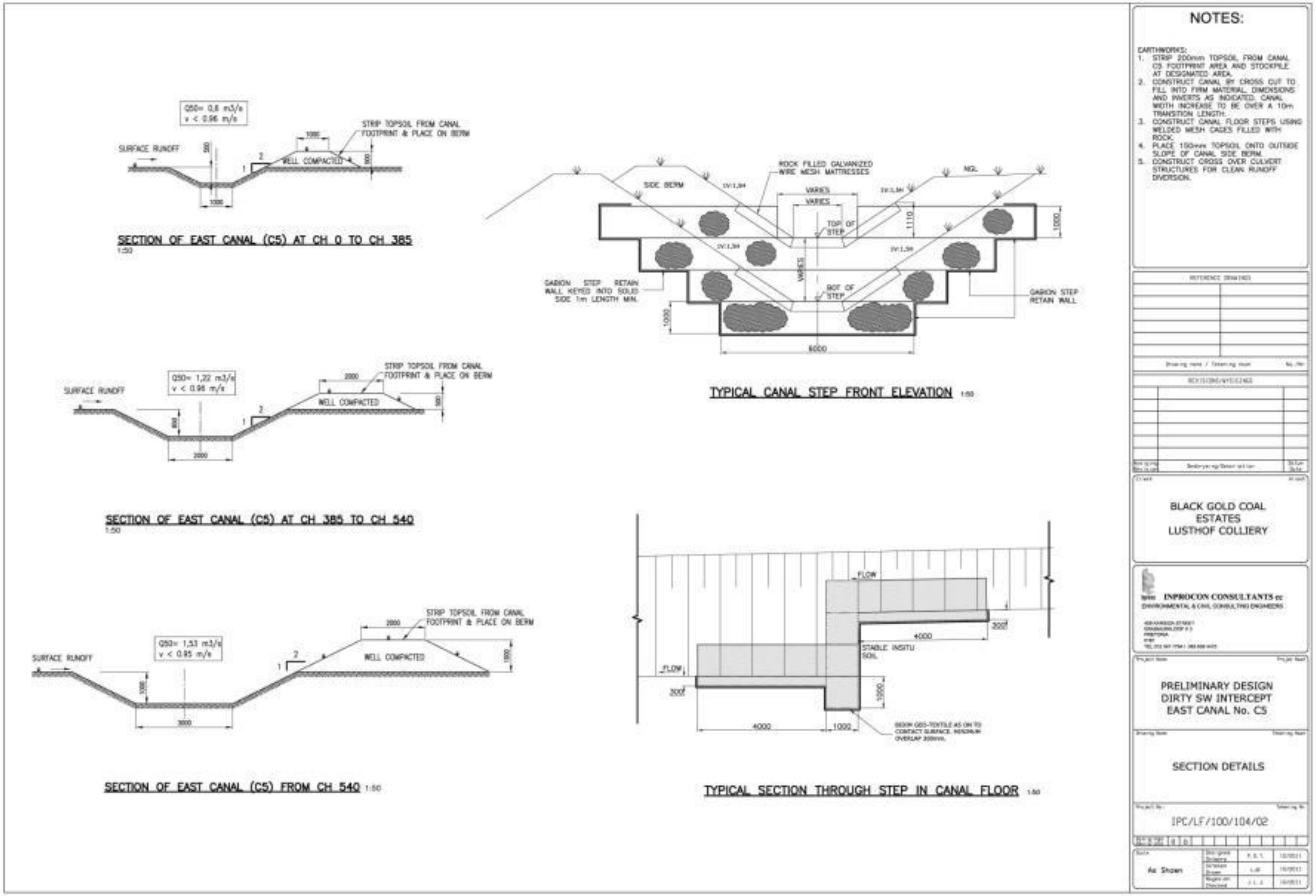


Figure 3.1.5.13.3 (b): Dirty Storm Water Intercept East Canal - Section Details.

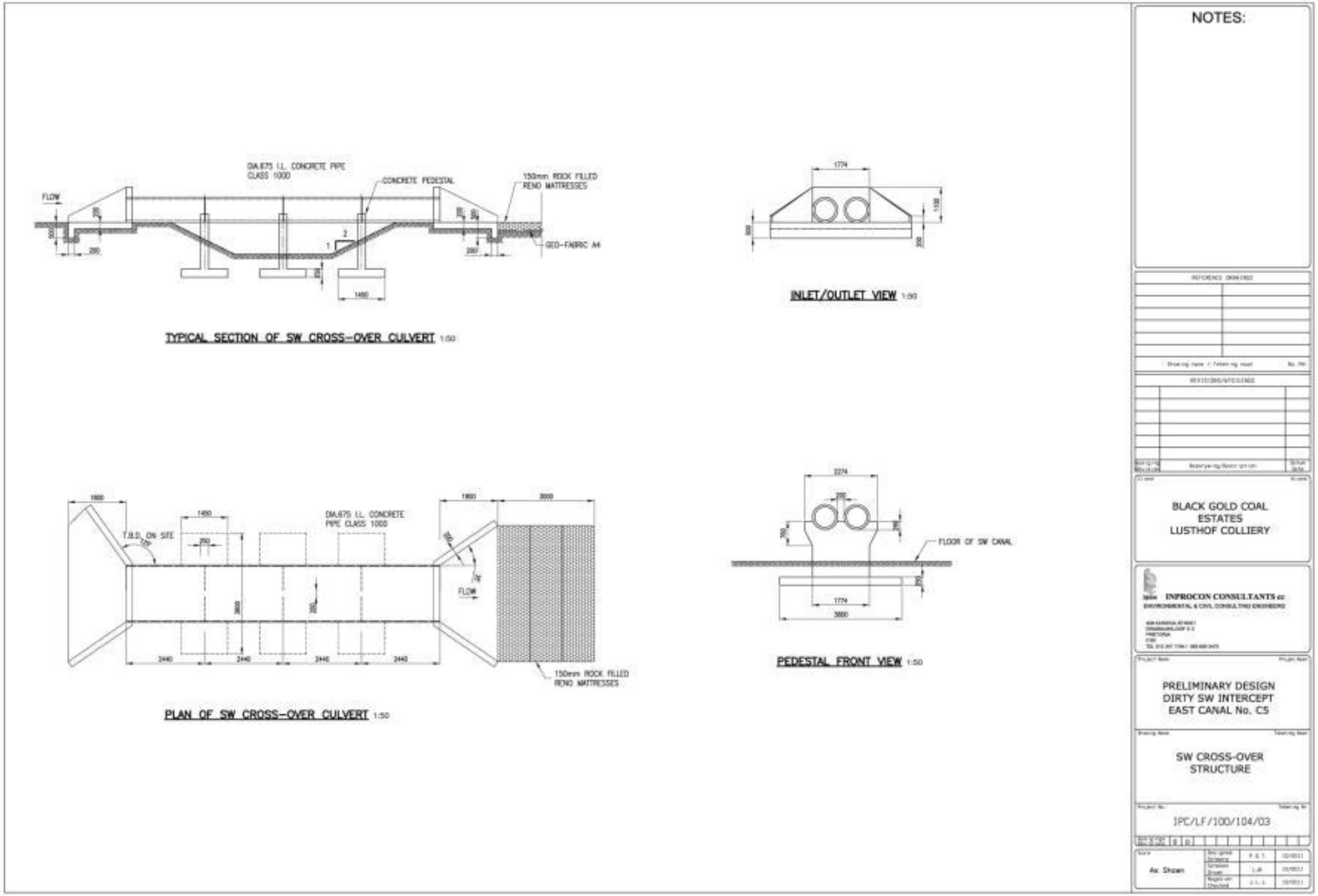


Figure 3.1.5.13.3 (c): Dirty Storm Water Intercept East Canal - SW Cross-Over Structure.

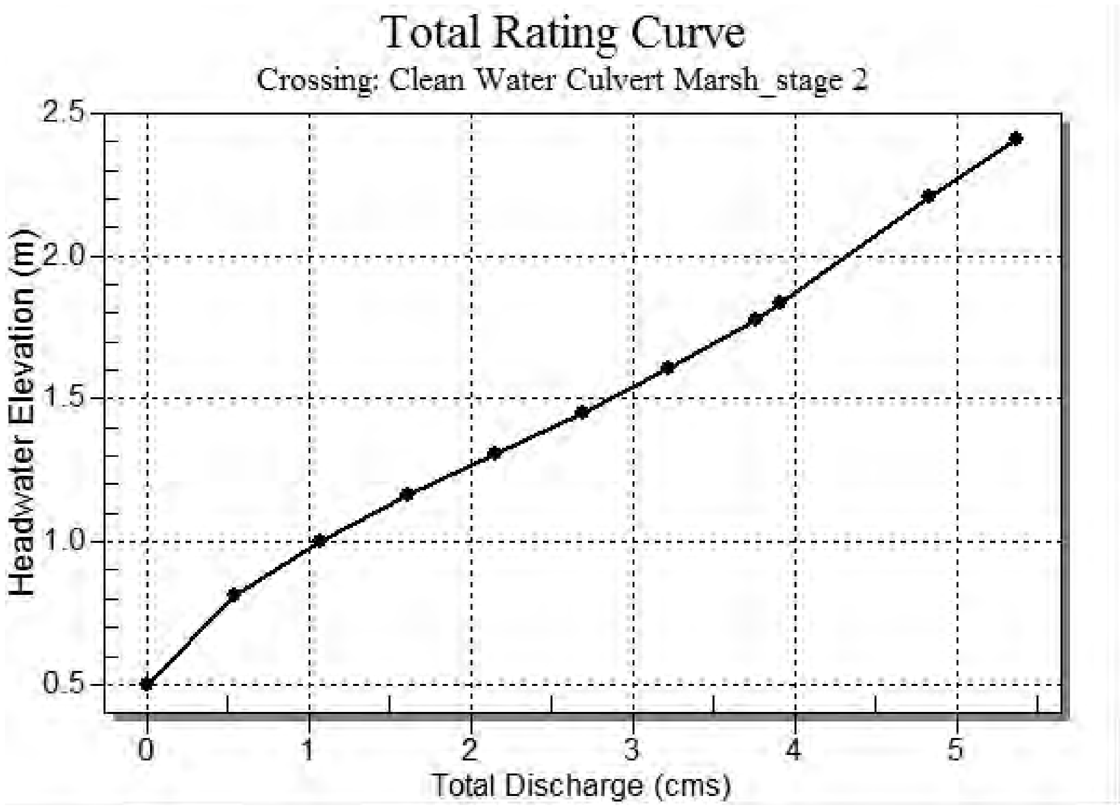
3.1.5.13.4 Clean Water Culvert and South Haul Road

A major clean water culvert will be provided underneath the southern haul road and across the dirty water drainage channel in order to drain clean surface water run-off from the marshy area between the ROM stockpile pad on the western side and the Contractor's camp on the eastern side. The culvert will be constructed of precast concrete box units and sized for the 1:50 year flood peak generated in the isolated catchment area.

The design parameters for the culvert are as follows:

- Maximum catchment area (stage 2) = 24.0 *Ha*
- Design overland flow (stage 2) = 5.37 m^3/s
- Longest flow path = 650 m
- Height difference = 38 m
- Size of box culvert = 1800 x 900 mm
- Length of culvert = 25 m
- Gradient of culvert = 1:50

The rating curve for the culvert is shown below.



Details of the culvert's flow characteristics are shown in Table 3.1.5.13.4 (a).

Table 3.1.5.13.4 (a): Flow Characteristics of Clean Water Culvert.

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
0.00	0.00	0.50	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
0.54	0.54	0.81	0.315	0.000	1-S2n	0.112	0.209	0.114	0.077	2.606	1.136
1.07	1.07	1.00	0.502	0.000	1-S2n	0.179	0.332	0.190	0.116	3.145	1.481
1.61	1.61	1.16	0.662	0.000	1-S2n	0.231	0.435	0.255	0.148	3.503	1.724
2.15	2.15	1.31	0.806	0.000	1-S2n	0.281	0.527	0.318	0.176	3.758	1.919
2.69	2.69	1.45	0.950	0.000	5-S2n	0.326	0.611	0.376	0.201	3.963	2.087
3.22	3.22	1.61	1.106	0.000	5-S2n	0.370	0.690	0.433	0.224	4.130	2.232
3.76	3.76	1.78	1.280	0.000	5-S2n	0.410	0.765	0.488	0.246	4.280	2.357
3.91	3.91	1.83	1.333	0.000	5-S2n	0.422	0.785	0.503	0.251	4.315	2.395
4.83	4.83	2.21	1.707	1.193	5-S2n	0.488	0.900	0.593	0.285	4.525	2.585
5.37	5.26	2.41	1.908	1.339	5-S2n	0.518	0.900	0.633	0.303	4.615	2.684

,

The long section and typical details for the haul road and clean water culvert structure are shown in drawings no. IPC/LF/100/105/01 to 03 in Figures 3.1.5.13.4 (a) through 3.1.5.13.4 (c).

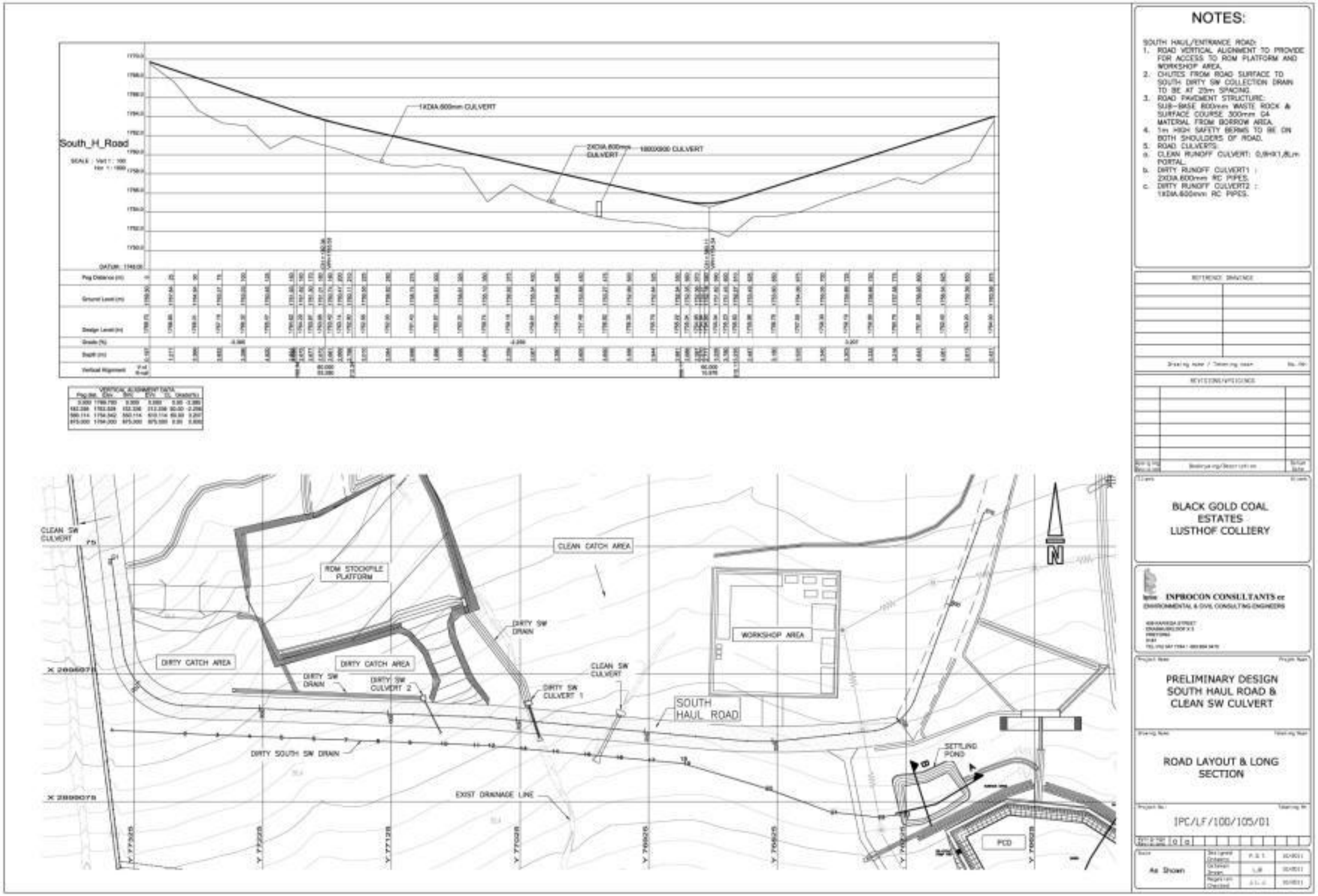


Figure 3.1.5.13.4 (a): Clean Water Culvert and South Haul Road - Road Layout and Long Section.

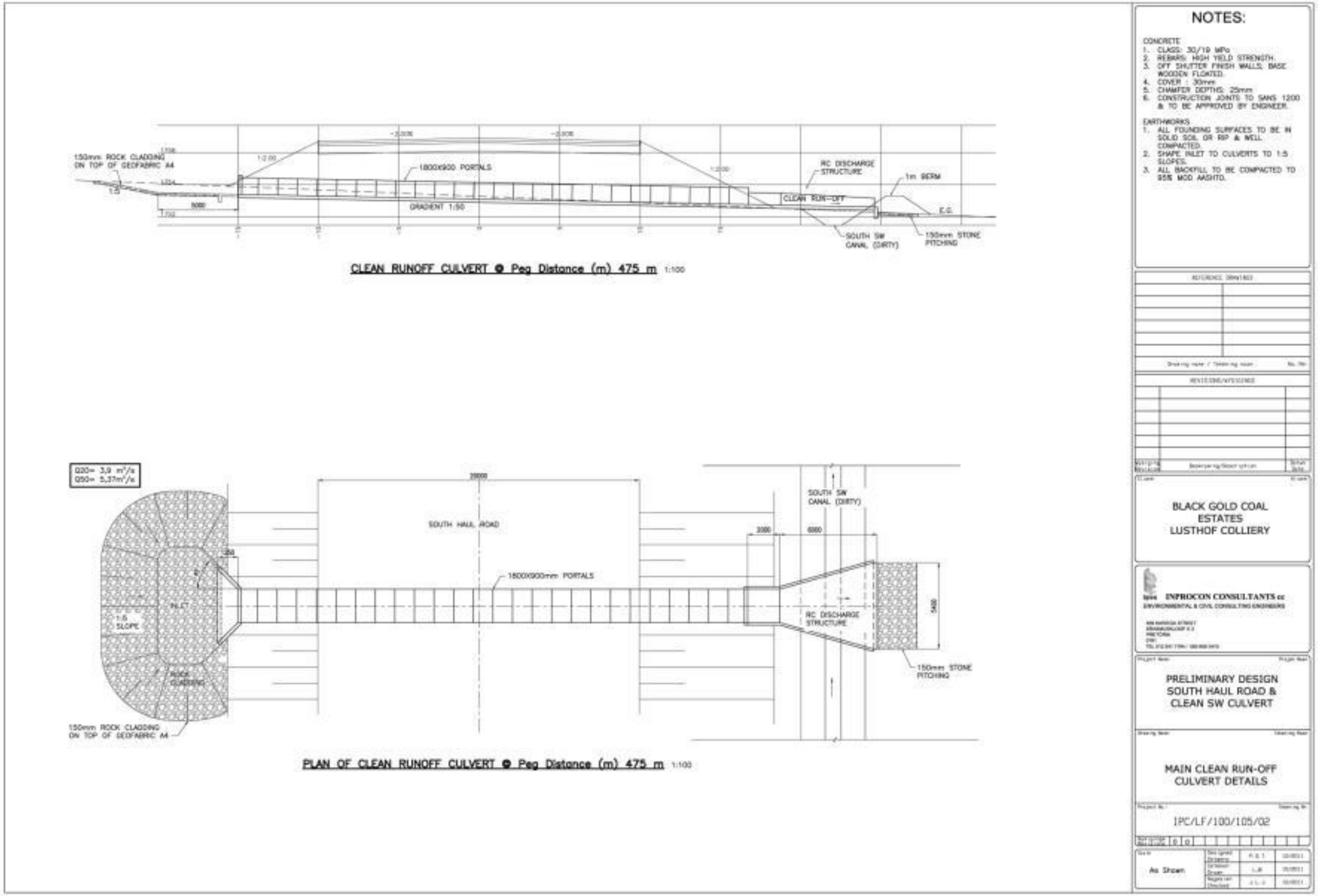


Figure 3.1.5.13.4 (b): Clean Water Culvert and South Haul Road - Main Clean Run-off Culvert Details.

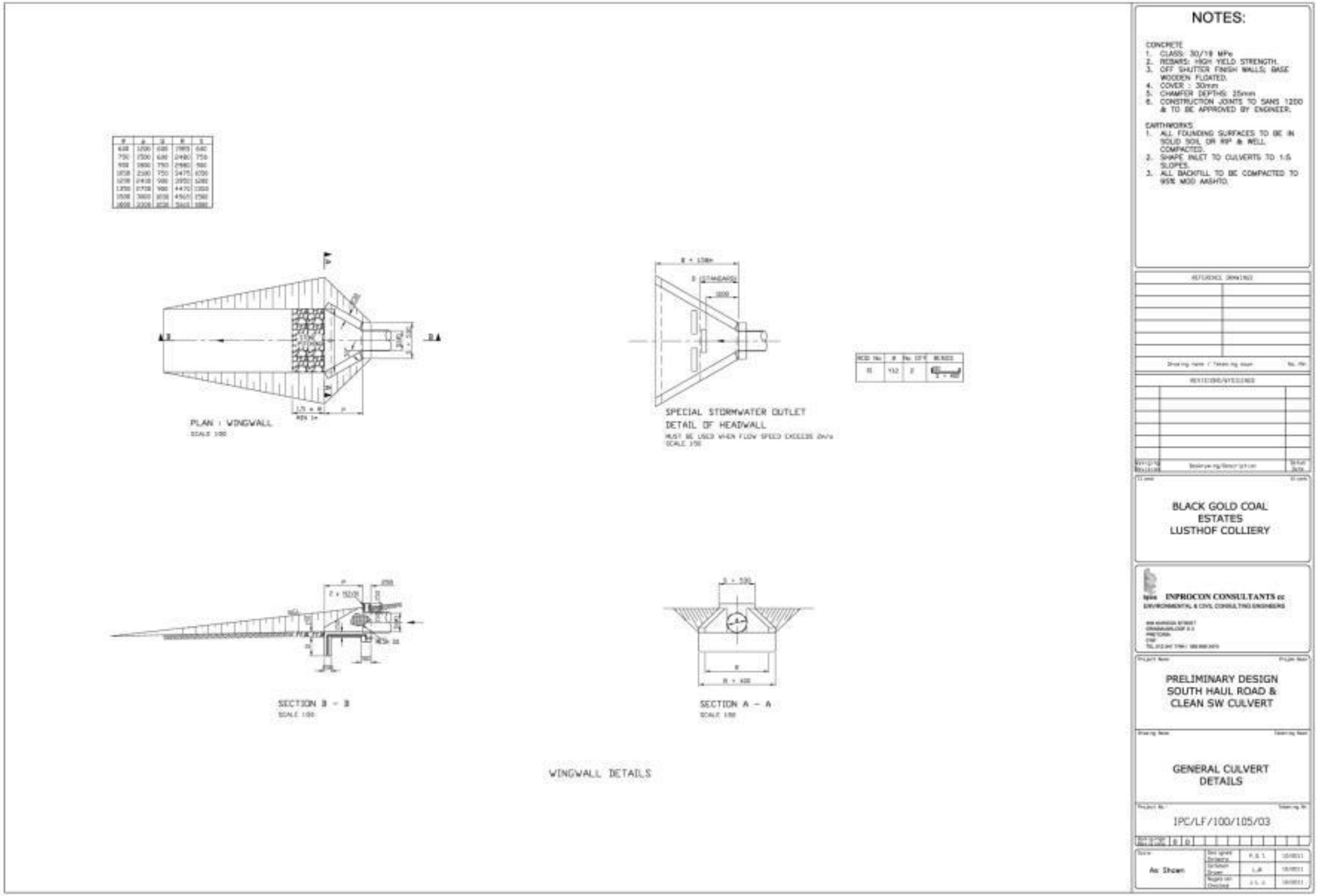


Figure 3.1.5.13.4 (c): Clean Water Culvert and South Haul Road - General Culvert Details.

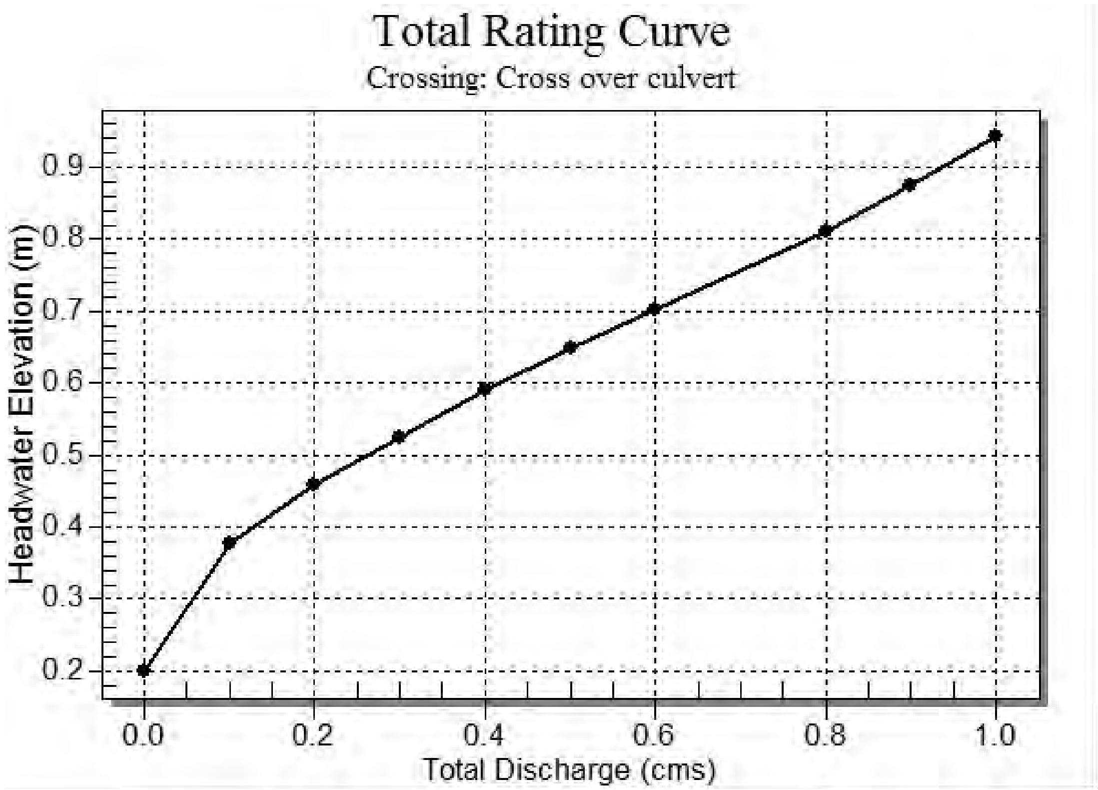
3.1.5.13.5 Cross-Over Structures

The purpose of the cross-over structures are to allow clean water to flow across the dirty water drain without being contaminated or mixing with the dirty water. The cross-over structures will consist of 2 x 600 mm diameter pipe culverts with a concrete inlet structure and bund walls to intercept clean water from the rehabilitated upslope areas and a concrete outlet structure to discharge the clean water on the downstream side of the dirty water drain. The outlet of the culvert will be protected against erosion by means of gabions or mattresses. Typical details of the crossing are shown in drawing no. IPC/LF/100/104/03 in Figure 3.1.5.13.5(a).

The design parameters for the cross-over culverts are as follows:

• Maximum catchment area	=	28 000 m^2
• Maximum 1:50 year flood peak	=	850 ℓ/s
• Length of pipe culvert	=	6.0 m
• Maximum flow velocity in culvert	=	3.60 m/s
• Water head at inlet	=	0.50 m
• Height of headwall	=	0.80 m
• Gradient of culvert pipes	=	1:12.5

The rating curve for the culvert is shown below.



Details of the culvert's flow characteristics are shown in Table 3.1.5.13.5(a).

Table 3.1.5.13.5 (a): Flow Characteristics of Clean Water Cross-over Culvert.

Total Discharge (cms)	Culvert Discharge (cms)	Headwater Elevation (m)	Inlet Control Depth (m)	Outlet Control Depth (m)	Flow Type	Normal Depth (m)	Critical Depth (m)	Outlet Depth (m)	Tailwater Depth (m)	Outlet Velocity (m/s)	Tailwater Velocity (m/s)
0.00	0.00	0.20	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
0.20	0.20	0.46	0.257	0.257	1-S2n	0.089	0.200	0.090	0.043	3.646	0.773
0.40	0.40	0.59	0.391	0.391	1-S2n	0.130	0.288	0.156	0.064	3.386	1.015
0.60	0.60	0.70	0.501	0.501	1-S2n	0.160	0.357	0.201	0.082	3.603	1.183
0.80	0.80	0.81	0.612	0.612	5-S2n	0.187	0.414	0.241	0.098	3.764	1.321
0.90	0.90	0.87	0.674	0.674	5-S2n	0.198	0.438	0.259	0.105	3.841	1.384
1.00	1.00	0.94	0.743	0.743	5-S2n	0.209	0.461	0.277	0.112	3.921	1.441

As an alternative a typical culvert crossing underneath the dirty water drain has also been designed. This type of crossing could be used where it is topographically favourable to discharge clean storm water by means of a culvert below the dirty water drain rather than over the drain. Preliminary details of such a crossing are shown in drawing no. IPC/LF/100/104/04 in Figure 3.1.5.13.5 (b).

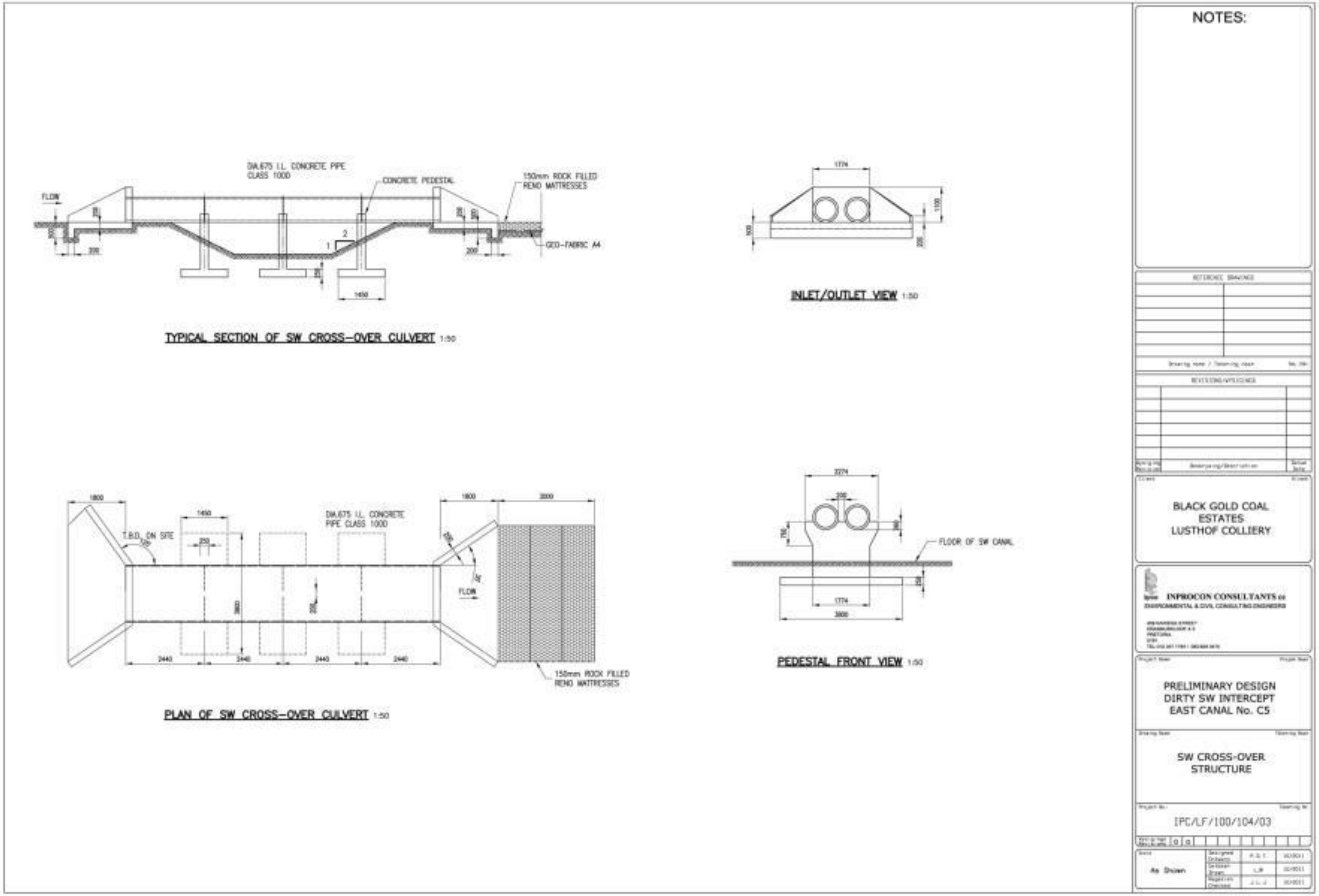


Figure 3.1.5.13.5 (a): Storm Water Cross-Over Structure.

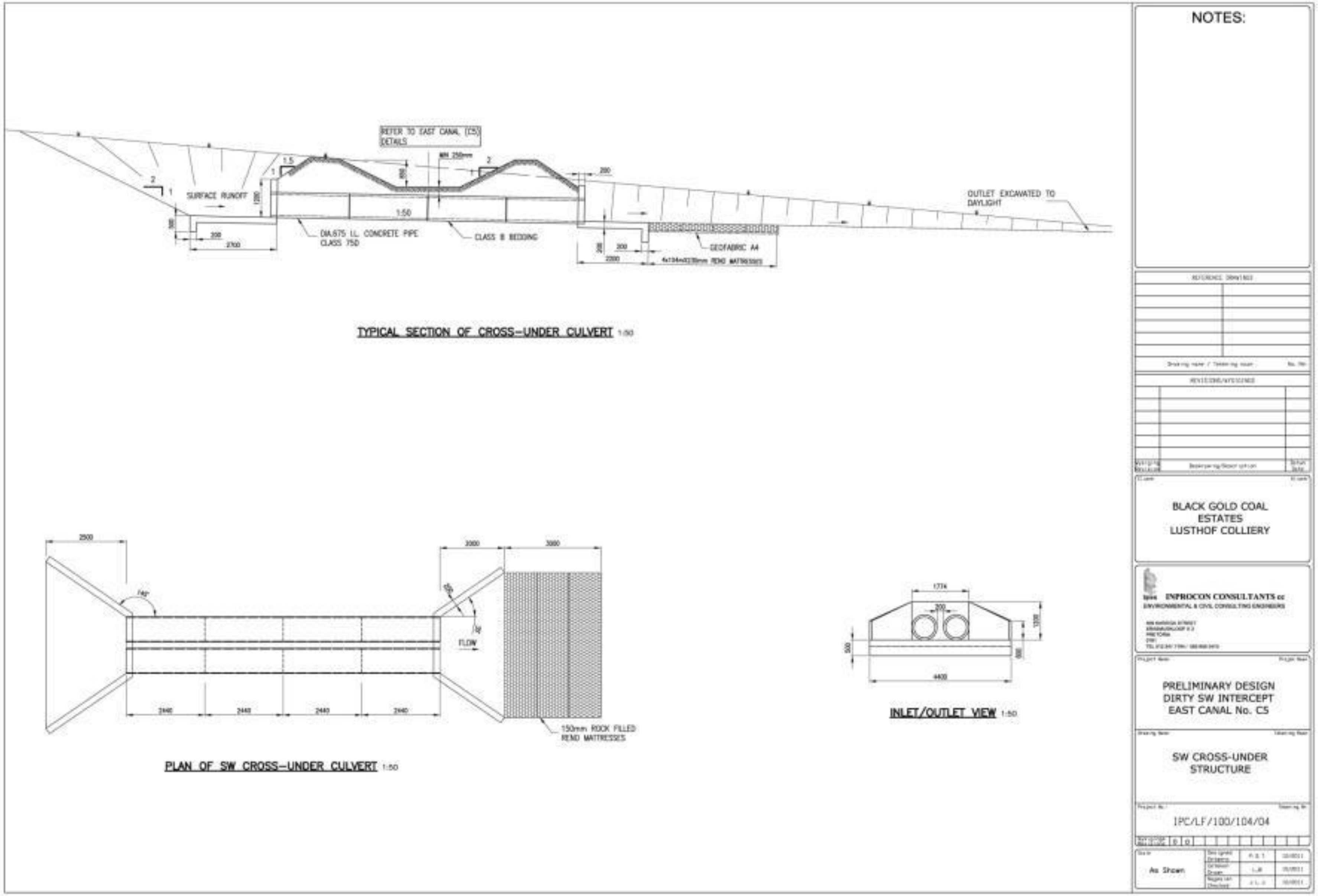


Figure 3.1.5.13.5 (b): Storm Water Cross-Under Structure.

3.1.5.13.6 Silt Traps / Settling Ponds

Two silt traps / settling ponds will be constructed where the dirty water from the western diversion drainage channel and the northern diversion drain is discharged into the PCD. An overflow will be provided in each silt trap / settling pond for discharging into the PCD.

The layout and typical details for the silt trap / settling pond are shown in drawings no. IPC/LF/100/106/01 and 02 in Figure 3.1.5.13.6 (a) and Figure 3.1.5.13.6 (b). The silt trap on the northern side of the PCD will be sized to accommodate the average flow rate and to allow particles in suspension to settle out before overflowing occurs into the PCD.

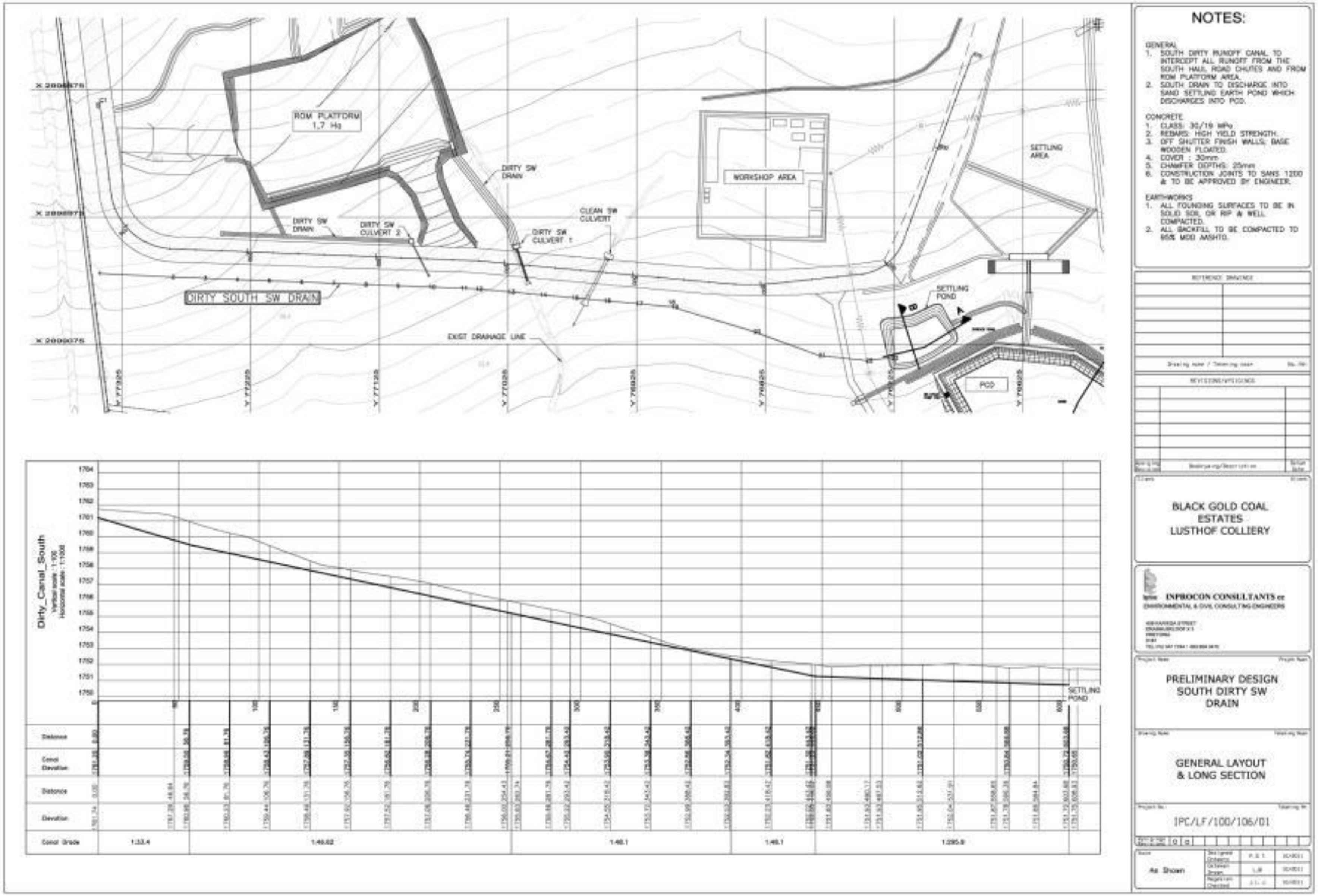


Figure 3.1.5.13.6 (a): South Dirty Surface Water Drain and Settling Pond - General Layout.

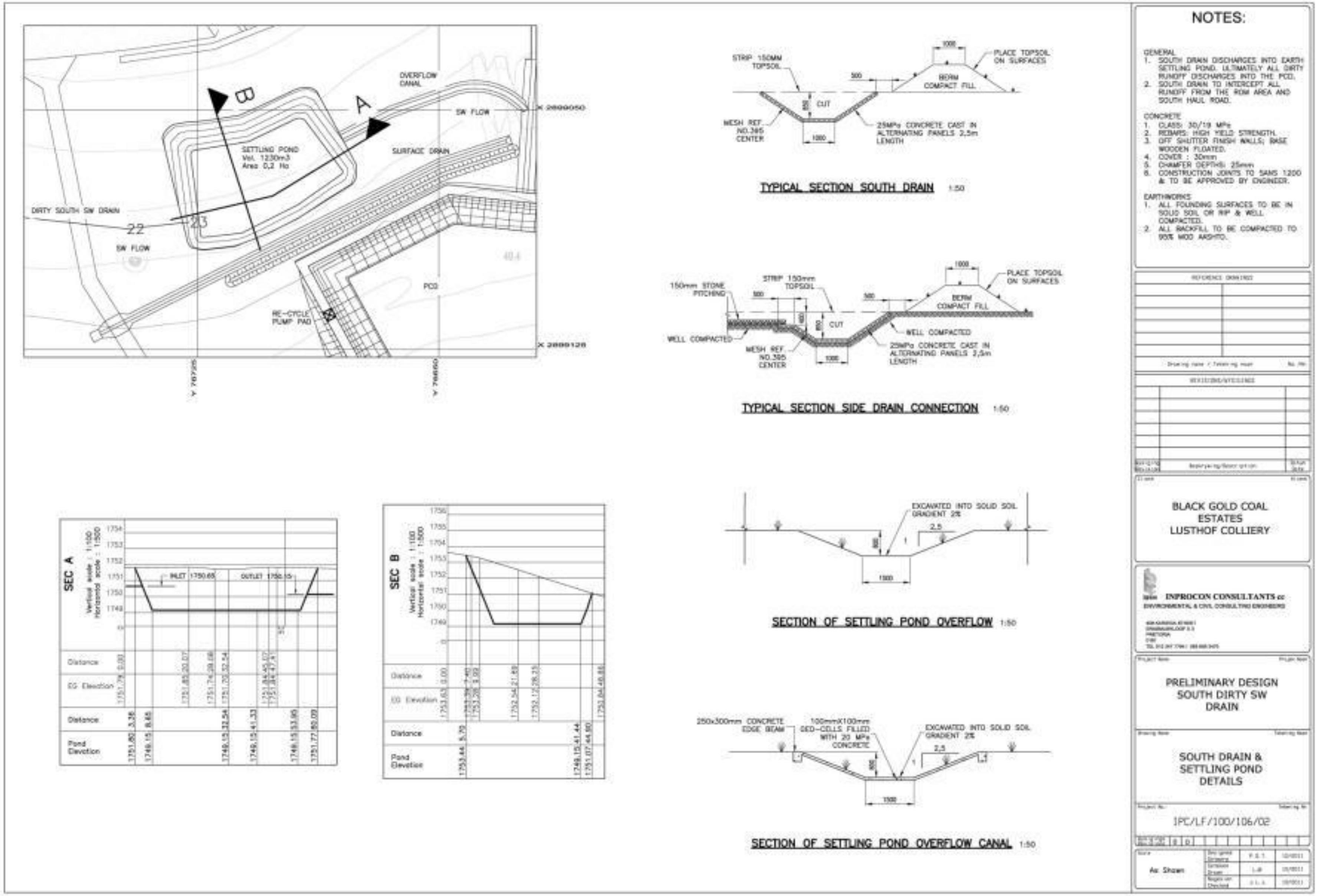


Figure 3.1.5.13.6 (b): South Dirty Surface Water Drain and Settling Pond - Drain and Settling Pond Details.

3.1.5.13.7 Clean Storm Water Diversion Pond

The purpose of the Clean Water Diversion Pond (CWDP) is to catch clean water run-off via a diversion berm for temporary storage and use before the water is discharged into the open pit where it will be contaminated with dirty water. Excess clean storm water will be allowed to overflow from the CWDP and be discharged into the natural environment via another diversion berm at the overflow structure.

The design parameters are as follows:

- Maximum storage volume = 9 800 m^3
- Average depth = 1.60 m
- Average surface area = 6 000 m^2
- Maximum wall height = 6.4 m
- Length of crest = 175 m
- Crest width = 3.0 m
- Upstream slope = 1V:2H
- Downstream slope = 1V:2H
- Freeboard = 0.80 m
- Slope stability: Minimum Factor of Safety= 1.30
- Embankment material (USCS) = SC; ML or CL

The dam will be constructed of clayey/sandy material with waste rock on the upstream slope, with topsoil and grassing on the downstream slope for erosion protection. The layout and typical details for the CWDP are shown in drawing no. IPC/LF/100/103/01 in Figure 3.1.5.13.7 (a).

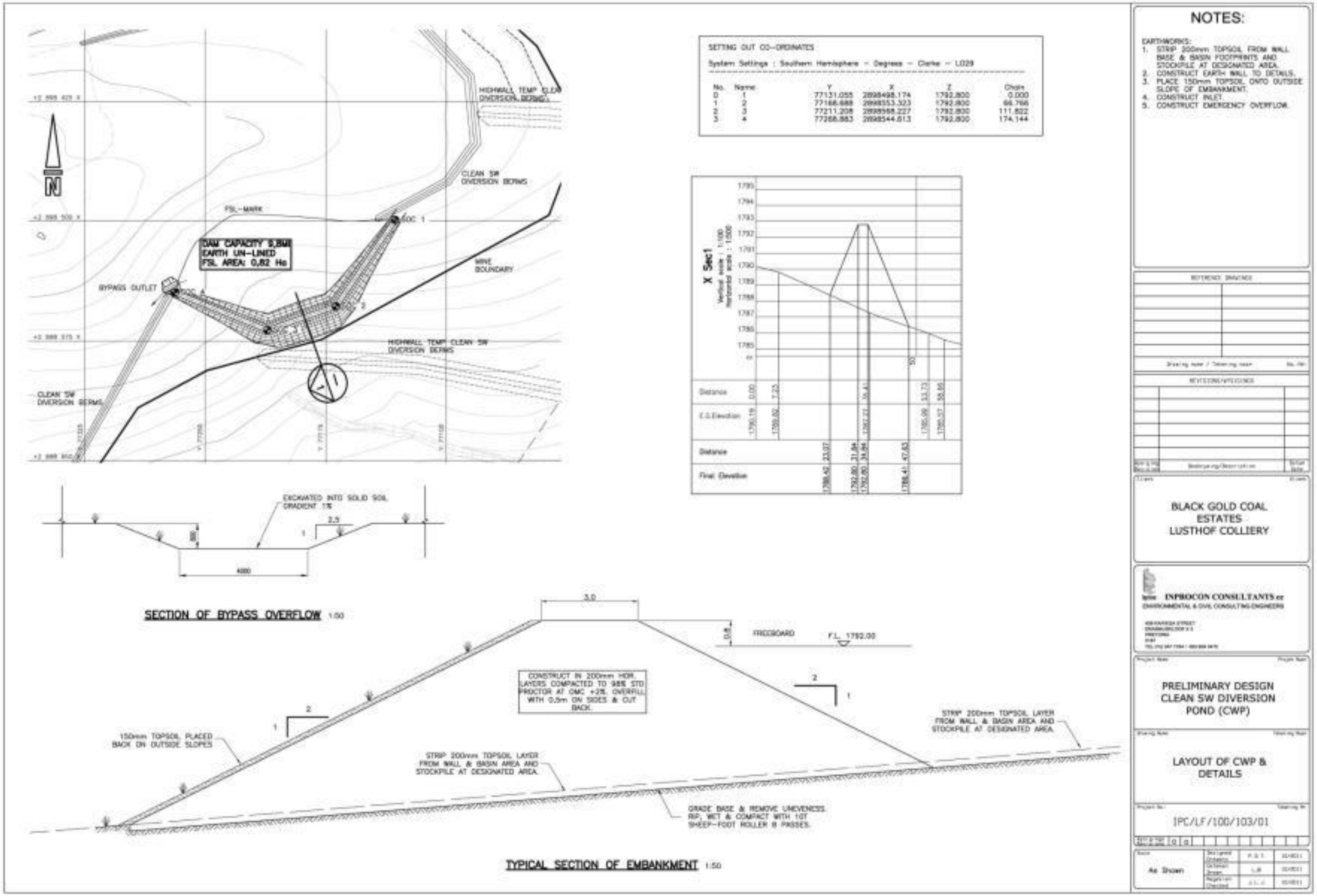


Figure 3.1.5.13.7 (a): Clean Water Diversion Pond - Layout and Details.

3.1.5.13.8 Storm Water Pollution Control Dam

The purpose of the Strom Water Pollution Control Dam (PCD) is to catch and contain dirty water run-off from contaminated mining areas via diversion berms and interception drains for storage, evaporation and use for dust suppression on internal mine haul roads. Before the dirty water is discharged into the PCD it is routed through a system of settlement ponds / silt traps in order to settle out any silt in suspension before discharging into the PCD.

No water will be allowed to overflow from the PCD into the natural environment, except in the case of extreme events where floods exceed the 1:50 year design flood peak and the flood volume exceeds the 1:50 year 24 hour flood volume. In such a case the excess flows will be discharged via the trapezoidal emergency spillway on the south-eastern side of the dam.

The design parameters are as follows:

- Maximum storage volume = 19 000 m^3
- Average depth = 2.35 m
- Average surface area = 8 100 m^2
- Maximum wall height = 4.5 m
- Length of crest = 420 m
- Crest width = 3.0 m
- Upstream slope = 1V:3H
- Downstream slope = 1V:2H
- Freeboard = 0.80 m
- Slope stability: Minimum Factor of Safety= 1.30
- Spillway capacity (3m base width) = 4.80 m^3/s

The dam will be constructed of clayey/sandy material with a 1.5 mm HDPE lining on the inside and grassing on the downstream slope for erosion protection. A herringbone seepage collection drain under the base of the dam will be constructed to intercept any leakage through the HDPE membrane. The under drain will be connected to a collection sump from where the collected seepage water will be pumped back into the PCD.

The layout and typical details for the PCD are shown in drawings no. IPC/LF/100/100/01 to 05 in Figures 3.1.5.13.8 (a) through 3.1.5.13.8 (e).

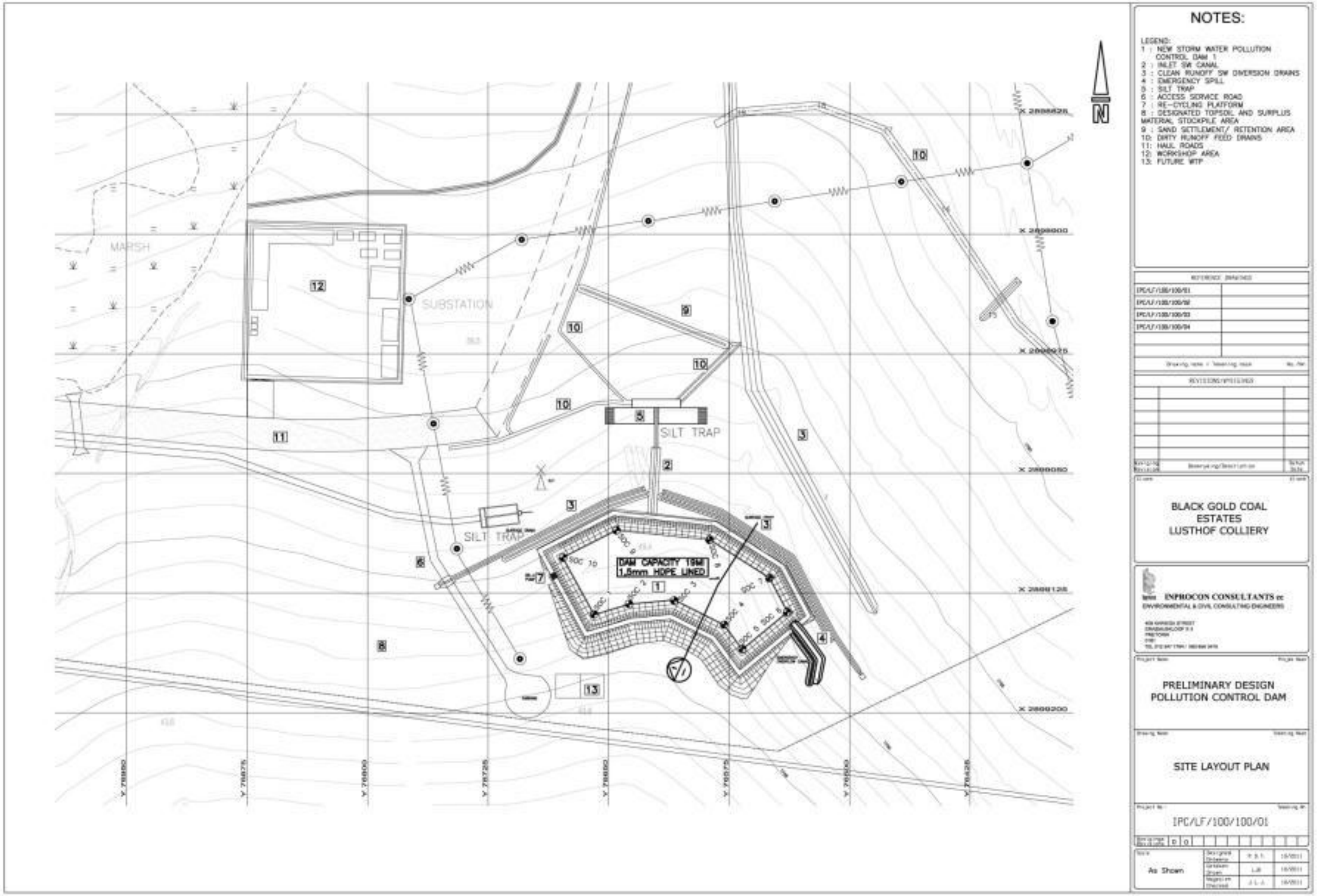


Figure 3.1.5.13.8 (a): Pollution Control Dam - Site Layout Plan.

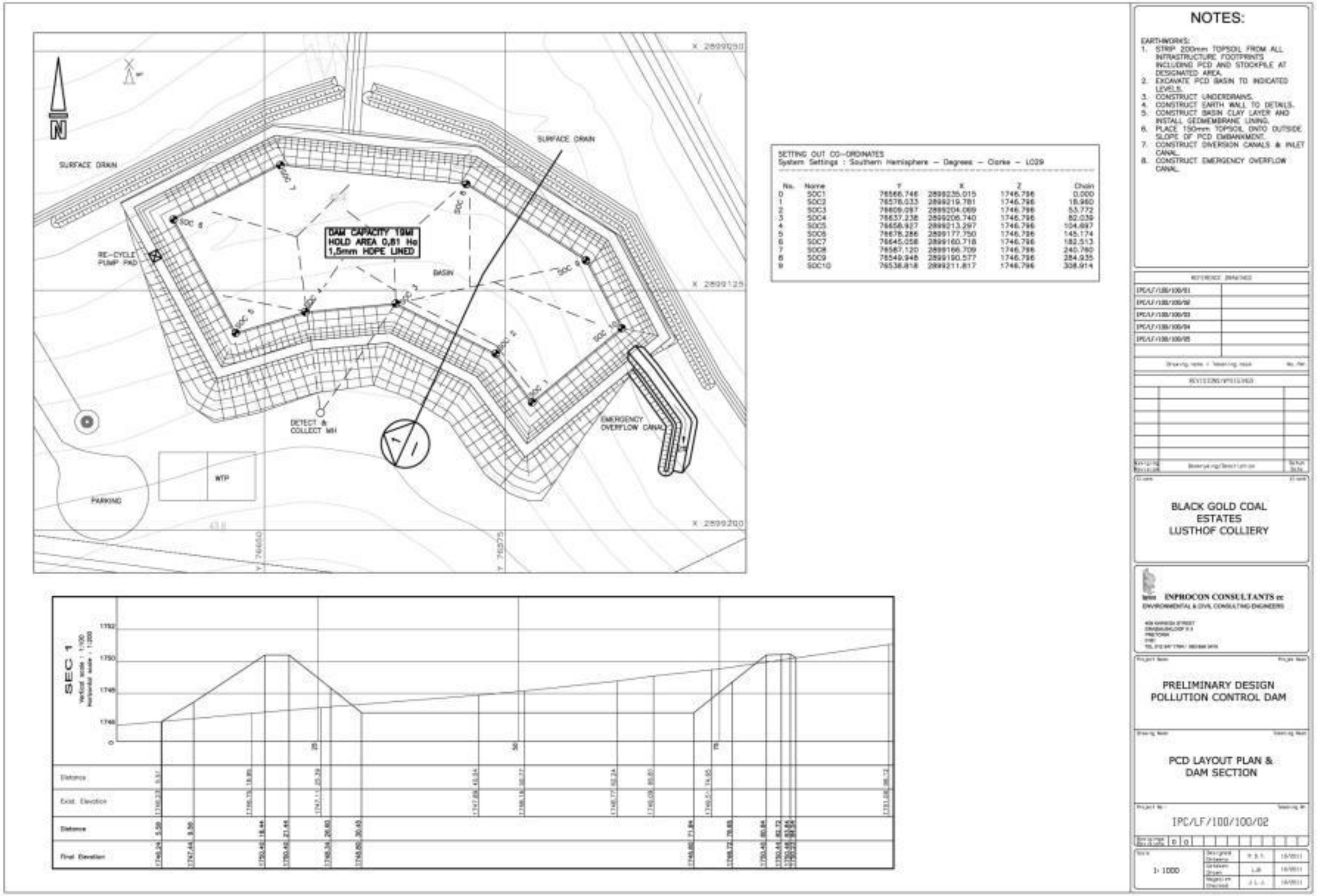


Figure 3.1.5.13.8 (b): Pollution Control Dam - Layout Plan and Dam Section.

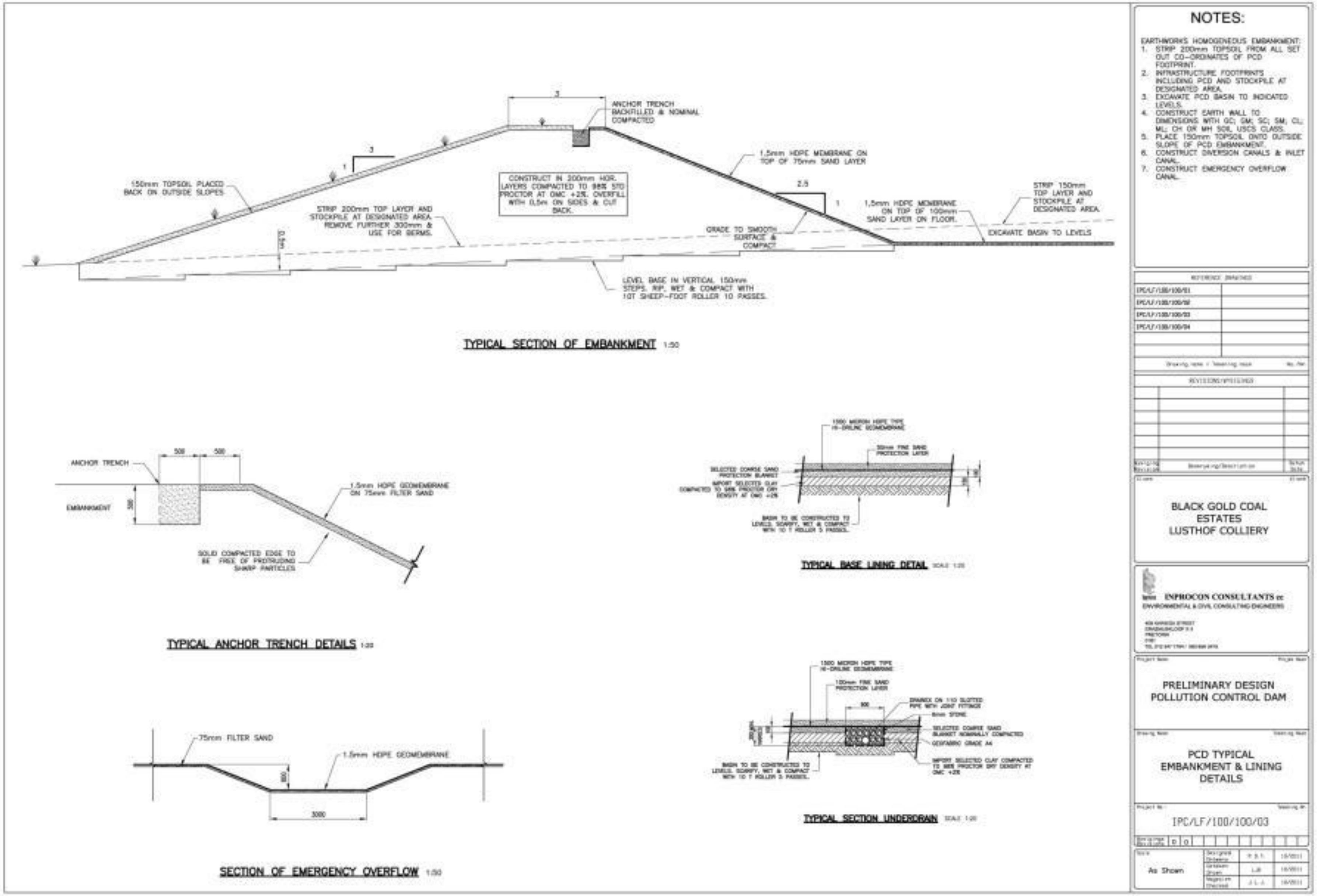


Figure 3.1.5.13.8 (c): Pollution Control Dam - Typical Embankment and Lining Details.

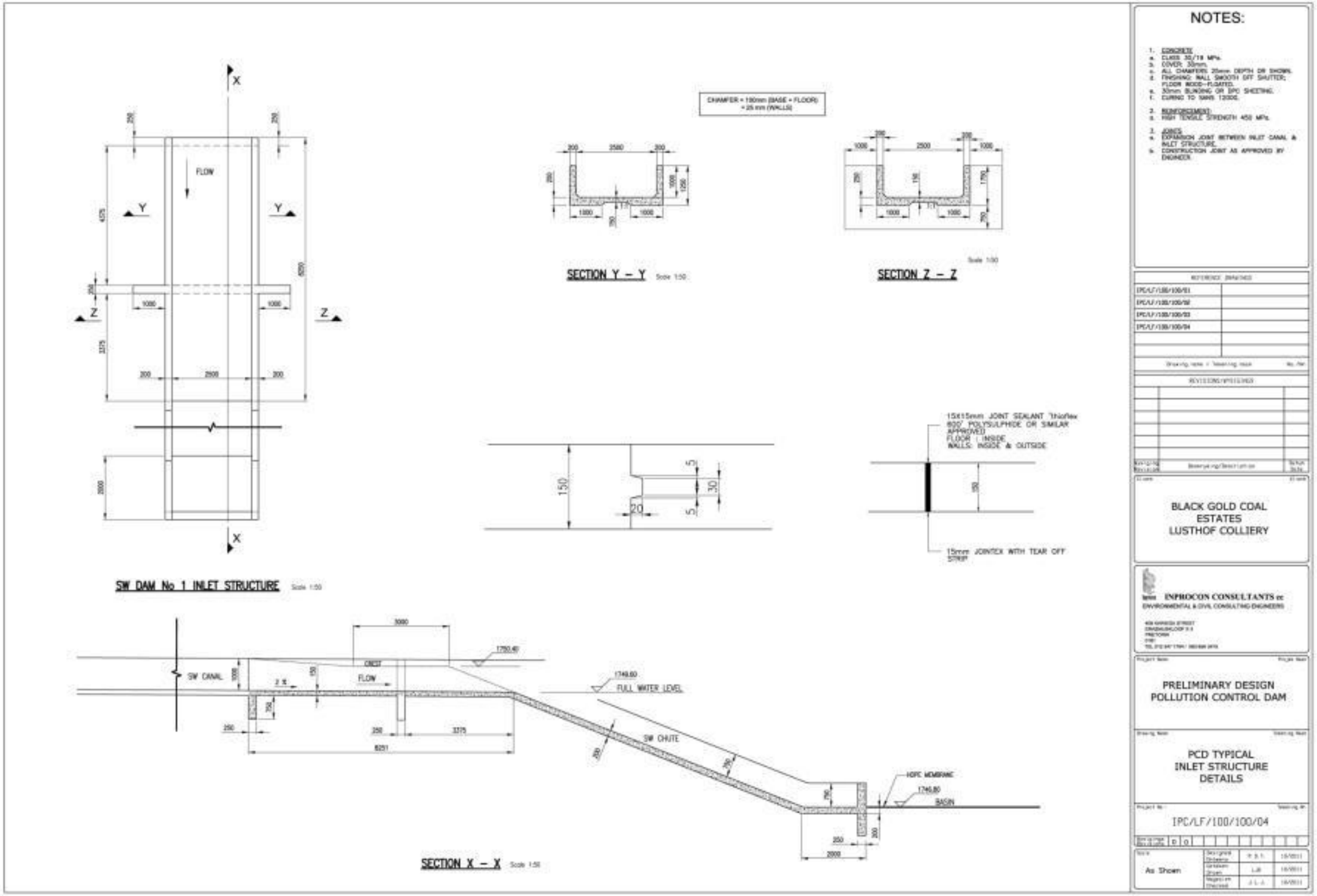


Figure 3.1.5.13.8 (d): Pollution Control Dam - Typical Inlet Structure Details.

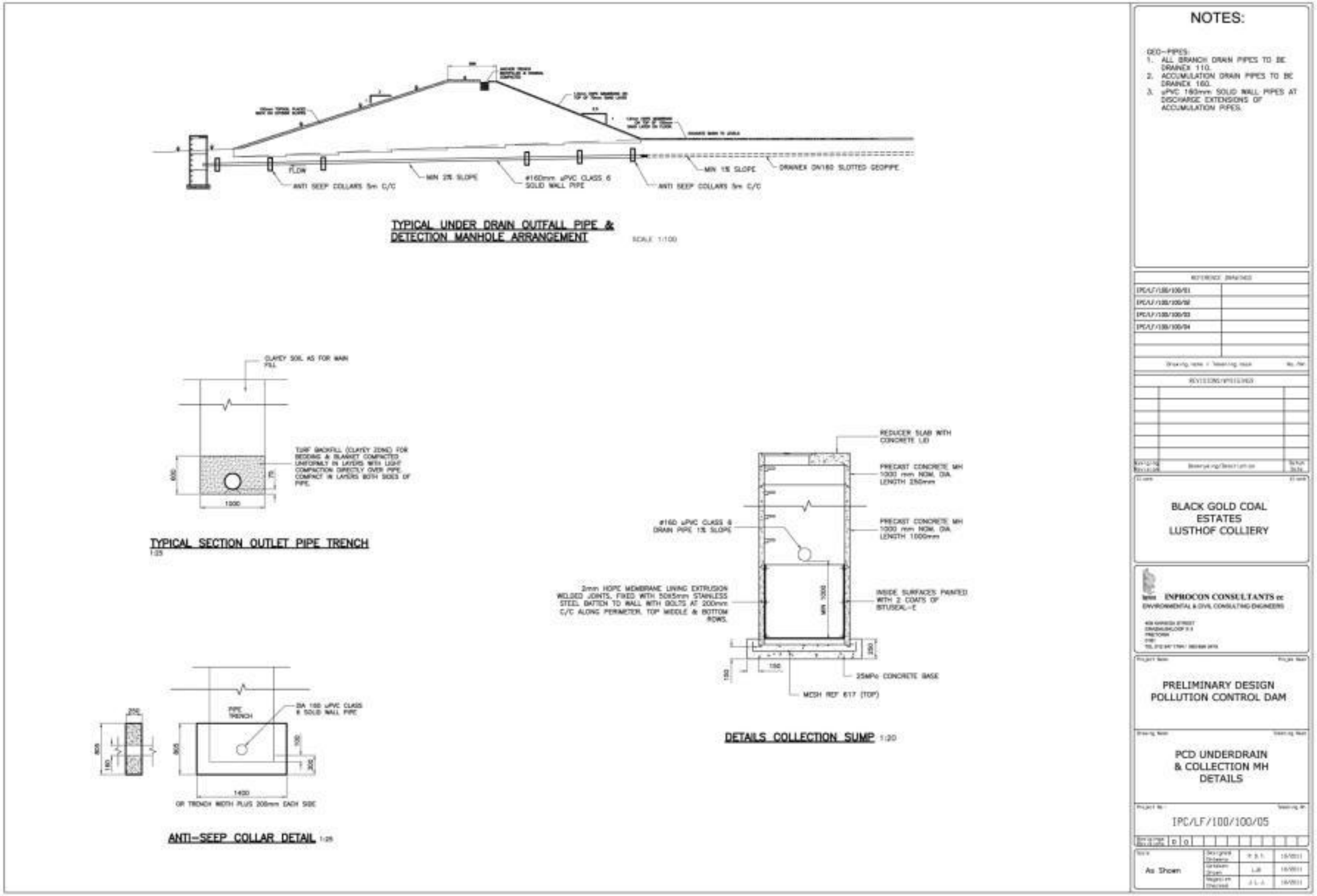


Figure 3.1.5.13.8 (e): Pollution Control Dam - Underdrain and Collection Man Hole Details.

3.1.5.13.9 Storm Water Dirty Water Dam

The purpose of the Dirty Water Dam (DWD) is to catch and contain surface water run-off and silt generated from the areas where the hards stockpiles will be placed via diversion berms/drains for storage, evaporation and use for dust suppression on internal mine haul roads. No water will be allowed to overflow from the DWD into the natural environment, except in the case of extreme events where floods exceed the 1:50 year design flood peak and the flood volume exceeds the 1:50 year 24 hour flood volume. In such a case the excess flows will be discharged via the trapezoidal emergency spillway on the northern side of the dam.

The design parameters for the DWD are as follows:

- Maximum storage volume = 37 000 m^3
- Average depth = 2.70 m
- Average surface area = 14 000 m^2
- Maximum wall height = 6.10 m
- Length of built up embankment crest = 375 m
- Crest width = 3.0 m
- Upstream slope (poor foundation) = 1V:3H
- Upstream slope (good foundation) = 1V:2.5H
- Downstream slope (sufficient space) = 1V:2H
- Downstream slope (insufficient space) = 1V:1.5H
- Freeboard = 0.80 m
- Slope stability: Minimum Factor of Safety= 1.30
- Spillway capacity (3m base width) = 4.80 m^3/s

The dam will be constructed of clayey/sandy material with a 1.5 mm HDPE lining on the inside and grassing on the downstream slope for erosion protection. Allowance has been made for an HDPE lining at this stage. However, the HDPE lining may not be required subject to the availability of suitable clayey material and the water quality testing results from the leachates generated in the hard and soft material stockpiles near the DWD.

The layout and typical details for the DWD are shown in drawings no. IPC/LF/100/102/01 and 02 in Figure 3.1.5.13.9 (a) and Figure 3.1.5.13.9 (b).

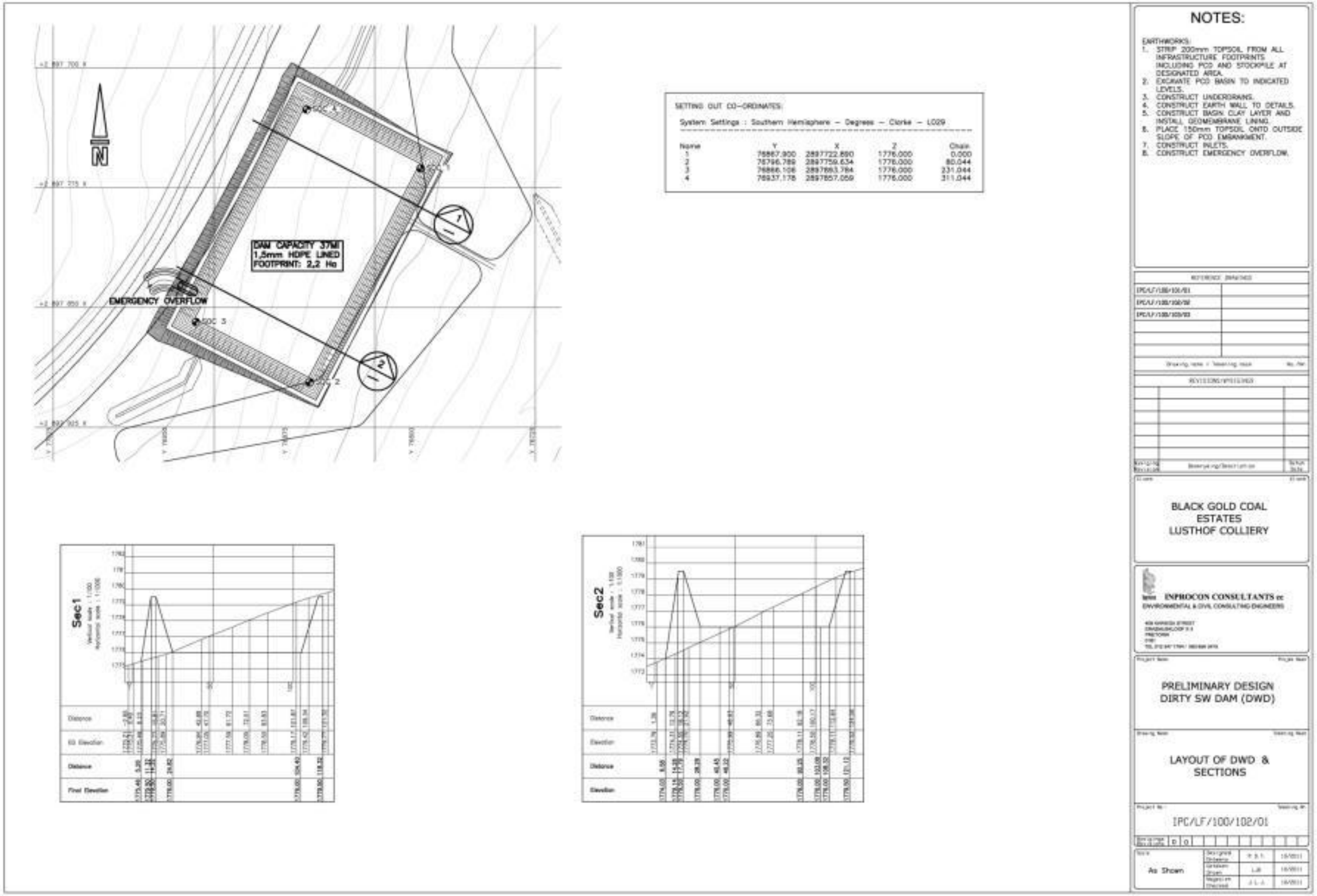


Figure 3.1.5.13.9 (a): Dirty Water Dam - Layout and Sections.

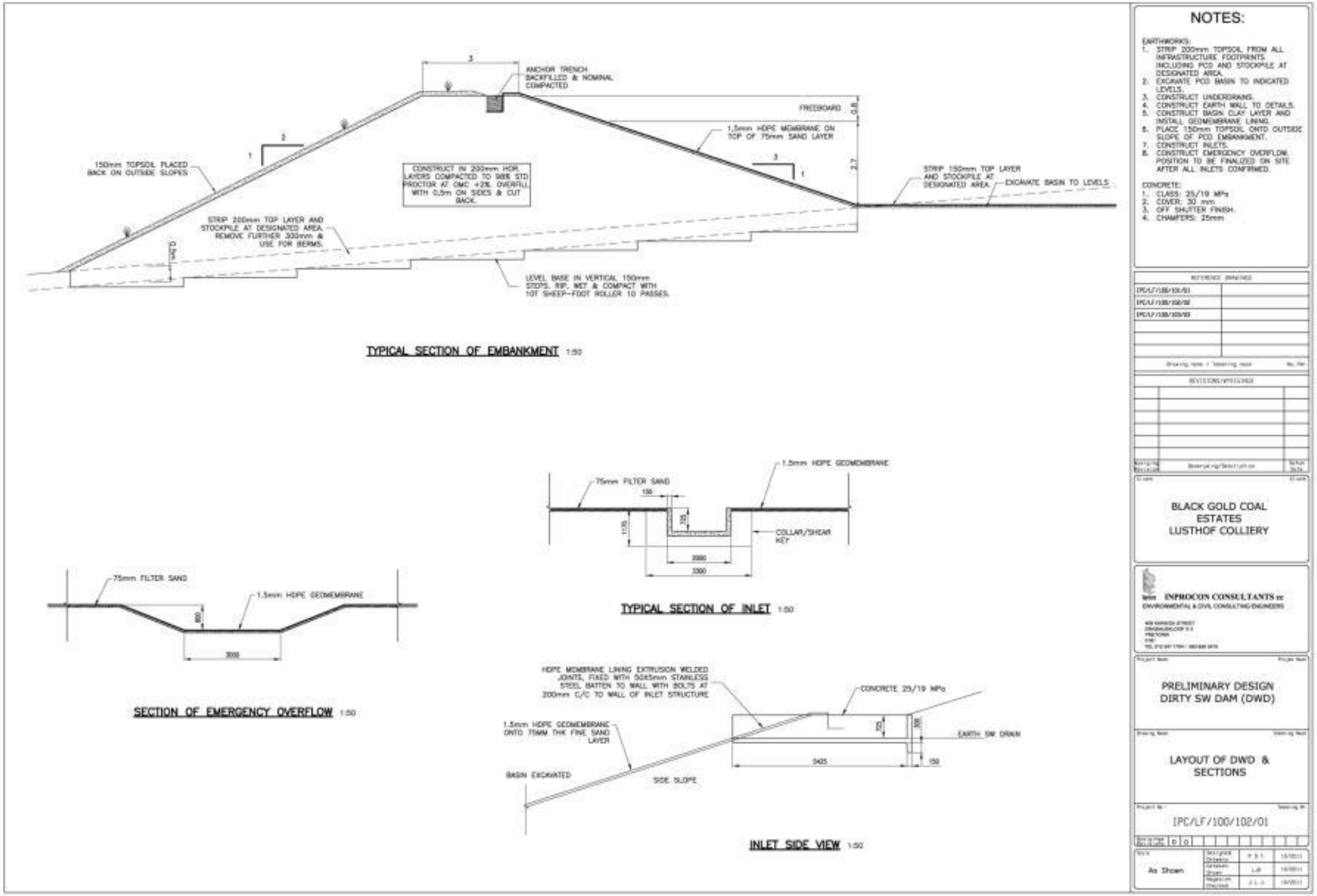


Figure 3.1.5.13.9 (b): Dirty Water Dam - Typical Embankment, Inlet and Overflow Details.

3.1.5.13.10 ROM Stockpile Platform and Drains

The design parameters for the ROM stockpile platform are dependent on the requirements for the proposed storm water management system, as well as on the findings of the ground water impact assessment related to possible contamination of the underlying ground water system as a result of possible AMD generation and subsequent infiltration into the sub-surface.

The ground water impact assessment indicated that provided that the effective roll over protocol of the coal footprint areas on the ROM Stockpile platform is adhered to, a low permeability footprint needs to be affected at a design permeability of $1x10^{-6}$ cm/s.

The ROM stockpile will be placed on an engineered platform with a drainage channel on its perimeter to isolate the stockpile area and capture all surface water run-off and discharge it via an open lined drain and settling pond / silt trap into the Pollution Control Dam. A dirty storm water diversion berm/drain will be constructed along the lower side of the haul road on the northern side of the ROM stockpile platform in order to isolate and divert contaminated upslope surface water generated from the haul road and mining area into the perimeter drain of the ROM stockpile.

The design parameters for the ROM platform are as follows:

- Surface area of ROM platform =17 000 m^2
- In-situ compaction of bed material to CBR of 8%
- Main fill compacted to minimum CBR of 15%
- 4 x 150 layers waste rock and gravel fill
- 1 x 150 mm G4 sub-base layer compacted to 95% Mod AASHTO density
- 1 x 150 mm G4 base course layer compacted to 98% Mod AASHTO density, stabilised with cement or bentonite to achieve permeability of less than $1x10^{-6}$ cm/s
- Cross fall on platform north to south at an average slope of 1:125
- Cross fall on platform west to east at an average slope of 1:200
- Access roads/ramps to be provided on the northern, southern and western sides of the platform, with a weighbridge installed on the western access road

All surface water generated on the ROM stockpile pad will be deemed dirty and the inflow of clean surface water onto the platform will be minimised by the installation of clean water diversion berms on the upslope side. The containment of contaminated surface water run-off from the platform will be by means of lined interception side drains at least 600 mm deep on the western and eastern perimeters and about 800 mm deep on the southern side which will then discharge via lined concrete channels into the south diversion drain discharging into the PCD. The longitudinal slopes of the drains will follow the natural and excavated or filled up contours along the perimeter of the ROM stockpile platform.

The design parameters for the ROM platform drains are as follows:

- Total catchment area per 10 m wide strip =1 000 m^2
- 1:50 year flood peak overland flow = 40 ℓ/s
- Depth of drain – west & east = 800 mm

- Bottom width of drain – west & east = 800 mm
- Depth of drain – south & discharge = 800 mm
- Bottom width of drain – south & discharge = 1 500 mm
- Side slopes of all trapezoidal drains = 1V:1.5H
- Height of storm water diversion berms = 1.0 m
- Crest width of SW diversion berms = 1.0 m
- Side slopes of SW diversion berms = 1V:1.5H

All platform drains will be lined with either Geo cells filled with concrete, Gobi blocks or Armorflex. The Geo cells and Armorflex will be underlain by a geofabric of Grade A4. The layout and typical details for the ROM Platform and Drains are shown in drawings no. IPC/LF/100/101/01 to 03 in Figures 3.1.5.13.10 (a) through 3.1.5.13.10 (c).

3.1.5.13.11 Provisional Capital Cost Estimate

For budgetary purposes a provisional cost estimate was prepared for the storm water management infrastructure and preparatory works required related to the development of the opencast mine. The cost estimate is tabulated below:

Project: Lusthof New Mine - Preliminary Infrastructural Cost Estimate (November 2011)					
No	**Item**	**uom**	**Qty**	**Rate**	**Total**
1	**Pollution Control Dam**				
1.1	Dam wall	m3	13 700	40	548 000
1.2	Dam Lining	m2	10 000	65	650 000
1.3	Ancilliaries	Sum	1	300 000	300 000
2	**Dirty Water Dam**				
2.1	Dam wall - cut to fill	m3	19 200	40	768 000
2.2	Dam Lining	m2	18 400	65	1 196 000
2.3	Ancilliaries	Sum	1	170 000	170 000
3	**Clean Water Diversion Pond**				
3.1	Dam wall	m3	3 100	40	124 000
3.2	Dam foundation compaction	m2	6 800	20	136 000
4	**Canals, Berms & Culverts**				
4.1	Canal - east (cut to fill, trim & steps)	m3	7 600	45	342 000
4.2	Canal - south (cut to fill & trim)	m3	875	40	35 000
4.3	Canal - south (concrete lining & mesh)	m3	160	1 800	288 000
4.4	Berms	m3	7 600	30	228 000
4.5	Clean Water Culvert (1800 x 900)	No	1	300 000	300 000
4.6	Dirty Water Culvert (900 pipe)	No	2	100 000	200 000
4.7	Drains at ROM pad (cut to fill & trim)	m3	900	40	36 000
4.8	Lining for drains (geocells or armorflex)	m2	2 000	140	280 000
5	**Silt Traps & Settling Ponds**				
5.1	Settling pond at PCD from channel	Sum	1	80 000	80 000
5.2	Silt trap at PCD from up-slope areas	Sum	1	250 000	250 000
6	**Platforms & bases**				
6.1	ROM pad	m2	18 000	65	1 170 000
6.2	Contractor's yard	m2	10 000	50	500 000
7	**Roads**	No	20	4 500	90 000
7.1	Haul roads	km	2.0	600 000	1 200 000
7.2	New farm road diversion	km	1.0	300 000	300 000
7.3	Upgrade of existing farm road	km	0.8	100 000	80 000
8	Storm Water Crossings - clean water	No	15	40 000	600 000
9	**Pit Southern Abstraction**				
9.1	Boreholes & pumps	No	3	85 000	255 000
9.2	Pipeline	m	500	400	200 000
9.3	Sump	No	1	20 000	20 000
10	**Pit Eastern Abstraction**				
10.1	Boreholes & pumps	No	5	85 000	425 000
10.2	Pipeline	m	100	400	40 000
10.3	Sump	No	1	20 000	20 000
11	Water Treatment Plant	Sum	1	4 000 000	4 000 000
	Sub-Total				**14 831 000**
15	P & G	25%			3 707 750
16	Contingencies	10%			1 853 875
	Total				**20 392 625**

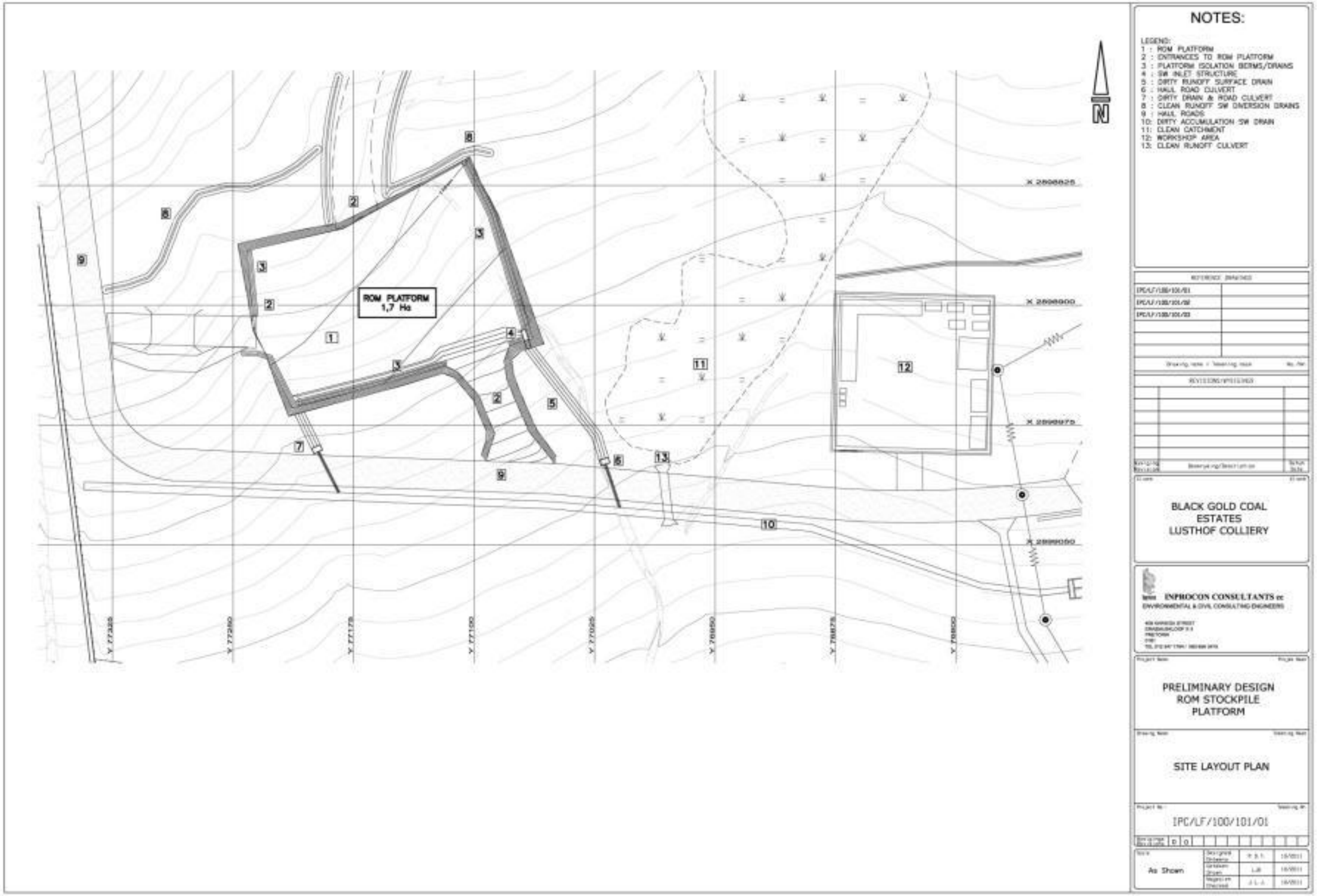


Figure 3.1.5.13.10 (a): ROM Stockpile Platform - Site Layout Plan.

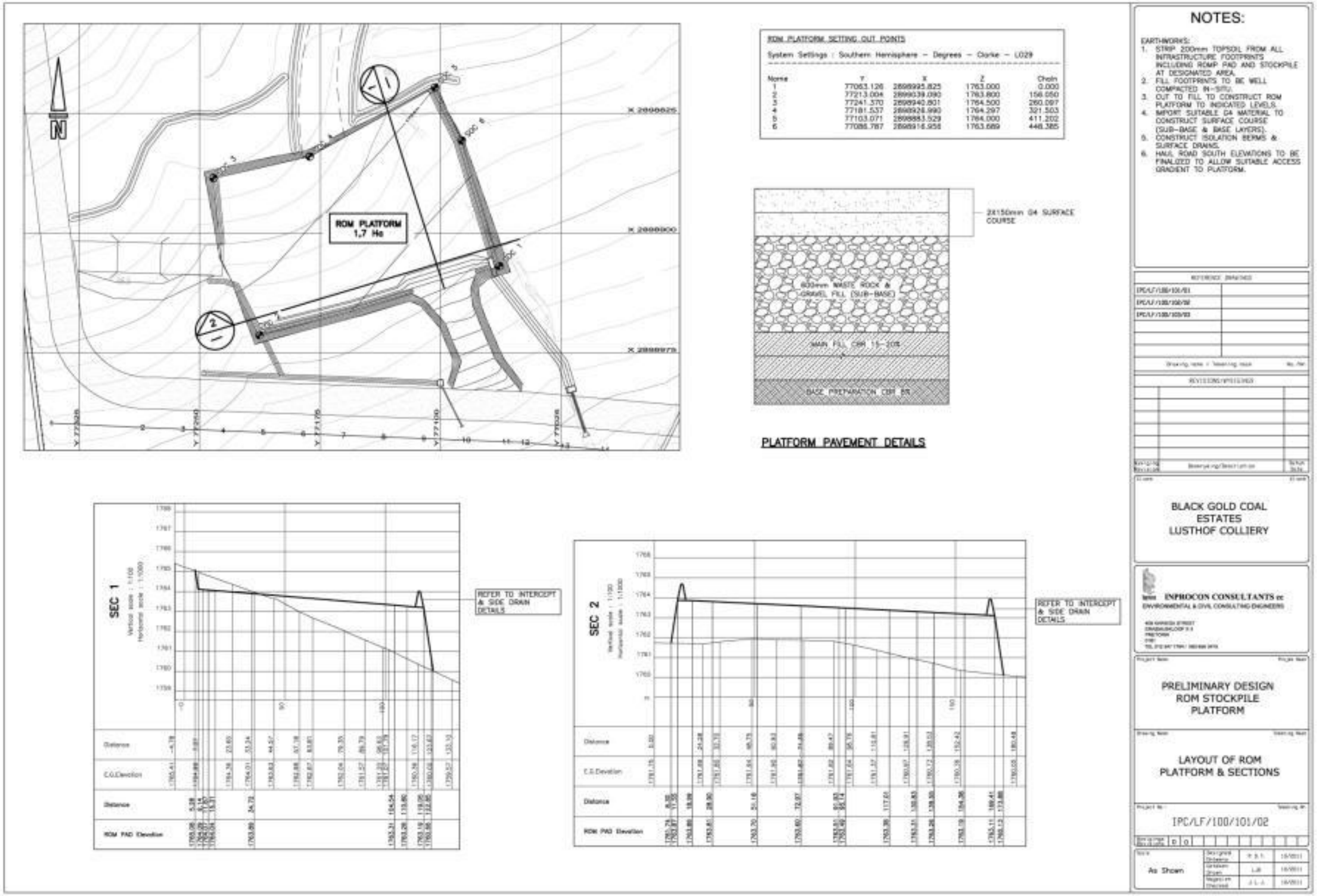


Figure 3.1.5.13.10 (b): ROM Stockpile Platform - ROM Platform Layout and Sections.

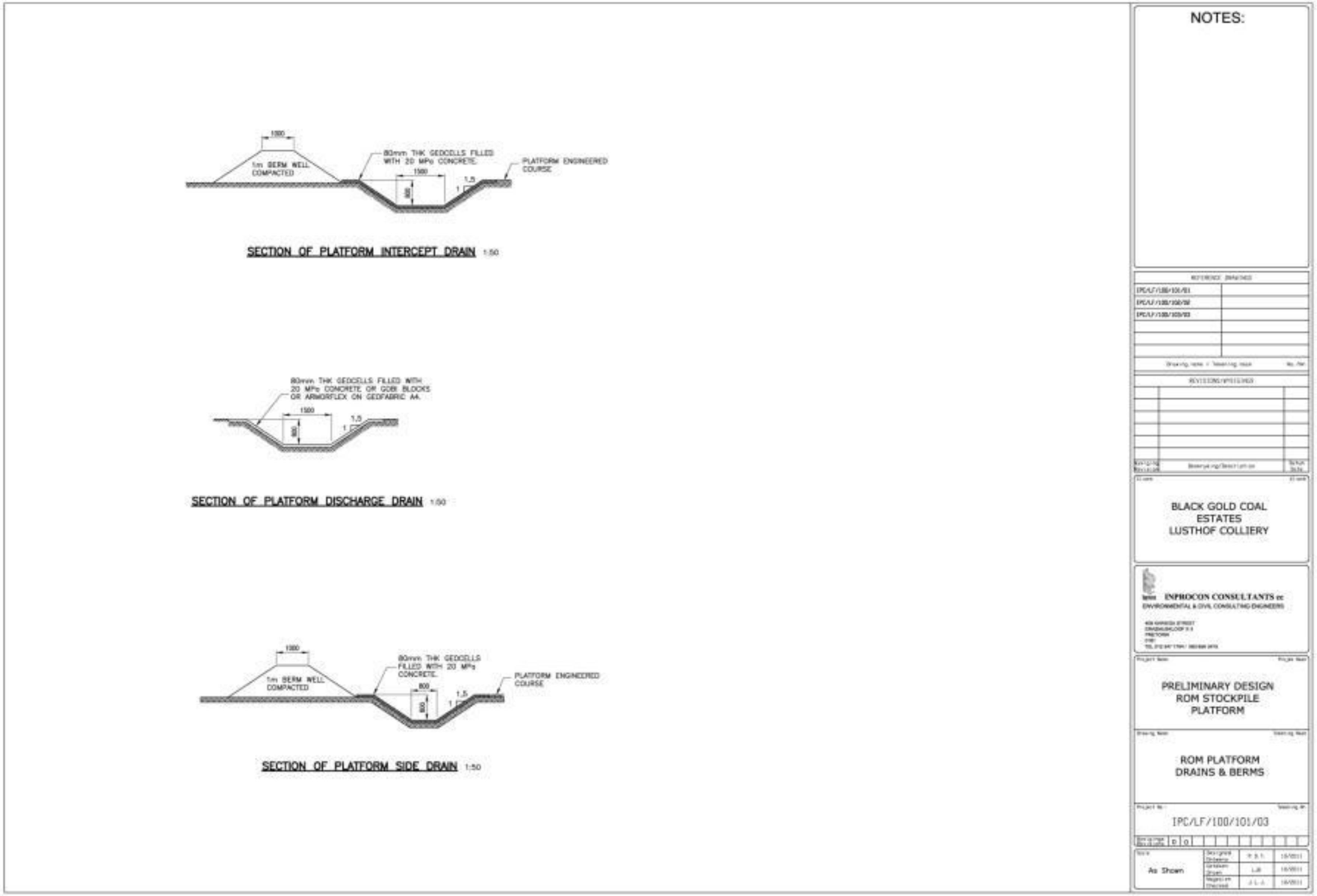


Figure 3.1.5.13.10 (c): ROM Stockpile Platform - Drains and Berms.

3.1.5.14 Mine Water & Ground Water Balance

The mine water and ground water balance refer to all water that will accrue to, and/or exit from the open cast mine workings during the construction, operational and post closure life cycle phases of the mine. It therefore represents a combined rainfall and ground water balance for the entire open pit area.

3.1.5.14.1 Life of Mine (LOM) Scheduling

The mining schedule at Lusthof Colliery is shown in Figure 3.1.5.14.1 (a). A Life of Mine (LOM) is suggested for a period of 8 years, with mining commencing in the south of the reserve. It is understandable that market conditions and spot contracts will necessitate mining of some sections at a faster or slower rate. Overall the total LOM is seen as 8 years (96 months). The total areas to be mined per year (based on a steady rate of mining) are given in Table 3.1.5.14.1 (a). These are the figures used in the water balance calculations for average rainfall events. To incorporate the extremities of seasonal rainfall, the mining progression are also shown on a quarterly basis:

Table 3.1.5.14.1 (a): Progressive Mining areas at Lusthof Colliery.

Mining year	Area mined per year (m^2)	Progressive area mined per year (m^2)	Area mined per quarter for given year (m^2)
Year 1	130 060	130 060	32 505
Year 2	98 033	228 093	24 508
Year 3	98 609	326 702	24 652
Year 4	96 733	423 435	24 183
Year 5	94 816	518 251	23 704
Year 6	99 711	617 962	24 927
Year 7	89 016	706 978	22 254
Year 8	100 434	807 412	25 109
TOTAL	807 412	807 412	

For the purposes of the LOM discussion and the progressive water balance, the following progressive mining sequence will be used in all calculations:

Un-mined area (Green-fields).	↑	Unaffected green fields, kept free-draining. Not included in water balance.
Pre-stripped area 1.		Removal of vegetation and topsoil.
Pre-stripped area 2.		Removal of vegetation and topsoil.
Overburden removal to top of coal seam.		Depending on width of strip, this can include part or most of pre-stripped area 2.
Active coal face.		Maximum Depth of mining. Void water to be collected in sump and pumped out.
40% dozed spoils and partially rehabilitated.		The strip directly the active cut will be partially rehabilitated.
100% compacted and fully rehabilitated spoils.		These strips will be compacted to the post-mining topo-graphical level.
Fully rehabilitated spoils that have been shaped, grassed and made free-draining away from active mining.		Post-mining rehabilitation: Residual settlement completed, seeded and grassed to rehabilitation standard.

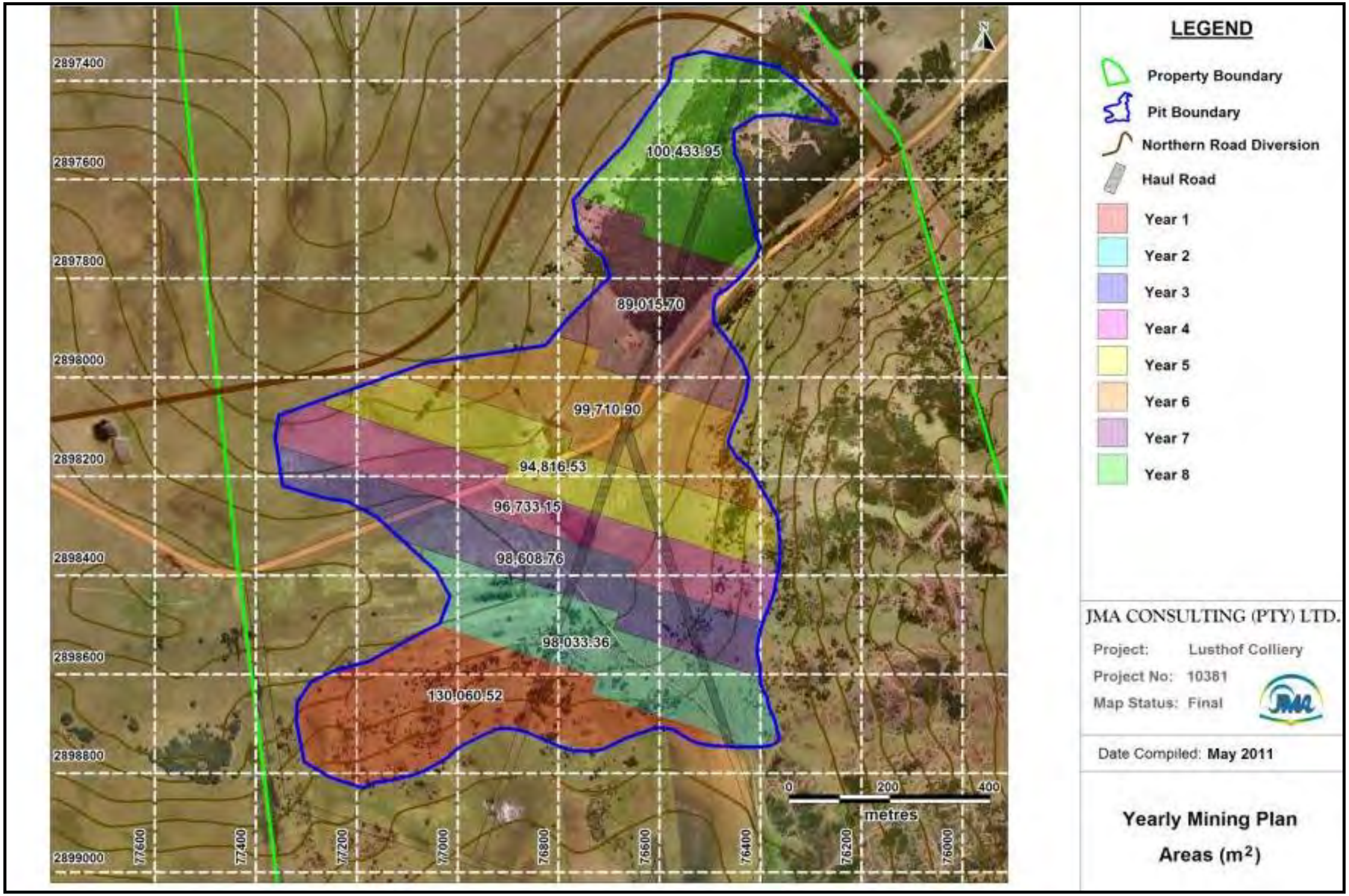


Figure 3.1.5.14.1 (a): Proposed 8 Year Mining Plan for Lusthof Colliery.

The mining sequence illustrated above will roll over as mining progresses. The active areas are:

- The pre-stripped areas.
- Overburden removal.
- The active coal face.
- The area of 40% dozed spoils.

Once the mining sequence reach equilibrium, all that will change is the reduction in un-mined areas and the increase in full rehabilitation strips (at the top and bottom of the sequence).

It should be noted that some changes were made to the initial proposed mining layout. The original mine schedule included some 15 ha coal reserve to be mined further to the south and south-east of the current layout (as can be seen in Figure 3.1.5.14.1(a)). These reserves are all below a surface elevation of 1770 *mamsl*. Since the south-eastern corner of the reserve is at the decant elevation, the mining layout was reduced considerably to prevent mining through the decant point of the reserve.

This environmentally friendly measure was critical in establishing the measures required for in-pit water management and the prevention of decant to surface. This will be illustrated in the section of the discussion dealing with the operational and post-closure phase water balance.

3.1.5.14.2 B-seam Floor Contour Elevations

Figure 3.1.5.14.2 (a) indicates the floor contour elevations of the B-coal seam. The elevation distribution is based on exploration data obtained from 31 exploration boreholes drilled in the reserve areas.

The final layout will change as more information becomes available (especially in the northern part of the reserve). The maximum change in elevation distribution is seen as less than 1m and will not change the mining layout or management measures to be implemented for water balance purposes.

From Figure 3.1.5.14.2 (a) the following conclusions can be drawn:

- The coal seam floor has a topographical low in the south at around 1751.4 mamsl. This is the lowest recorded value of all boreholes. Actual mining in the area can influence this elevation by ±1m.

- The coal seam floor dips up towards the NW and N to a central high of 1777.6 mamsl in the top northern section. The most northern 10% of the reserve dips slightly down to an elevation of around 1774 mamsl, although this has to be confirmed by drilling/mining activities.

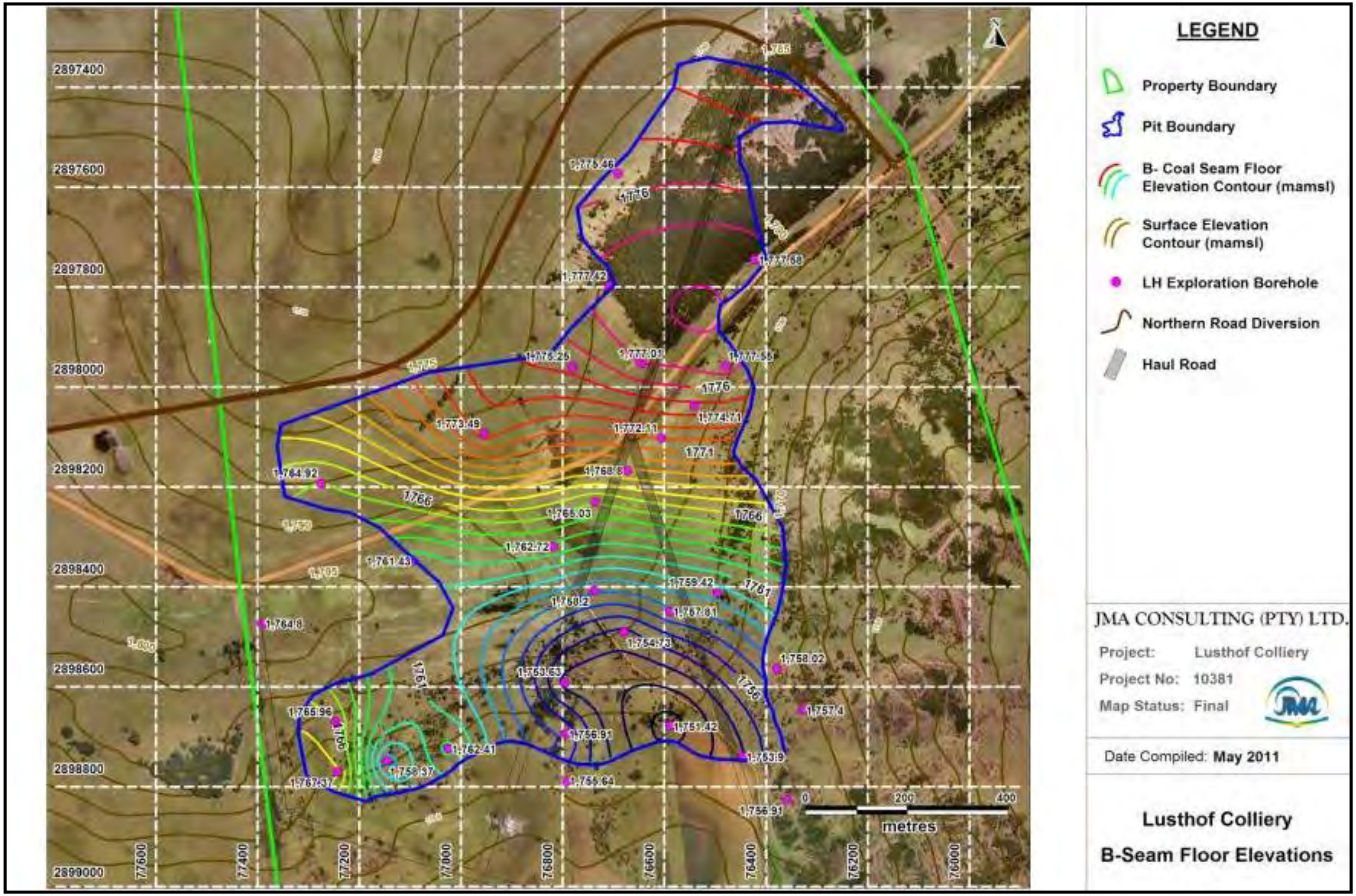


Figure 3.1.5.14.2 (a): B Coal Seam Floor Elevation Contours (mamsl).

- The reason for changing the mine layout becomes apparent.

  - Firstly, the design was changed from a north-to-south layout to that of a south-to-north layout, to ensure that mining will always be up-gradient. In this way storage of dirty water can be established in the partially and fully rehabilitated spoils in the south of the reserve (below surface elevation 1770 mamsl).

  - Secondly, the initial mine plan provided for mining some 15ha of coal in the topographical low areas in the SW of the reserve. This would have meant that mining would take place down to topographical lows of ~1755. This would have left little to no storage space available in-pit for water balance management. No in-pit decant control would have been possible, and the size of the dirty water dam on surface would have been bigger by some margin.

Also to be considered is the post-mining measures to be implemented to drain water from the northern portion of the reserve through the "saddle" at 1777 mamsl. Final haul road cutting to an elevation of 1774 mamsl (without full compaction) is suggested. This highly permeable strip will allow for pit water to drain to the south. All in-pit decant will be handled in the south at the proposed Environmentally Safe Water Level (**ESWL**). This level is 5m below the surface decant point of the mining complex and is thus taken as 1765 mamsl.

3.1.5.14.3 Calculation of the Mine/Ground Water Balance

Water balance calculations for opencast pits consist of 3 components, namely:

- Rainfall recharge on all active, spoiled and rehabilitated strips.
- Release in storage of ground water from saturated aquifer units.
- The influx of ground water from the perimeter of the pit. The aerial extend of this component will increase due to the pit perimeter increasing, but will also have a reducing component due to the partial cone of depression forming due to dewatering.

The rainfall data used for the average rainfall and seasonal rainfall water balance is listed in Table 3.1.5.14.3 (a) and was obtained from the Carolina Weather Monitoring Station.

Table 3.1.5.14.3 (a): Monthly Rainfall Data.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm)	126.7	95.6	75.7	48.4	14.5	8.4	6.2	12.4	34.2	92.5	131.4	129.9	**775.9**

In addition to this, the same rainfall data was used to determine the quarterly precipitation as listed in Table 3.1.5.14.3 (b).

Table 3.1.5.14.3 (b): Quarterly Rainfall Data.

Quarter	Rainfall (mm)	% of annual rainfall (mm)
Quarter 1 (January – March)	298	38%
Quarter 2 (April – June)	71.3	9%
Quarter 3 (July – September)	52.8	7%
Quarter 4 (October – December)	353.8	46%
Total	**775.9**	**100%**

From the above table it is evident that 84% of all rainfall occurs in the months October – March of each year.

Construction Phase Mine/Ground Water Balance

Construction phase activities will consist of the clearing of vegetation and soil stripping for the box-cut. During this phase all water make in the pre-strip and strip areas will be considered clean. The only change to water pre-mining water quality is the addition of suspended solids. These solids will be removed by settlement in the storm water dam. In terms of water management all excess water make generated during the construction phase can be used for dust suppression purposes.

The total construction phase should not last longer than 3 months. The total area opened for the box-cut and follow-up pre-strips is calculated as 32 515 m^2. Based on the information given in Table 3.1.5.14.3 (a) and Table 3.1.5.14.3 (b), the range in water make expected is indicated in Table 3.1.5.14.3 (c).

Table 3.1.5.14.3 (c): Total Water Make for the Construction Phase.

Time of construction phase	Rainwater make (m^3/day)	Ground water make (m^3/day)	Total water make (m^3/day)
Quarter 1	89	16	95
Quarter 2	18	16	34
Quarter 3	13	16	29
Quarter 4	75	16	91
Average rainfall	**49**	**16**	**65**

From the information indicated in Table 3.1.5.14.3 (c), the following conclusions can be reached:

- The modeled ground water make remains constant, since it is not a function of rainfall patterns.
- The rain water make in the dry months (Q2 and Q3) is very low (18 m^3/day and 13 m^3/day respectively). The combined water make for these months should be adequate for construction phase in-pit dust-suppression on a daily basis.

- The rainwater make for Q1 and Q4 is in excess of what is required for construction phase dust suppression purposes. This water must be collected and stored in the PCD.

- No clean rainwater should be allowed to accrue in this section of the mine. The box-cut will be developed in the south of the mine (Refer to Figure Figure 3.1.5.14.2 (a)), at the lowest point of the mine. Later water balance calculations will show that the total mining area for Years 1-4 is required for in-pit water management.

In the unlikely event that no water is used for dust suppression, the following volumes of water must be catered for in storm water control facilities (Table 3.1.5.14.3 (d)).

Table 3.1.5.14.3 (d): Storage needed for Construction Phase Water Balance

Time of construction phase	Storage needed for no dust suppression (m^3)
Quarter 1	8 159
Quarter 2	1 644
Quarter 3	1 218
Quarter 4	6 872
Average Rainfall	**4 473**

Operational Phase Mine/Ground Water Balance

The operational phase water balance is an interactive model based on quarterly mining advances. The input parameters and active cells for all stages of mining were captured in an Excel spreadsheet. The most pertinent data is discussed in this section. The aspects addressed in the water balance are:

- Time slot of mining. The 8 years LOM was divided into 4 quarters each. Based on the time of scheduling, the rainfall data in Table 3.1.5.14.3(b) was used for seasonal water balance calculations. The total water balance consists of 32 Quarters (4 for each of the 8 years LOM) and a final post closure field - in total 33 fields. Note that the last field is representative of full rehabilitation after the operational phase, and not the final post-closure water make.

- A progressive ground water make was calculated for each quarter, taking into account the non-recurring release in storage from saturated units and the progressively bigger ground water cone of depression. Values displayed as m^3/day.

- Progressive rainfall on the in-pit haul road. Mine-specific data was used for the extension of the haul roads on an annual basis. Water make values displayed as m^3/day.

- Rainfall on the Pre-strips, Overburden strips, Active Void, 40% Rehabilitated and 100% Rehabilitated areas, assuming the mine progression as described in the mine schedule. After a set period of time the size of these areas will remain constant. Water make values displayed as m^3/day.

- Progressive rainfall on fully rehabilitated, shaped, seeded and free-draining strips. This area will become progressively bigger as mining commences. After Year 3 of mining this is the most important contributor for water make. Timeous rehabilitation and final shaping of this area is the most important aspect for operational phase water balance management. Water make values displayed as m^3/day.

- Cumulative total water make for all components. Two datasets exist: One for average water make and a separate balance for seasonal water make. Water make values displayed as m^3/day.

- It was assumed that rainfall accruing on the pre-strips and overburden strip can be captured for in-pit dust suppression. The figure can range between 0 m^3/day and 59 m^3/day, with a value of 14 m^3/day for average rainfall.

- Part of the operational phase water balance is the management of water inside pit spoils. The cumulative storage available from the pit bottom (~1751 mamsl) to the Environmentally Safe Water Level (ESWL) of 1765 mamsl is also given on a quarterly basis. The ESWL was chosen at this level taking cognizance of the surface decant level (1770 mamsl), sufficient storage to make pit usage viable, and the control of pre-mining ground water levels.

- The ESWL has a dual purpose:
  - contain water in the pit without decant, and
  - prevent reverse flow of aquifer water into the pit.

- The total water make for the operational phase using the average rainfall figures is summarized in Table 3.1.5.14.3 (e).

From Table 3.1.5.14.3 (e), the following conclusions can be drawn:

- The water make for ground water flux is initially a major component, but gradually decreases to less than 20% of water make.

- The water make from the haul road increases as mining continues. This water should be removed from the pit as soon as possible, to prevent seepage into spoils (if in-pit storage is not the management option at that stage).

- The recharge on the rehabilitated, free-draining areas becomes bigger as mining progresses.

- The average water make for Y6 Q1 begin to exceed the post-closure water make of 300 m^3/day. This volume is considered the post-closure management volume that will be implemented for desalination. From a practical point-of-view all excess water make for Y6 Q1 to Y8 Q4 should be stored in the pit storage facility.

Table 3.1.5.14.3 (e): Water make for Operational Phase (average rainfall)

Mining Node	Ground Water make (m^3/day)	Recharge from haul road (m^3/day)	Recharge from active areas* (m^3/day)	Recharge from shaped and seeded rehab (m^3/day)	Total Water Balance make (m^3/day)
Y1 Q1	16.0	2.1	35.4	0.0	53.5
Y1 Q2	18.3	4.3	52.2	0.0	74.7
Y1 Q3	20.6	6.4	54.6	9.2	90.7
Y1 Q4	22.9	8.5	57.0	18.4	106.7
Y2 Q1	25.2	10.6	51.0	27.2	114.0
Y2 Q2	27.5	12.8	52.7	34.0	127.0
Y2 Q3	29.8	14.9	54.5	40.9	140.1
Y2 Q4	32.1	17.0	56.3	47.7	153.2
Y3 Q1	34.4	19.1	58.2	54.6	166.4
Y3 Q2	36.7	21.3	60.2	61.4	179.6
Y3 Q3	39.0	23.4	60.2	69.4	192.0
Y3 Q4	41.3	25.5	60.2	77.5	204.5
Y4 Q1	43.6	27.6	59.7	85.5	216.5
Y4 Q2	45.9	29.8	59.7	93.4	228.8
Y4 Q3	48.2	31.9	59.7	101.3	241.1
Y4 Q4	50.5	34.0	59.7	109.1	253.4
Y5 Q1	52.8	36.1	59.3	117.0	265.2
Y5 Q2	55.1	38.3	59.3	124.7	277.4
Y5 Q3	57.4	40.4	59.3	132.4	289.5
Y5 Q4	59.7	42.5	59.3	140.2	**301.7**
Y6 Q1	62.0	44.6	60.5	148.0	**315.1**
Y6 Q2	64.3	46.8	60.5	156.1	**327.7**
Y6 Q3	66.6	48.9	60.5	164.3	**340.2**
Y6 Q4	68.9	51.0	60.5	172.4	**352.8**
Y7 Q1	71.2	53.2	57.9	180.3	**362.5**
Y7 Q2	73.5	55.3	57.9	187.5	**374.2**
Y7 Q3	75.8	57.4	57.9	194.8	**385.8**
Y7 Q4	78.1	59.5	57.9	202.0	**397.5**
Y8 Q1	80.4	61.7	60.6	209.5	**412.2**
Y8 Q2	82.7	63.8	60.6	217.7	**424.8**
Y8 Q3	83.3	65.9	60.6	225.9	**435.7**
Y8 Q4	84.0	68.0	60.6	234.1	**446.8**
Post Closure	**44.1**	**0.0**	**0.0**	**247.8**	**291.9**

*Recharge from Pre-strip, Overburden, Open Void, and all spoil areas (m^3/day).

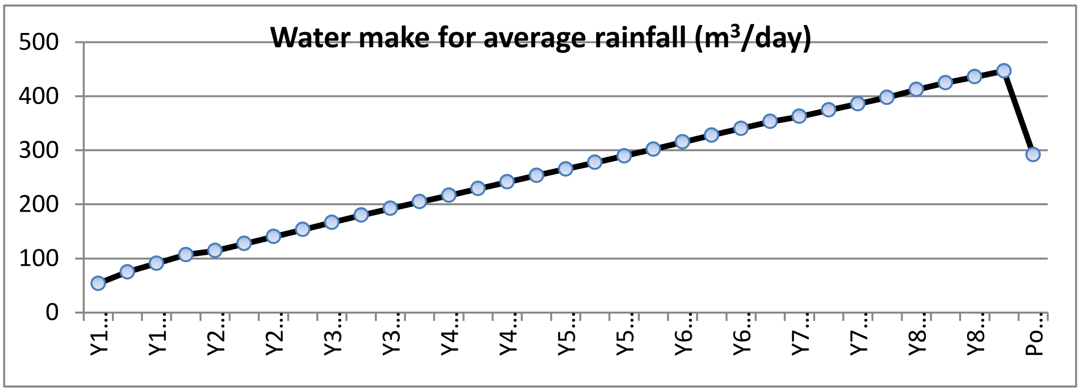


Figure 3.1.5.14.3 (a): Cumulative Water Make using Average Rainfall

The total water make for the operational phase at Lusthof Colliery, using the average rainfall figures is summarized in Table 3.1.5.14.3 (f).

Table 3.1.5.14.3 (f): Water Make for Operational Phase (average rainfall)

Mining Node	GW make (m^3/day)	Recharge from haul road (m^3/day)	Recharge from active areas* (m^3/day)	Recharge from shaped and seeded rehab (m^3/day)	Total Water Balance make (m^3/day)
Y1 Q1	16	0.8	13.0	0.0	30
Y1 Q2	18.3	1.2	14.2	0.0	34
Y1 Q3	20.6	11.6	99.5	16.8	148
Y1 Q4	22.9	13.1	87.5	28.2	152
Y2 Q1	25.2	3.9	18.7	10.0	58
Y2 Q2	27.5	3.5	14.4	9.3	55
Y2 Q3	29.8	27.1	99.4	74.6	231
Y2 Q4	32.1	26.1	86.5	73.3	218
Y3 Q1	34.4	7.0	21.4	20.1	83
Y3 Q2	36.7	5.8	16.4	16.7	76
Y3 Q3	39	42.6	109.8	126.6	**318**
Y3 Q4	41.3	39.2	92.5	119.0	292
Y4 Q1	43.6	10.2	22.0	31.4	107
Y4 Q2	45.9	8.1	16.3	25.4	96
Y4 Q3	48.2	58.2	108.9	184.7	**400**
Y4 Q4	50.5	52.3	91.8	167.7	**362**
Y5 Q1	52.8	13.3	21.8	43.0	131
Y5 Q2	55.1	10.4	16.1	33.9	116
Y5 Q3	57.4	73.7	108.1	241.5	**481**
Y5 Q4	59.7	65.3	91.0	215.3	**431**
Y6 Q1	62	16.4	22.2	54.4	155
Y6 Q2	64.3	12.7	16.5	42.5	136
Y6 Q3	66.6	89.2	110.3	299.6	**566**
Y6 Q4	68.9	78.4	92.9	264.8	**505**
Y7 Q1	71.2	19.5	21.3	66.3	178
Y7 Q2	73.5	15.0	15.7	51.0	155
Y7 Q3	75.8	104.7	105.5	355.2	**641**
Y7 Q4	78.1	91.4	88.9	310.3	**569**
Y8 Q1	80.4	22.7	22.3	77.0	202
Y8 Q2	82.7	17.4	16.5	59.2	176
Y8 Q3	83.3	120.2	110.6	412.0	**726**
Y8 Q4	84	104.5	93.1	359.6	**641**
Post Closure	**44.1**	**0.0**	**0.0**	**247.8**	**292**

*Recharge from Pre-strip, Overburden, Open Void, and all spoil areas (m^3/day).

From Table 3.1.5.14.3 (f), the following conclusions can be drawn:

- The water make for ground water flux is only a factor in the first two years of mining during dry quarters.
- Haul road water make is a major contributor during wet quarters. Water must be gravitated to the active void and disposed of as soon as possible, to prevent drainage into spoils.

- The recharge on the rehabilitated, free-draining areas becomes bigger as mining progresses. The seasonality of rainfall recharge is evident.

- The water make for each of the two wet quarters from Year 3 is evident. At that stage the quarterly water balance begins to exceed the estimated post-closure water make of 300 m^3/day. This volume is considered the post-closure management volume that will be implemented for desalination. From a seasonal management view all excess water make for the two wet quarters must be managed in pit from Year 3, onwards, until the end of the LOM.

The seasonal cumulative water make is illustrated on Figure 3.1.5.14.3 (b) below.

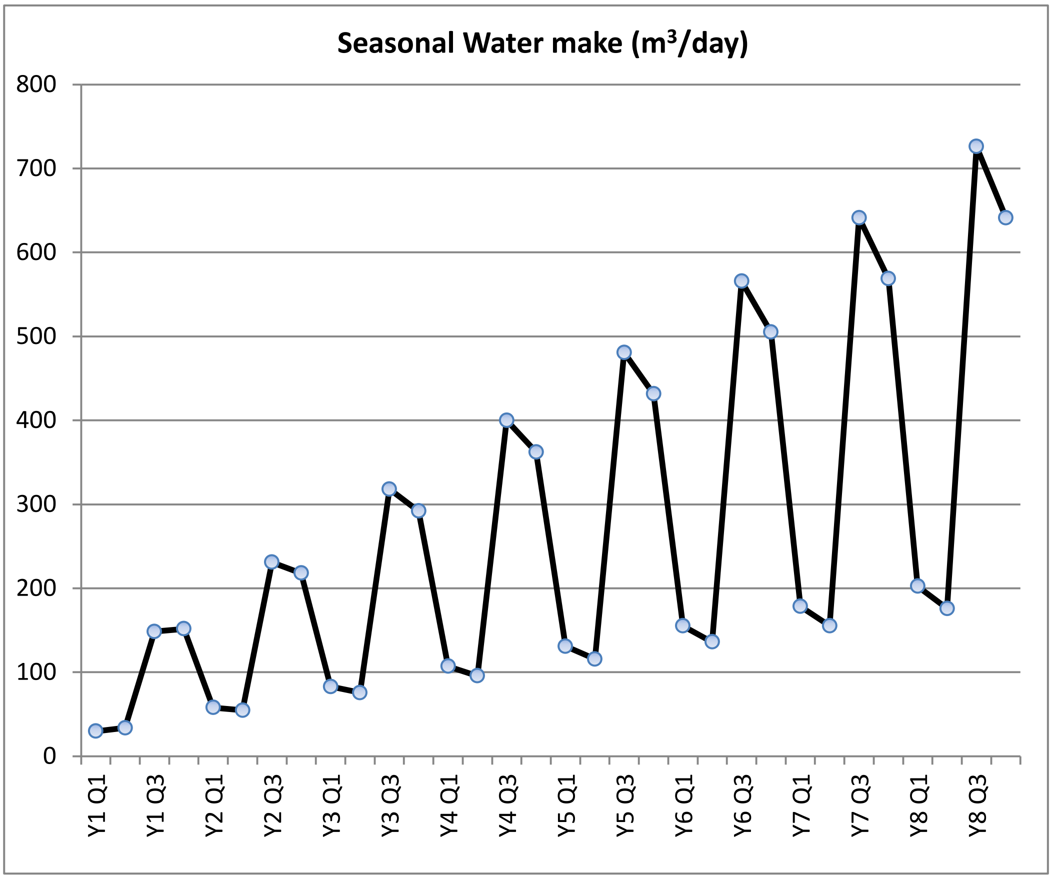


Figure 3.1.5.14.3 (b): Seasonal Cumulative Water Make

3.1.5.15 Mine/Ground Water Management

3.1.5.15.1 Mine/Ground Water Management Options

A Dirty Water Dam and/or a Pollution Control Dam for the management of all polluted water is a given at all opencast collieries. The opportunity to reduce the size of the dirty water management facilities arises when in-pit storage can be created in rehabilitated opencast spoils, on condition that these spoils are down gradient of active mining cuts, and water can be stored below the Environmentally Safe Water Level (ESWL) for the sub-catchment.

The mining layout at Lusthof Colliery was subjected to a series of **environmental** mine-planning iterations. The following aspects were considered:

- Sensitive landscapes (wetland type soils).
- Seep-zone landscapes.
- Drainage lines.
- Geological features that can act as preferential flow zones.
- Geological contour distribution of the coal seams to be mined.
- The surface decant level of the total pit complex.
- The establishment of the Environmentally Safe Water Level (ESWL) for the mine and the sub-catchment.

Based on the above criteria, the final pit layout, as well as the direction of mining was changed to make provision for the practical establishment of the ESWL for Lusthof Colliery. The pit perimeter was reduced to a surface contour level of 1770 mamsl in the south. Mining will also progress from south to north, as indicated previously.

By making these changes, an in-pit storage facility was created at Lusthof Colliery. Rehabilitated spoils in the south can be flooded from the bottom of the pit (1751 mamsl) up to an elevation of 1765 mamsl (the ESWL). This is some 5 m below the surface decant elevation of 1770 mamsl.

The area of the total in-pit storage facility is delineated in Figure 3.1.5.15.1 (a).

The stage curve for the total mine area, as well as the ESWL and maximum volume of water storage to surface decant elevation, is depicted on the graph illustrated as Figure 3.1.5.15.1 (b).

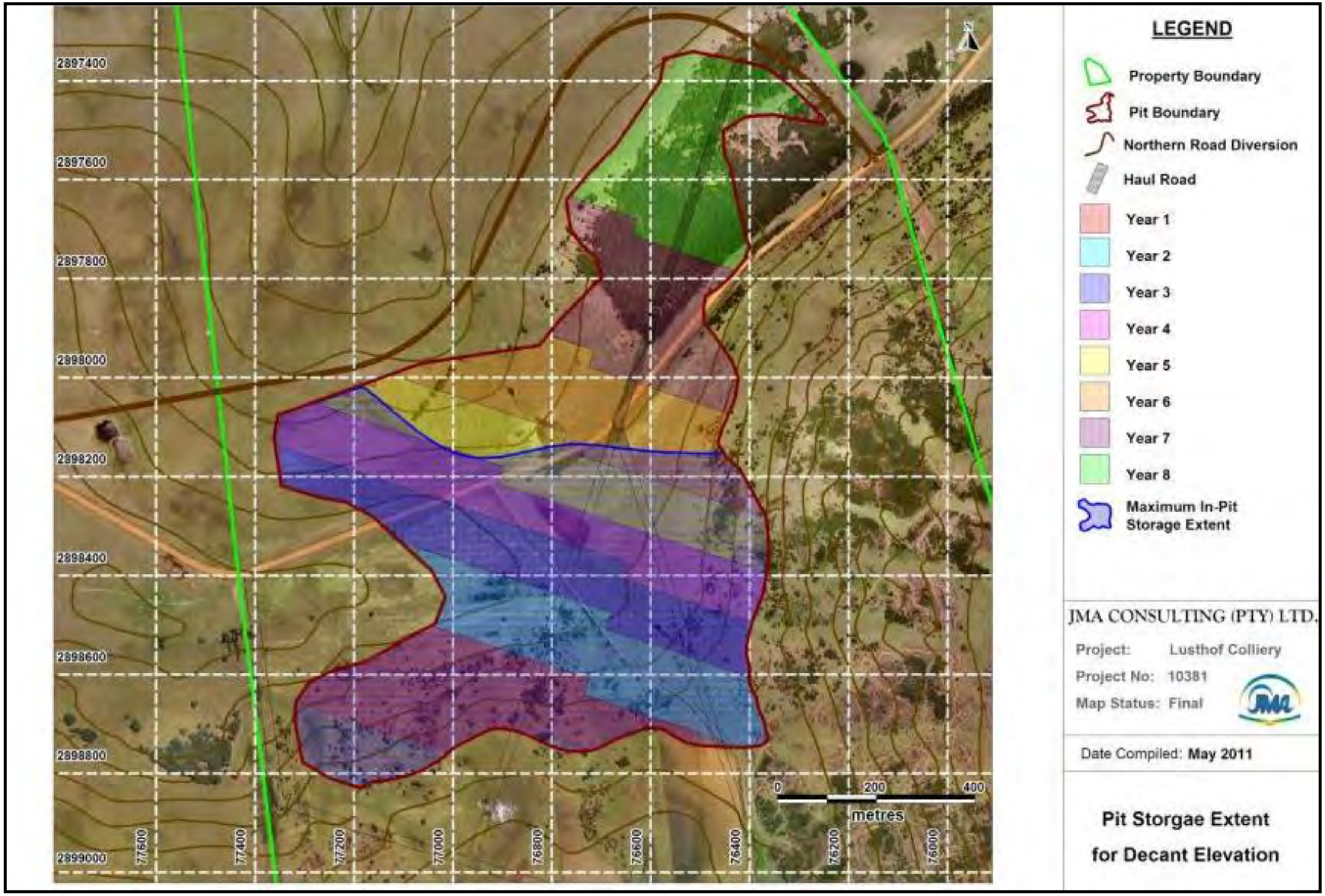


Figure 3.1.5.15.1 (a): Extent of In-pit Storage at the Decant Elevation

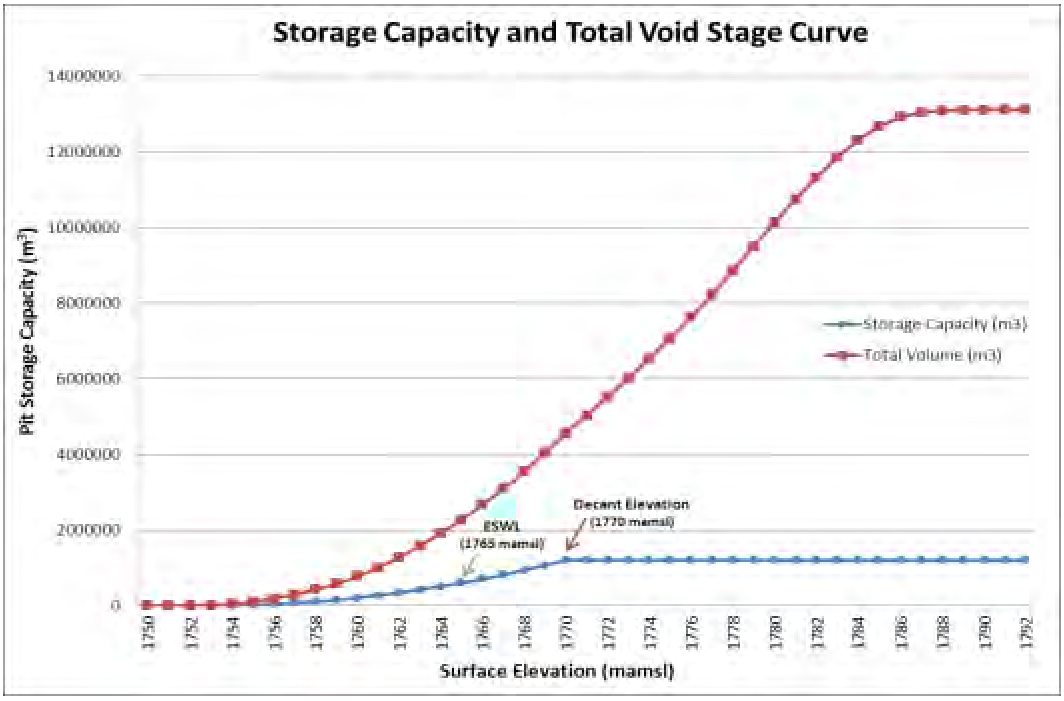


Figure 3.1.5.15.1 (b): Pit Storage Stage Curve for Lusthof Colliery

The in-pit storage available per unit elevation up to 1765 mamsl is summarized in Table 3.1.5.15.1 (a).

Table 3.1.5.15.1 (a): In-Pit Storage per unit Elevation

Elevation (mamsl)	Available Storage (m^3)
1752	168
1753	2751
1754	11 165
1755	27 008
1756	49 508
1757	78 535
1758	114 010
1759	156 060
1760	205 935
1761	266 215
1762	338 617
1763	419 849
1764	508 202
1765	604 084

3.1.5.15.2 Construction Phase Mine/Ground Water Management

No in-pit storage is available for the first two quarters of mining which actually represents the mine construction phase and comprise the box cut development and the first cut of the mining operation. Storage becomes available in quarter 3 of mining when the first cut has been backfilled with roll over spoils from cut 2. The storage needed for the first two quarters of mining, can be gleaned from the information shown in the Table below.

Table 3.1.5.15.2 (a): Storage needed for Construction Phase Water Balance

Time of construction phase	Storage needed for no dust suppression (m^3)
Quarter 1	8 159
Quarter 2	1 644
Quarter 3	1 218
Quarter 4	6 872
Average Rainfall	**4 473**

The benefit of starting the mine in quarter 2 is quite obvious because it implies that only 2 862 m^3 of storage needs to be provided out of pit. However, if mining starts in quarter 4, 15 031 m^3 of storage will be required out of pit within a suitably lined Dirty Water Dam or Pollution Control Dam.

In order to cater for the worst case scenario, the required storage capacity for the two wettest quarters of 15 000 m^3 will be catered for in the design of the proposed new Lusthof PCD.

3.1.5.15.3 Operational Phase Mine/Ground Water Management

The volume of storage that progressively becomes available as mining progresses is indicated in Table 3.1.5.15.3 (a).

Table 3.1.5.15.3 (a): Operational Phase Storage per Mining Schedule

Mining Node	In-pit storage available (m3)
Y1 Q1	0
Y1 Q2	0
Y1 Q3	90,011
Y1 Q4	180,022
Y2 Q1	241,734
Y2 Q2	303,446
Y2 Q3	365,158
Y2 Q4	426,870
Y3 Q1	456,506
Y3 Q2	486,142
Y3 Q3	515,778
Y3 Q4	545,415
Y4 Q1	557,863
Y4 Q2	570,311
Y4 Q3	582,759
Y4 Q4	595,210
Y5 Q1	597,428
Y5 Q2	599,646
Y5 Q3	601,864

The total cumulative water make for Lusthof Colliery (with no dust suppression or re-use considered) is indicated in Table 3.1.5.15.3 (b).

Table 3.1.5.15.3 (b): Total Cumulative Water Make for Lusthof Colliery

Year of Mining	Total water make (m3/year)	Cumulative water make (m3)
Year 1	33,180	33,180
Year 2	51,228	84,408
Year 3	70,130	154,538
Year 4	88,053	242,590
Year 5	105,713	348,303
Year 6	124,249	472,552
Year 7	140,842	**613,394**
Year 8	159,271	**772,665**

From the above Tables the following conclusions can be drawn:

- The storage of water in spoils is based on a bulking factor of 26%.
- The mine sequence for Y1Q1 and Y1Q2 assumed no spoil space. This is a conservative approach.
- Notable storage becomes available during Y1Q3 when rehabilitated spoils can be blooded.

After this period sufficient space is available to handle all water make until the end of LOM. Note that this assumes that no clean water is used for in-pit dust-suppression and no operational phase desalination takes place. Total water make will exceed the storage of 604 000 m3 below the ESWL of 1765 mamsl after Year 7, but will still be well below the surface decant elevation of 1770 mamsl.

However, if a conservative approach is to be adopted, the Water Treatment Plant should be commissioned timeously to prevent exceedance of the ESWL for in-pit storage. This implies that a treatment capacity of 300 m^3/day needs to be implemented from Year 7 onwards.

3.1.5.15.4 Post Closure Phase Mine/Ground Water Management

The post closure water balance for the mine has been calculated as 292 m^3/day.

The proposed way to manage the post closure water balance is the abstraction of mine/ground water from a series of boreholes located in the saturated rehabilitated spoils to manage the in-pit mine/ground water level at the safe environmental elevation and to treat the water in a Reverse Osmosis Water Treatment Plant.

A further component of the post closure ground water balance that needs to be managed relates to the seepage of contaminated ground water from the pit at a pit flooding level of 1765 mamsl. This water balance was modelled as part of the numerical ground water modelling exercise which will be discussed in the ground water specialist report to be attached to the EIA/EMP report. The post closure seepage ground water balance across the western and southern pit perimeters was modelled to be 11 653 m^3/year or 32 m^3/day.

The proposed way to address this seepage is to abstract ground water from a series of boreholes located 50 m outside the pit perimeter along a line located along the eastern and southern pit perimeters.

The actual localities of the abstraction boreholes will be determined based on monitoring of the ground water elevations and qualities in a series of monitoring boreholes along these lines.

The feasibility of effectively cutting off this seepage is obvious in view of the fact that the total seepage water balance only represents a flux of 32 m^3/day, or expressed in borehole yield terms, only 0.37 l/s per 24 hour cycle. If it is assumed that say 5 boreholes will be pumped along the seepage line for 12 hours per day cycles, it calculates to required boreholes yields of 0.14 l/s, which has been confirmed as possible in the area.

The water pumped from the boreholes can be recirculated into the pit as the seepage water balance was calculated assuming a constant head distribution in the pit. Furthermore the water balance itself has also been accounted for in the pit mine water balance of 292 m^3/day, which means that the design specification for the WTP can accommodate the ground water abstraction.

The quality of water generated in the Water Treatment Plant can meet the objectives of current background surface water as measured in the area which means that the treated water can be discharged into the environment, in the event that an off-take agreement cannot be reached between all involved parties.

3.1.5.16 Sewage Plant

No sewage plant will be required as a French drain is considered to be suitable for the site.

3.1.5.17 Dirty Water Treatment Plant

A comprehensive water treatment facility will be implemented at Lusthof Colliery when the need arises. For the Post Closure Phase the required capacity of the Water Treatment Plant is 300 m^3/day to cater for the post closure Mine/Ground Water Balance. Using this design capacity, the WTP must be commissioned to start operation at the beginning of Year 7 of mining.

The final position of the facility will be determined by the position of total-pit water abstraction points (boreholes). The treated water can either be used in accordance with an off-take agreement or else discharged into the natural environment downstream of the Pollution Control Dam.

Specialist consultants PROXA were commissioned by JMA Consulting (Pty) Ltd to assess the feasibility of providing a water treatment plant for the management of the Mine Water/Ground Water Balance.

3.1.5.17.1 Introduction

The objective of the PROXA study is to provide a concept design, technical information and costs for the design, supply, construction, commissioning and operation & maintenance of a mobile water treatment plant to treat the excess mine water from the proposed Lusthof Colliery. The water will originate from the underground mining activities and must be treated to the quality of the surrounding natural water sources.

Various process options were evaluated for the water treatment plant as well as the waste generated by the treatment processes. One of the main goals was to strive towards a solution with zero waste discharge. The treatment plant route selected makes use of a number of processes that have been proven successful on a large scale in the market.

The design offered will treat 300 kl/day on average with an availability of 82% as a monthly average with zero waste discharge. The product water quality will be of the same order as that of the surrounding natural water sources which was found to be of exceptional good quality. This factor played a major role in the final process selection.

3.1.5.17.2 Design Basis

The water treatment plant will treat superfluous mine water from coal mining activities at Lusthof Colliery from year 7 onwards into and beyond closure. The estimated time for mining activities is 8 years. For the first 5 years of treatment, the water to be treated will be neutral and thereafter the pH of the water will gradually decline with the associated increase in solubility of heavy metals such as iron, manganese and aluminium. Sulphate levels will also gradually increase from about 850 mg/l to a maximum of 1200 mg/l. After the 8 years of mining, when mining activities cease, the pumping of water to be treated will continue.

The treatment plant capable of treating 300 m^3/day of effluent must be a ZED (zero effluent discharge) facility and all final waste must be treated to the desired quality or removed offsite. Different solutions for the final brine/waste are offered. The first solution includes an evaporator and crystalliser and the second solution makes use of an evaporation pond facility. The third option includes softening of the brine and then blending it with the product water.

Essentially all the parameters fall outside the specification limits as set out above. The water quality of the surrounding natural water sources were of extremely good quality and even of considerably higher standard than that of SANS241 Class 1 Drinking Water Standards (e.g. TDS standard of 1000 mg/l vs specification guideline of 47 mg/l required). Both monovalent and multivalent species are over the required specification and thus desalination is required as a major process step.

Table 3.1.5.17.2 (a): Feed Water Design Basis

Parameter	Units	Feed	SANS 241 Class 1	Average Regional Natural Water Quality + 2 Std Dev
Feed flow rate	m^3/day	300		
Plant availability	%	82%		
Al	mg/l	1.5	0.15	0.80
Ca	mg/l	360	150	3.92
Cl	mg/l	165	200	20.21
Electrical Conductivity	mS/m	350-450	150	10.51
F	mg/l	6.5	1	0.12
Fe (first 5 years)	mg/l	<1	0.2	0.89
Fe (year 6 onwards)	mg/l	10	0.2	0.89
K	mg/l	35	50	6.34
Mg	mg/l	210	70	2.53
Mn	mg/l	5	0.1	0.16
Na	mg/l	110	200	9.17
pH (first 5 years)		7-8	5.0 – 9.5	5.4-7.2
pH (year 6 onwards)		4.5	5.0 – 9.5	5.4-7.2
SO_4	mg/l	1200	400	13.45
Total Alkalinity (first 5 years)	mg/l as	160	No specification	17.6
Total Alkalinity (year 6 onwards)	mg/l as $CaCO_3$	0	No specification	17.6
TSS	mg/l	<10	No specification	
Turbidity	NTU		1	
TOC	mg/l	2	10	
TDS		2100	1000	46.7

- Please note: feed analyses that fall outside the specification limit for SANS 241 Class 1 and/or the required product water guideline specification are indicated in red; analyses indicated in black fall within the specification limits for both class.
- The complete sample analyses of the regional natural water sources that were used to compile the required product water specification is given in Table 3.1.5.17.2 (c) on the next page.

In addition to those constituents specified in Table 3.1.5.17.2 (a), the proposed process makes provision for the following maximum values:

Table 3.1.5.17.2 (b): Additional Water Specifications

Component	Unit	Limit
Fats, oils and grease	mg/l	<1
Total organic carbon	mg/l	< 5
Pseudomonas	cfu/100ml	<1000
Yeasts	cfu/100ml	<100
Moulds	cfu/100ml	<100
Algae	cfu/100ml	<100

Components not specified in either Table 3.1.5.17.2 (a) or Table 3.1.5.17.2 (b) were assumed to be zero.

BH No.		LC-SW 2	LC-SW 3	LC-SW 9	LC-SW10	LC-SW21	LC-SW22	LC-SW23	Min	Avg	Max	Std Dev	Avg + 2 Std Dev
pH		6.39	5.66	6.08	5.9	6.73	6.93	6.41	5.66	6.30	6.93	0.45	5.4-7.2
EC	(mS/m)	5.81	7.04	7.96	3.96	5.73	9.01	8.64	3.96	6.88	9.01	1.82	10.51
TDS	(mg/l)	30.8	30.2	35.9	20.6	28.7	40.3	40.7	20.60	32.46	40.70	7.12	46.69
T.Alk	(mg/l)	9.56	3.08	5.88	6.92	8.6	17.7	7.32	3.08	8.44	17.70	4.58	17.60
NH_4	(mg/l)	0.01	0.23	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.23	0.08	0.21
Ca	(mg/l)	2.44	2.32	1.46	0.94	2.09	3.78	1.98	0.94	2.14	3.78	0.89	3.92
Cl	(mg/l)	7.42	16.1	16.4	5.81	9.81	15.2	10	5.81	11.53	16.40	4.34	20.21
Mg	(mg/l)	1.79	1.51	1.01	0.75	0.84	2.13	1.91	0.75	1.42	2.13	0.55	2.53
NO_3	(mg/l)	0.15	0.14	0.14	0.25	0.36	0.29	0.2	0.14	0.22	0.36	0.09	0.39
PO_4	(mg/l)	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.00	0.02
K	(mg/l)	0.22	2.51	1.49	0.82	1.33	3.93	5.96	0.22	2.32	5.96	2.01	6.34
Na	(mg/l)	6.94	5.92	9.24	4.92	5.89	6.05	5.59	4.92	6.36	9.24	1.40	9.17
Si	(mg/l)	3.54	0.89	1.5	2.67	3.91	4.68	0.89	0.89	2.58	4.68	1.53	5.64
SO_4	(mg/l)	5.49	0.93	3.28	2.6	2.62	0.42	14	0.42	4.19	14.00	4.63	13.45
Al	(mg/l)	0.01	0.1	0.03	0.03	0.266	0.17	0.85	0.01	0.21	0.85	0.30	0.80
Sb	(mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
As	(mg/l)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.000	0.01
B	(mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
Cd	(mg/l)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.00	0.00	0.00	0.00	0.00
Cr(T)	(mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
Cr^{6+}	(mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
Co	(mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
Cu	(mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
F	(mg/l)	0.076	0.093	0.12	0.066	0.067	0.093	0.09	0.07	0.09	0.12	0.02	0.12
Fe	(mg/l)	0.11	0.27	0.18	0.11	0.31	0.46	0.9	0.11	0.33	0.90	0.28	0.89
Pb	(mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
Mn	(mg/l)	0.01	0.17	0.02	0.03	0.04	0.02	0.02	0.01	0.04	0.17	0.06	0.16
Hg	(mg/l)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.00	0.00	0.00	0.00	0.00
Se	(mg/l)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.01	0.01	0.01	0.00	0.01
V	(mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01
Zn	(mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01

Table 3.1.5.17.2 (c): Chemical Analyses Results for Site Pristine Surface Water

3.1.5.17.3 Process Selection and Alternative Technologies

All calculations were based on an average feed water capacity of 300 m^3/day with a plant availability of 82%.

In most acid mine drainage water applications typical from the coal mining industry in South Africa, the following main water characteristics are seen:

- High sulphate concentrations
- High metal (Al, Mn, Fe) concentrations
- Acidic pH conditions

The focus of most acid mine drainage applications is thus towards removal of sulphate and metals and neutralisation. The industrial water regulations in South Africa have become more stringent in recent years and with that the need for additional treatment of these types of waters, where in some cases a desalination step is also required. The treatment process may thus be divided in the following steps:

- Neutralisation, removal of metals and sulphate
- Desalination
- Final waste treatment

Neutralisation and Removal of Metals and Sulphate

The following processes were evaluated for neutralisation, removal of metals and sulphates:

Barium Precipitation Process

Barite (barium sulphate) is highly insoluble making it an excellent candidate for removal of sulphate by precipitation. The barium salts commonly used for sulphate removal are $BaCO_3$, $Ba(OH)_2$ and BaS. However, barium salts are very expensive. Barium sulphate sludge may be recycled and treated further for the production of elemental sulphur by thermal reduction at 1200 ^oC.

The process has not been proven on full scale and the plant capacity is too small to justify the construction of an oven for the recycling of the barium. As barium salts are also at saturation in the product water, it poses a scaling risk and limits recovery for downstream membrane processes. The removal of metals is also poor in comparison to other processes and further process treatment is required to meet the product water qualities.

SAVMIN Process

The SAVMIN process uses precipitation reactions during successive stages to remove dissolved sulphate. In the first stage lime is added to raise the pH to approximately 12 for precipitation of metals and magnesium as hydroxides. In the second stage the water is seeded with gypsum crystals to catalyse the precipitation of gypsum from the supersaturated solution with a portion of the gypsum being recycled for seeding. In the third stage aluminium hydroxide is added which results in the precipitation of ettringite ($3CaO.3CaSO_4.Al_2O_3.31H_2O$).

This reaction occurs between a pH of 11.6 and 12 and removes calcium and sulphate from the feed water. The ettringite slurry is removed from the feed water by thickening and filtration.

In the fourth stage CO_2 is added to the waste water stream to lower the pH and to precipitate $CaCO_3$ which is removed by filtration. The ettringite slurry is decomposed with sulphuric acid to regenerate aluminium hydroxide for reuse in the third stage.

Sulphates are removed to below 200 mg/l in pilot studies, but the process has also not been proven on full scale. The resulting product water will still require further treatment in order to meet the stringent product water qualities for the Lusthof Colliery region. The SAVMIN process generates an excessive amount of sludge waste that has to be in this case removed from site at an excessive cost.

SPARRO Process

The Sparro process makes use of a tubular reverse osmosis process operating at a high pH under scaling conditions. The tubular membranes is more robust to scale and solids and can also be more effectively cleaned. The feed water is seeded with gypsum crystals which serve as nucleation sites for the scale to attach to and thereby limiting scale formation on the membrane.

Pilot studies has shown that although marginal success is possible, the long term effects are poor salt rejection and short membrane lifetime expectancy which makes the SPARRO process a less promising option.

Ion Exchange Processes

Various ion exchange processes has been evaluated of which two will be briefly discussed. The Gypcix ion exchange process is most effective where the water is almost saturated with calcium sulphate (gypsum), this however is not the case for Lusthof. The water is fed to a series of fluidized cation ion exchange bed reactors followed by a degasser tower for removal of carbon dioxide. Then the anions are removed from the water by a series of anion ion exchange bed reactors. The novelty of the Gypcix process is that it uses low-cost resin regeneration with sulphuric acid and lime instead of the conventional chemicals such as hydrochloric acid and caustic soda. Gypsum ($CaSO_4$) is produced as a byproduct. The recovery of the Gypcix process is 70-90%. An excessive amount of gypsum sludge is produced in the process.

The other ion exchange process that was evaluated was to produce valuable by products from the ion exchange regeneration waste by manipulation of regeneration chemicals and processes. Valuable products such ammonium sulphate for use in the fertiliser industry may be produced, but the market for these by products has not been established on a sustainable basis in South Africa and cannot be guaranteed for long term either. The capacity of the plant is also too small to put long term agreements for off-take of these products in place.

Biological Processes

Biological processes remove sulphates, nitrates and trace metals do not remove salts such sodium, chloride, calcium and magnesium and is thus not an applicable solution.

Membrane Processes

Membrane processes such as electro deionisation reversal (EDR) and spiral reverse osmosis have been evaluated as well. Spiral reverse osmosis (RO) is more robust than EDR and has also been proven on large scale for several processes. It also desalinates the water from all species and not selective species only. The high product water quality required at Lusthof demands exactly that.

The key however would be to maximise the recovery over the RO system and thereby maximising the concentration of salts in the brine waste stream and minimising the volume of brine (RO reject) that has to be treated and is usually much more expensive.

The scaling species that prohibited a recovery of 90% was metals such as iron, manganese and aluminium. With the use of proprietary anti-scalants no additional removal of sulphates of calcium was required in the pre-treatment. Relatively low-cost pre-treatment processes are available for the removal of the metals to the levels required to obtain a high recovery in the RO process. The combination of high recovery in the primary process together with the high quality product water quality achieved made this process a solution that meets the all requirements.
A detailed process description is given in the next section.

For the final waste/brine treatment process, three different options have been evaluated and are discussed in more detail in the following section.

3.1.5.17.4 Process Description

In this section the process equipment and integration will be discussed.

<u>Water Recovery</u>

The total water recovery of the treatment plant is +99 % with no liquid waste discharge. The solid waste generated in the process will be removed off site, thus qualifying this treatment process as a ZED (zero effluent discharge) facility.

Primary Plant : Pre-Treatment and Desalination

Please refer to Figure 3.1.5.17.4 (e) for a simplified process flow diagram.

The feed water to the treatment plant will be abstracted from the underground mining area to a feed water tank at the treatment plant. The feed water tank also receives recycled water from the water treatment plant processes. The feed water from the feed water tank is pumped to a lamella clarifier. The flow to the plant is controlled with a manual flow control valve.

Upstream of the clarifier caustic soda (NaOH) or sulphuric acid (H_2SO_4) and an oxidant (e.g. sodium hypochlorite or calcium hypochlorite) are dosed to precipitate the iron (Fe) and manganese (Mn) present. The caustic soda or sulphuric acid is dosed to bring the water to the desired pH range for the precipitation reaction and also to adjust the pH of the water to the minimum solubility for aluminium (Al). A coagulant as well as a flocculant is dosed in the feed stream to the clarifier in order to enhance floc formation and settling. This precipitate, together with the suspended solids in the feed water, is removed in the lamella clarifier.

Figure 3.1.5.17.4 (a): Lamella Clarifiers

The sludge (precipitate and suspended solids) removed at the bottom of the clarifier is collected in a sludge sump from where it is pumped to a sludge dewatering facility. The overflow or product water from the clarifier is collected in a clarified water tank.

Downstream of the clarified water tank the water is pumped through manganese dioxide contactors. The manganese dioxide material is housed in filters from fibreglass or galvanised and coated mild steel.

The main function of the manganese dioxide contactor is to remove residual metal (Fe, Mn, Al) compounds from the clarified water (feed water to the membrane processes) to below 0.2 ppm per element. Three filters will be installed to achieve the required contact time for efficient metal removal and to allow the system to continue normal operation while one filter is being backwashed.

To regenerate the manganese dioxide, an oxidant is dosed either continuously or during backwashing of the filter. The backwash water is returned to the feed tank and the precipitated metals removed in the existing lamella clarifiers.

This backwash waste will contain an oxidant, but because this chemical is dosed before the lamella clarifiers, the backwash waste will aid in oxidising the metals in the feed to the treatment plant.


Figure 3.1.5.17.4 (b): Manganese Dioxide Filters

The pre-conditioned raw water from the manganese dioxide filters is fed directly to an Ultra Filtration (UF) plant to remove any residual suspended or colloidal solids. The UF plant will be completely automated and use capillary type modules. The organic content of the feed water is within the specification for the most ultrafiltration and reverse osmosis membrane modules. Due to the low organic content of the water dosing of a coagulant to improve organics removal was not included.

Capillary UF membranes must be used and the advantages of this type of filtration for this application are:

- The use of capillary membranes as opposed to spiral UF membranes eliminates the build-up of organic, biological or colloidal matter in the feed spacers required for spiral membrane configuration.
- Back-wash efficiency and membrane life-time for capillary membranes in high SS conditions is proven to be superior to spiral membranes;
- The capillary membranes are manufactured from permanently hydrophilic polymer, reducing the risk of permanent irreversible membrane fouling;

Provision was made for frequent backwashing of the modules as well as periodic chemically enhanced backwashing (CEB). Chemicals such as hydrochloric acid (or sulphuric acid), caustic soda or sodium hypochlorite are typically used for chemically enhanced backwashes. The backwash and CEB waste from the UF process will be routed back to the raw water feed tank.


Figure 3.1.5.17.4 (c): Capillary UF Membrane Module and Typical UF Plant

The filtrate from the UF plant is routed to a buffer tank. The buffer tank will be the feed source for the backwash water required for the UF plant and the manganese dioxide filters as well as the feed water to the reverse osmosis (RO) plant.

Prior to entering the reverse osmosis process, the water is routed through 5µm cartridge filters. The cartridge filters is an additional safety measure to prevent solids larger than 5µm to be fed to the reverse osmosis membranes.

The reverse osmosis process is configured in a single pass array making use of eight (8) inch poly-amide membranes at a typical average flux of 20-21 litres per square metre of membrane area per hour (lmh). The water recovery is limited by the metals (Fe, Al and Mn) primarily and secondarily by calcium sulphate and calcium fluoride scaling potential.

Anti-scalant and sodium meta-bisulfite are dosed in the feed of the reverse osmosis plant to prevent scaling and remove free chlorine and other oxidants respectively. The anti-scalants inhibits scale formation by increasing the solubility of scalants in water and help to remain higher levels of scalants in dissolved form.

Two anti-scalants will be dosed as both have specific scale inhibition properties required to reach the high recovery at which the reverse osmosis plant will be operated. The recovery of the reverse osmosis step is 90% with the addition of the anti-scalants at the required dosage.


Figure 3.1.5.17.4 (d): Reverse Osmosis Treatment Skids

A dedicated CIP (cleaning-in-place) station will be provided to clean both the ultrafiltration and reverse osmosis membranes. The CIP system must contain amongst others a CIP tank with heating and a dedicated CIP pump. In the reverse osmosis desalination process the salts are concentrated into a brine stream as the permeate (or product) stream is abstracted through the membranes. The RO permeate is routed to a product water tank. The waste or brine from the reverse osmosis process is further treated in a secondary plant where the salts are removed as solids. Three different options were evaluated for the brine treatment plant. Please note that option three meets the product water specifications for SANS241:2006 Class 1 drinking water standards, but not the product quality of the regional natural water quality (see Table 3.1.5.17.2 (a))

Secondary Plant : Brine Treatment

Option 1 – Evaporator and Crystalliser – see Figure 3.1.5.17.4 (g)

The brine produced in the salt concentration section is routed to a brine storage buffer tank. This brine is fed to a softening clarifier. En route to the softening clarifier lime is dosed as slurry in a reaction tank with a combination of fast and slow mixing zones. The total reaction time in the reaction tank is approximately 3.5 hours. Lime softening is used to precipitate bivalent and trivalent species such as carbonates, magnesium, silica, phosphates, sulphates and metals. The sludge from the softening clarifiers is routed, together with the sludge from the volume reduction plant, to sludge dewatering equipment. The gypsum-dominated sludge is dewatered and stored for collection.


Figure 3.1.5.17.4 (e): Conventional Circular and Lamella Softening Clarifier

In this instance the main function of the softening process is to precipitate sulphates and to prevent sulphate scaling in the downstream evaporation process. In order to achieve the desired and maximum precipitation, the salts first had to be concentrated in the RO process to take it closer or over their saturation limits.

The combination of high concentrations of bivalent and trivalent salts and high pH achieved with the addition of lime causes the desired removal (by precipitation) of these salts. The water is also now less saturated and better conditioned for the down stream processes of evaporation and crystallisation.

The brine evaporator and crystalliser consist of a feed system, crystalliser system, vapour recompression system and condensate system vacuum system.

Softened brine from the brine softening section of the plant is fed to the crystalliser feed tank. The pH of the softened brine from the brine softening section is adjusted to the required set point before the evaporator feed tank. Softened brine from the feed tank is pumped through a plate heat exchanger to pre-heater feed before it is fed to the crystalliser body. The purpose of the pre-heater is to recover heat from the condensate stream in order to optimise the energy efficiency of the crystalliser. The forced circulation crystalliser consists of a vapour body, heat exchanger and circulation pump.

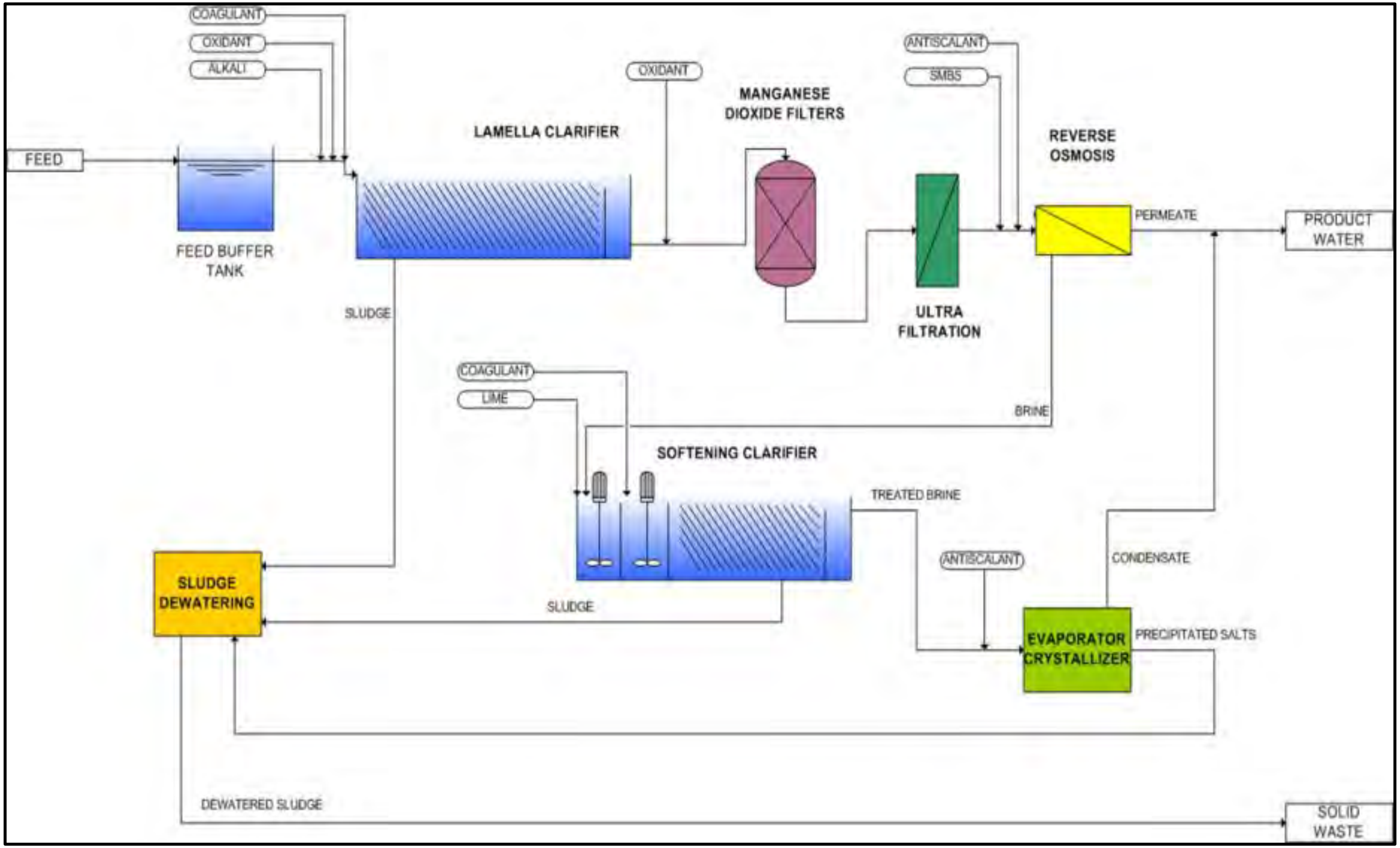


Figure 3.1.5.17.4 (f): Simplified Process Flow Diagram with Secondary Treatment Option 1

The crystalliser slurry is recirculated by the circulation pump from the vapour body through the heat exchanger back to the vapour body where the vapour is separated from the slurry before is recycled through the heat exchanger again. The vapour body and ducting will be constructed from GRP material for improved corrosion resistance against the high chlorides content of the slurry.

The vapour from the vapour body is recompressed by means of a thermal vapour re-compressor that used steam as motive fluid. The steam and vapour mixture enters the shell side of the heat exchanger where it is condensed. The efficiency of the vapour re-compressor and final steam consumption will depend on the steam pressure available.

Figure 3.1.5.17.4 (g): Evaporator-Crystallisers

The condensate is collected at the bottom of the heat exchanger shell in a condensate pot from where it is pumped through the pre-heater to pre-heat the feed before it is discharged to the battery limit. The condensate could be treated further to re-use as boiler feed water. The non-condensable gasses are withdrawn from the heat exchanger by means of a vacuum pump that control the vacuum in the crystalliser body and heat exchanger. The crystalliser will be operated under vacuum to reduce the operating temperature in order to decrease corrosion potential, heat losses and minimise cost of construction materials as a result.

Slurry is withdrawn from the crystalliser at a certain density and pumped through a centrifuge to dewater the crystals. The concentrate is recycled back to the crystalliser and the crystals discharged into a bin for disposal.

Figure 3.1.5.17.4 (h): Sludge Dewatering Filter press and Centrifuge

Steam consumption is estimated between 600 to 900 kg/hr depending on the pressure. Steam will be generated on site by means of a packaged coal boiler plant.

The condensate water from the evaporator and the reverse osmosis permeate are blended in the product water tank before being discharged.

Option 2 – Brine Evaporation Pond – see Figure 3.1.5.17.4 (i)

The brine produced in the salt concentration section is routed directly to a lined brine evaporation pond where the water is evaporated by natural evaporation. A nett evaporation rate for the Lusthof Colliery region of 0.8 m per year was used in calculations. Some of the details of the evaporation pond are summarised in the table below:

Table 3.1.5.17.4 (a): Details of the Required Evaporation Pond

Instantaneous flow rate to evaporation pond	m^3/hr	1.76
Plant availability	%	82.0%
Nett evaporation rate	m/year	0.8
Volume to be evaporated	m^3/year	12635
Safety factor	%	10%
Evaporation area required	m^2	17373
Estimated length of square pond	m	132

Option 3 – Brine Softening – see Figure 3.1.5.17.4 (j)

The brine produced in the salt concentration section is routed to a brine storage buffer tank. This brine is fed to a softening clarifier. En route to the softening clarifier lime is dosed as slurry in a reaction tank with a combination of fast and slow mixing zones. The total reaction time in the reaction tank is approximately 3.5 hours. Lime softening is used to precipitate bivalent and trivalent species such as carbonates, magnesium, silica, phosphates, sulphates and metals. The sludge from the softening clarifiers is routed, together with the sludge from the volume reduction plant, to sludge dewatering equipment. The gypsum-dominated sludge is dewatered and stored for collection.

In order to achieve the desired and maximum precipitation, the salts first had to be concentrated in the RO process to take it closer or over their saturation limits. The combination of high concentrations of bivalent and trivalent salts and high pH achieved with the addition of lime causes the desired removal (by precipitation) of these salts. The water is also now less saturated and consists mainly of monovalent salts.

100% of the softened brine stream may be blended into the product water tank with the permeate of the reverse osmosis process and then the blended product water stream will still comply with the specifications of SANS241:2006 class 1. The product water quality for this option will not be compliant with the stringent water qualities of the region's natural water.

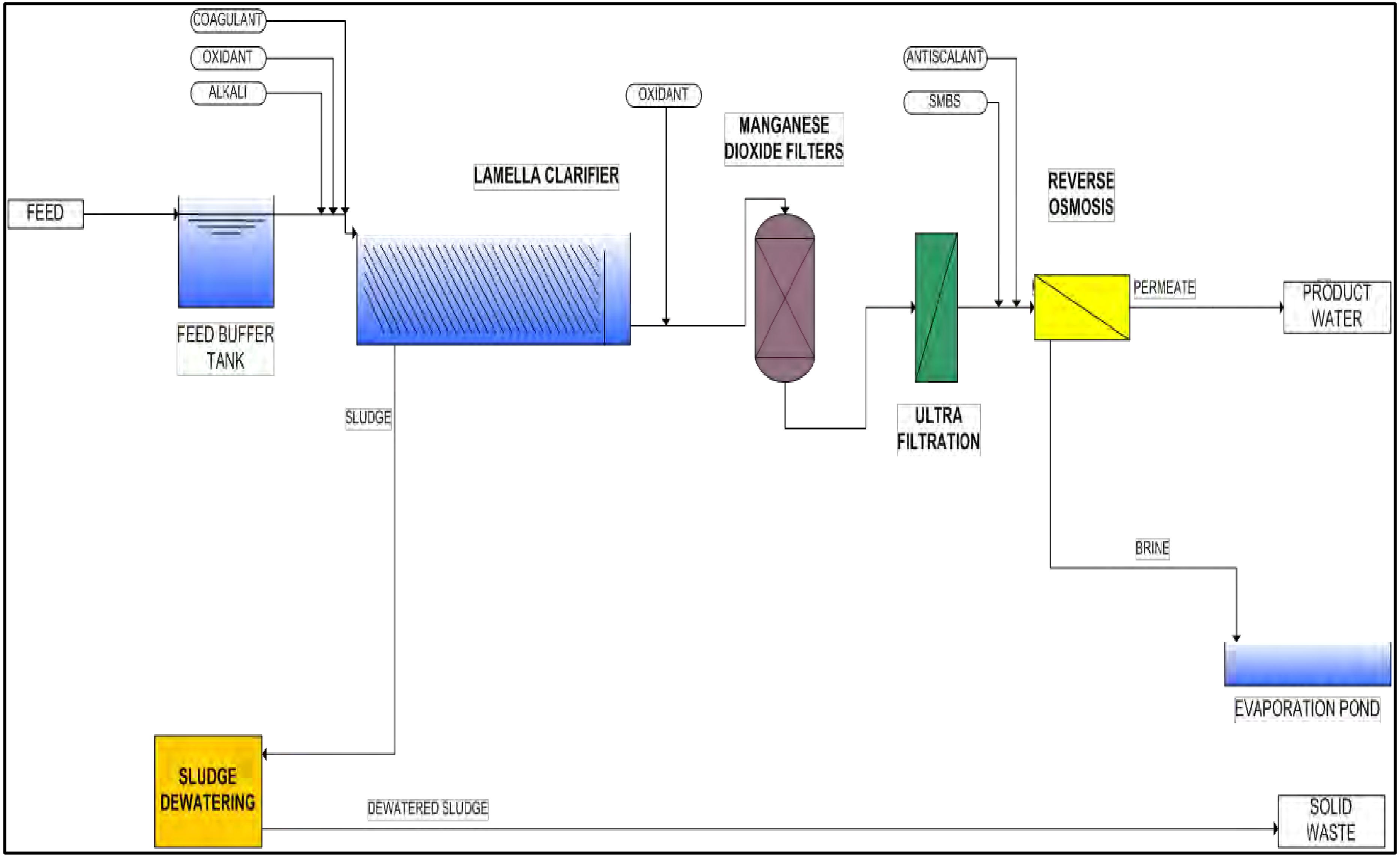


Figure 3.1.5.17.4 (i): Simplified Process Flow Diagram with Secondary Treatment Option 2

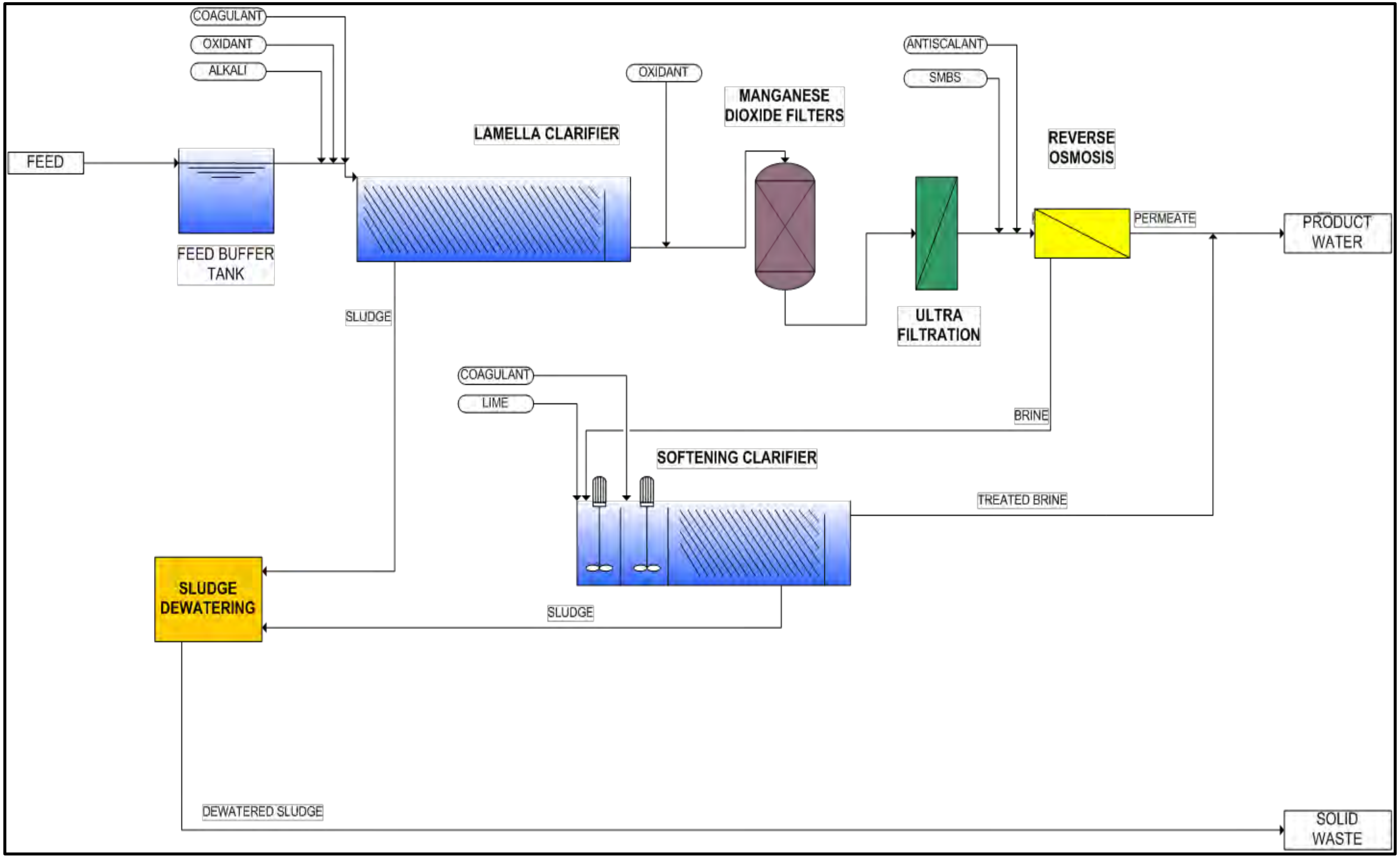


Figure 3.1.5.17.4 (j): Simplified Process Flow Diagram with Secondary Treatment Option 3

3.1.5.17.5 Product Water Quality

The product water quality for discharge is shown in Table 3.1.5.17.5 (a) below:

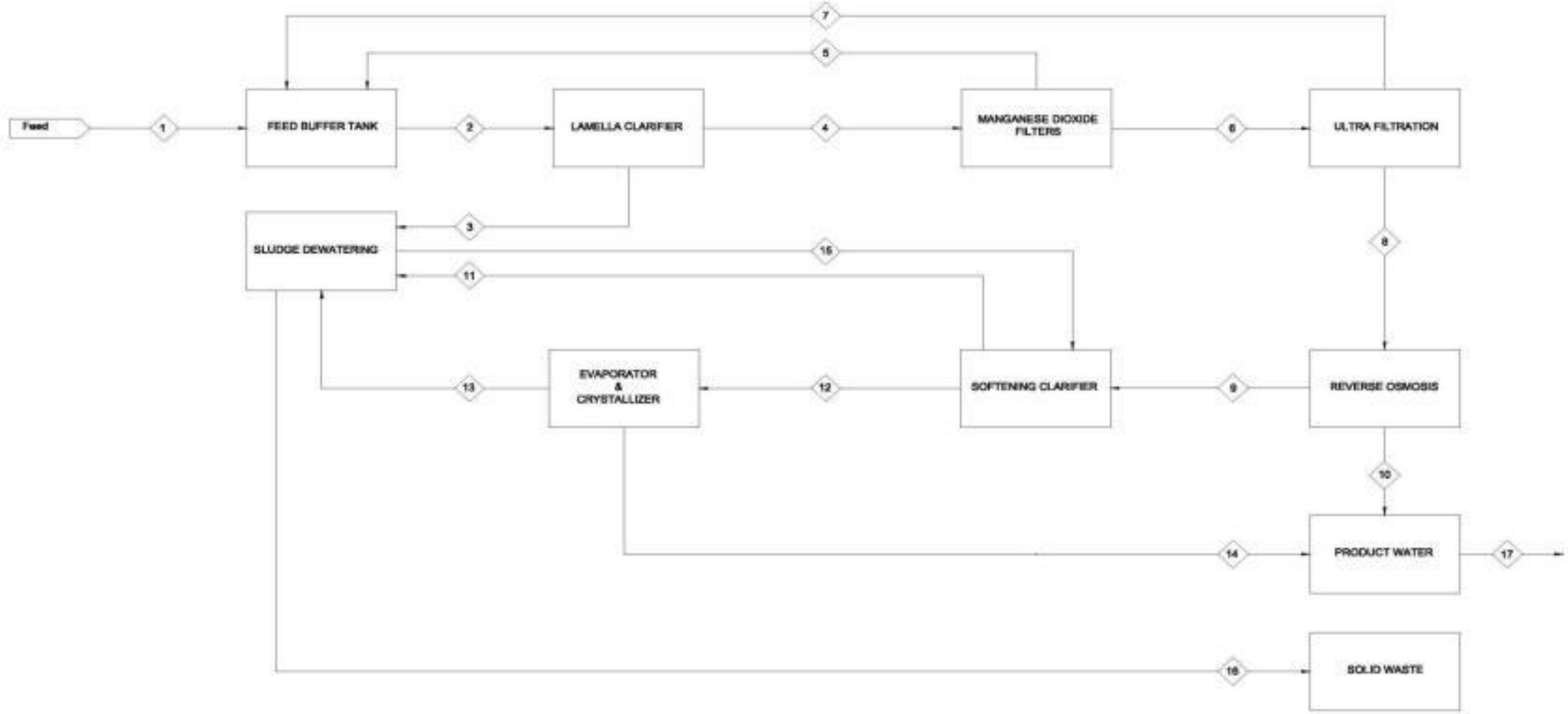
Table 3.1.5.17.5 (a): Product Water Quality

Parameter	Units	Estimated Product Water Quality Secondary Treatment Option 1 & 2	Estimated Product Water Quality Secondary Treatment Option 3	SANS 241 Class 1	Average Regional Natural Water Quality + 2 Std Dev
Al	mg/l	0.01	0.1	0.15	0.80
Ca	mg/l	4.5	118	150	3.92
Cl	mg/l	15.7	185	200	20.21
Electrical Conductivity	mS/m	<12.8	<126.3	150	10.51
F	mg/l	0.53	0.7	1	0.12
Fe (first 5 years)	mg/l	0.01	<0.1	0.2	0.89
Fe (year 6 onwards)	mg/l	0.01	<0.1	0.2	0.89
K	mg/l	2.2	35	50	6.34
Mg	mg/l	2.65	<5	70	2.53
Mn	mg/l	0.01	<0.1	0.1	0.16
Na	mg/l	8.4	<150	200	9.17
pH (first 5 years)		6.3	7.1	5.0 – 9.5	5.4-7.2
pH (year 6 onwards)		5.5	6.9	5.0 – 9.5	5.4-7.2
SO_4	mg/l	12.7	<270	400	13.45
Total Alkalinity (first 5 years)	mg/l as $CaCO_3$	15.8	<25	No spec	17.6
Total Alkalinity (year 6 onwards)	mg/l as $CaCO_3$	1.1	<15	No spec	17.6
TSS	mg/l	<1	<1	No	
Turbidity	NTU	<0.1	<0.5	1	
TOC	mg/l	<2	<2	10	
TDS		<75	<740	1000	46.7

All parameters with secondary treatment options 1 and 2 are within or close to the limits of the desired water quality, except for fluoride and total dissolved solids. Both of these parameters are however significantly lower than the standards for SANS241 drinking water Class 1. All parameters with the secondary treatment option 3 are within the limits for SANS241 class 1, but most of them do not meet the stringent average quality specifications of the regional natural water sources.

3.1.5.17.6 Block Flow Diagrams, Mass Balance and Process Flow Diagrams

Block flow diagrams with mass balance, and process flow diagrams are presented in the next 5 Figures covering all three options. Please note that a part of the water content is contained in the waste that is removed off-site.



		Stream																
Determinant	UOM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Mass flow rate	ton/hr	15.24	17.69	0.44	17.25	0.43	16.82	2.02	14.80	1.46	13.32	0.09	1.83	0.00	1.76	0.44	0.09	15.08
Volume flow rate	m3/hr	15.24	17.69	0.44	17.25	0.43	16.82	2.02	14.80	1.46	13.32	0.09	1.83	0.00	1.75	0.44	0.10	15.08
Pressure	bar (g)	1.50	1.50	1.50	2.50	2.50	2.50	2.50	10.00	7.00	ATM	1.50	2.00	1.50	ATM	1.50	ATM	2.00
Temperature	°C	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40
Density	kg/m^3	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.100	1.000
pH		4.5-8.0	8.0-8.0	8.0-8.0	8.0-8.0	8.0-8.0	8.0-8.0	8.0-8.0	8.0-8.0	8.0-8.0	5.5-7.5	11.7-12.2	11.7-12.2	6.0-6.0	6.0-6.0	7.0-12.0	7.0-12.0	5.5-7.5

NOTES | REF. DRG.NO | REVISION

Drawing description: MASS BALANCE Option 1

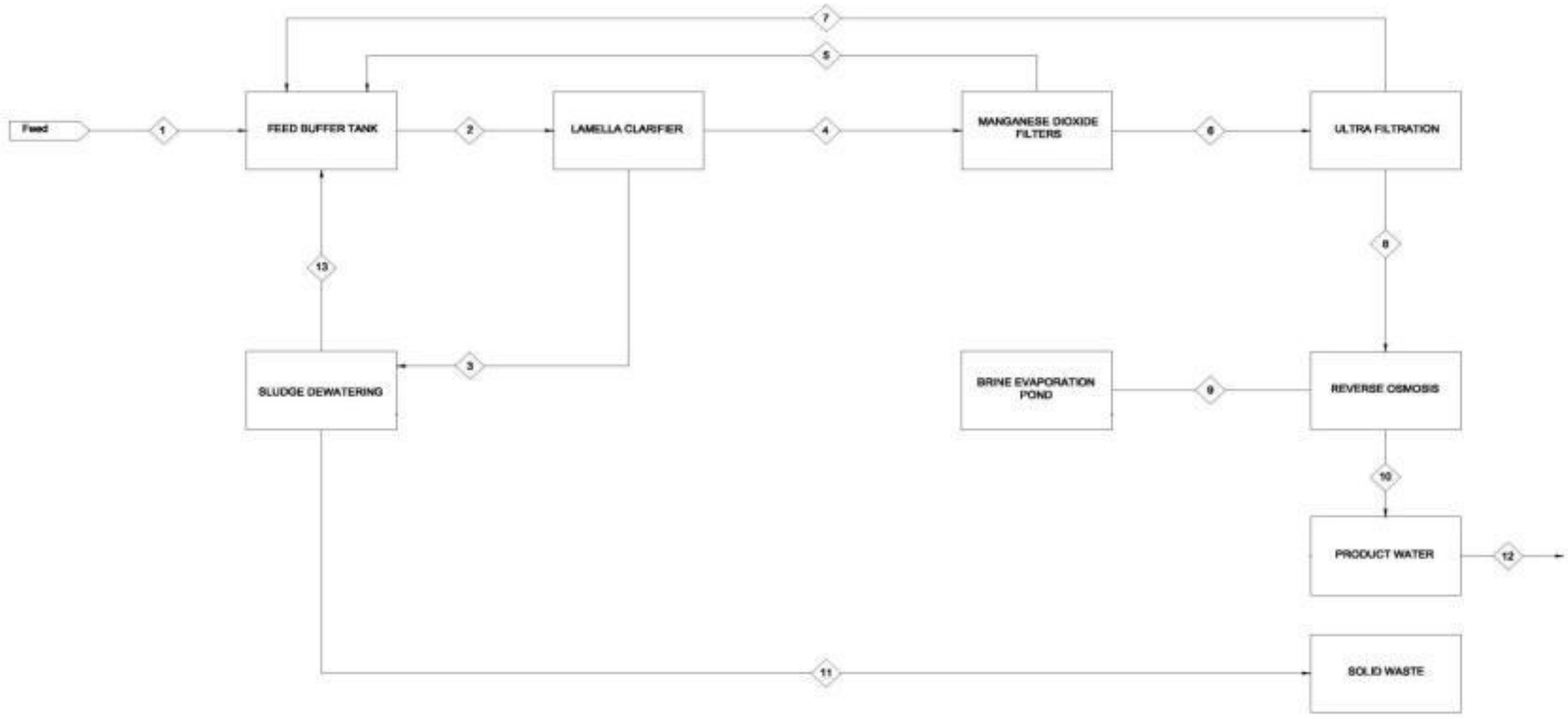
	BY	DATE
APPROVED		
CHECKED	AK	19.08.11
DRAWN	LL	19.08.11

Project: JMA CONSULTING

proxa

Drawing number: P-168-BFD-001 | Page: 1/1 | Rev.: 1

Figure 3.1.5.17.6 (a): Mass Balance Option 1



Determinand	UOM	Stream 1	2	3	4	5	6	7	8	9	10	11	12	13
Mass flow rate	ton/hr	15.24	18.22	0.48	17.76	0.44	17.32	2.08	15.24	1.52	13.72	0.083	13.72	0.45
Volume flow rate	m3/hr	15.24	18.22	0.46	17.76	0.44	17.32	2.08	15.24	1.52	13.72	0.00	13.72	0.45
Pressure	bar (g)	1.50	1.50	1.50	2.50	2.50	2.50	2.50	10.60	7.60	ATM	1.50	2.00	1.50
Temperature	°C	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40
Density	kg/m^3	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
pH		6.5-8.0	6.0-8.0	6.0-8.0	6.0-8.0	6.0-8.0	6.0-8.0	6.0-8.0	6.0-8.0	6.0-8.0	5.5-7.5	6.0-8.0	5.5-7.5	6.0-8.0

NOTES | REF. DRG.NO | REVISION

Drawing description: MASS BALANCE Option 2

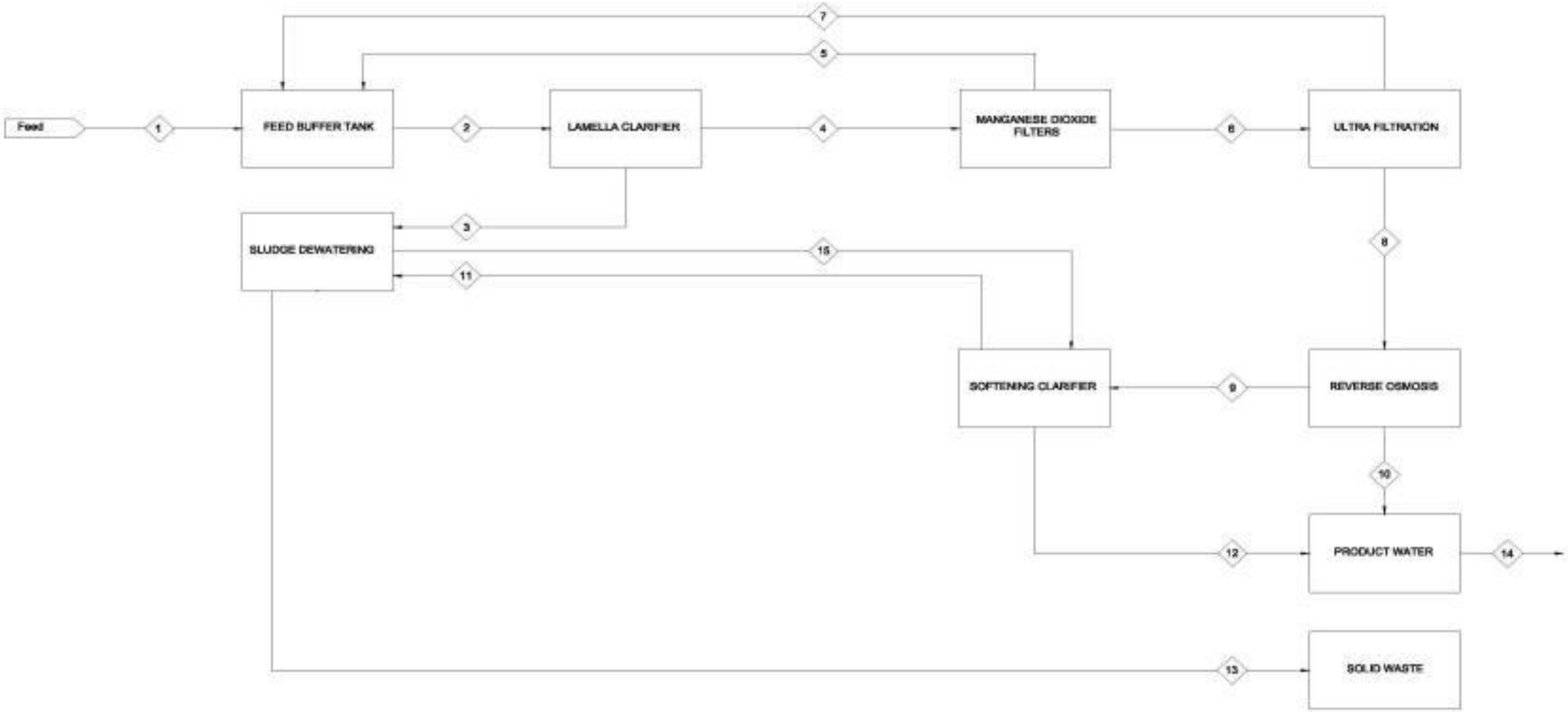
	BY	DATE
APPROVED		
CHECKED	AK	19.08.11
DRAWN	LL	19.08.11

Project: JMA CONSULTING

proxa

Drawing number: P-168-BFD-002 | Page: 1/1 | Rev.: 1

Figure 3.1.5.17.6 (b): Mass Balance Option 2



Determinant	UOM	Stream														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mass flow rate	ton/hr	15.24	17.69	0.44	17.25	0.43	16.82	2.02	14.80	1.48	13.32	0.09	1.87	0.05	15.19	0.48
Volume flow rate	m3/hr	15.24	17.69	0.44	17.25	0.43	16.82	2.02	14.80	1.48	13.32	0.09	1.87	0.05	15.19	0.48
Pressure	bar (g)	1.50	1.50	1.50	2.50	2.50	2.50	2.50	10.00	7.00	ATM	1.50	2.00	1.50	ATM	1.50
Temperature	°C	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40	10-40
Density	kg/m^3	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 100	1 000	1 000
pH		4.5-8.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	5.5-7.5	10.0-12.0	10.0-12.0	9.0-12.0	6.0-9.0	9.0-12.0

NOTES	REF. DRG.NO	REVISION	Drawing description		BY	DATE	Project	
			MASS BALANCE Option 3	APPROVED			JMA CONSULTING	proxa
				CHECKED	AK	19.08.11		Drawing number P-168-BFD-003 / Page 1/1 / Rev. 1
				DRAWN	LL	19.08.11		

Figure 3.1.5.17.6 (c): Mass Balance Option 3

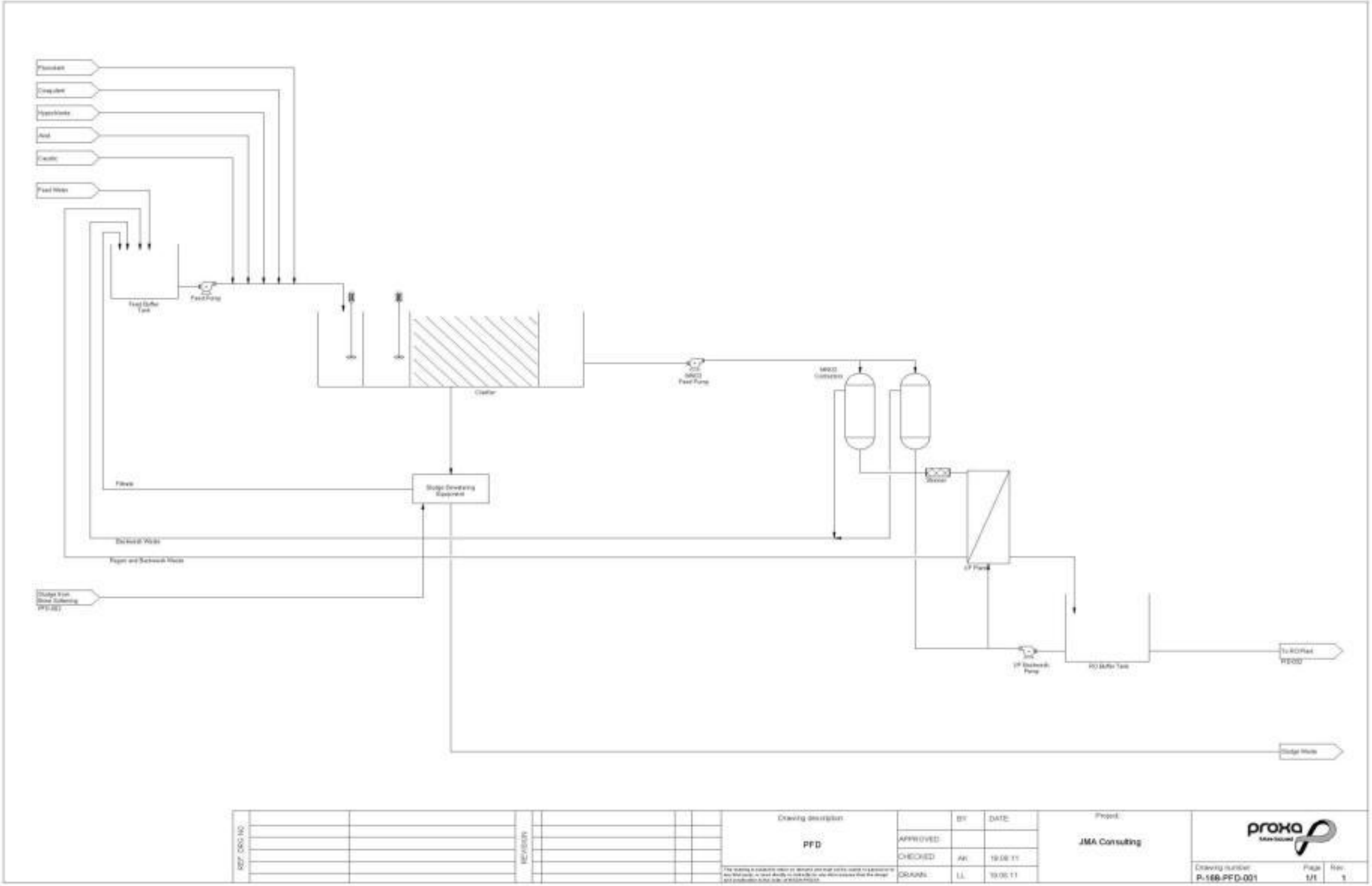


Figure 3.1.5.17.6 (d): Process Flow Diagram 1 of 2

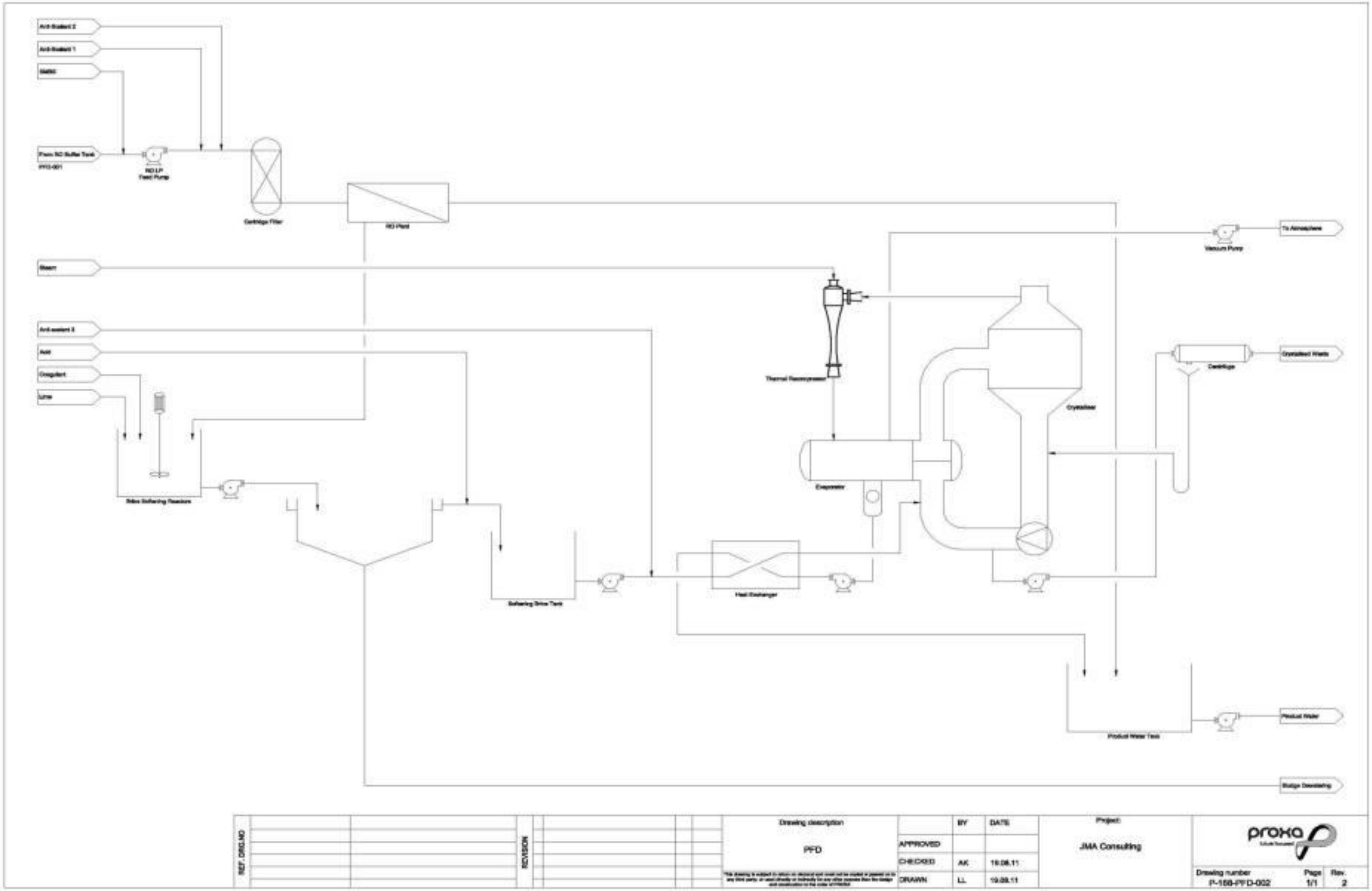


Figure 3.1.5.17.6 (e): Process Flow Diagram 2 of 2

3.1.5.17.7 Capital Cost Estimates

The capital cost estimates of the different options of the required water treatment plant are summarised in the Tables below.

Please note that the engineering and project management costs have been included in all the individual items.

Option 1: The cost of the evaporation and crystallisation unit is more than 55% of the total plant capital costs. The high quality required in the product water as well as the requirement for a ZED facility has increased the capital cost considerably.

Table 3.1.5.17.7 (a): Capital Costs Summary for Option 1

COST SUMMARY SHEET

CLIENT	JMA Consulting
TENDER NO.	P165 - Lusthof Colliery
DATE	2011/09/22
OPTION	1

General Specifications		Budget price
#	Item Description	R
	HARDWARE COST	
1	Motor Driven Equipment	R 496 807.23
2	Vessel and Auxiliary Equipment	R 1 702 862.09
3	Instrumentation	R 415 665.07
4	Manual and Control Valves	R 283 984.55
	SITE WORKS	
5	Earth and Civil Works	R 1 004 954.96
6	Piping and Mechanical Installation	R 1 248 394.86
7	EC&I Works	R 841 514.62
8	Commissioning	R 203 373.50
	ENGINEERING AND PROJECT MANAGEMENT	
9	Engineering and Project Management	R 0.00
	(incl in individual costs)	
	PRELIMINARIES AND GENERALS	
10	Preliminaries and Generals	R 245 634.40
	SPARES	
`11	Spares	R 170 851.55
12	**FINAL WASTE TREATMENT**	
	Evaporation Crystallisation unit	R 9 093 163.37
Notes:		R 15 707 206.19

Option 2: The capital cost of the evaporation pond is more than 63% of the total plant capital costs and this option has the highest capital cost. The cost of land has not been included in the calculation.

Table 3.1.5.17.7 (b): Capital Costs Summary for Option 2

	COST SUMMARY SHEET	
CLIENT	JMA Consulting	
TENDER NO.	P165 - Lusthof Colliery	
DATE	2011/09/22	
OPTION	2	
General Specifications		**Budget price**
#	Item Description	**R**
	HARDWARE COST	
1	Motor Driven Equipment	R 496 807.23
2	Vessel and Auxiliary Equipment	R 1 332 857.04
3	Instrumentation	R 390 237.73
4	Manual and Control Valves	R 270 673.83
	SITE WORKS	
5	Earth and Civil Works	R 911 039.34
6	Piping and Mechanical Installation	R 1 148 493.23
7	EC&I Works	R 821 482.38
8	Commissioning	R 158 374.74
	ENGINEERING AND PROJECT MANAGEMENT	
9	Engineering and Project Management	R 0.00
	(incl in individual costs)	
	PRELIMINARIES AND GENERALS	
10	Preliminaries and Generals	R 245 634.40
	SPARES	
`11	Spares	R 170 851.55
12	**FINAL WASTE TREATMENT**	
	Evaporation pond	R 10 484 583.00
Notes:		R 16 431 034.47

Option 3: The capital cost for this option is far less than any of the other options. Salts from the process are removed via the precipitated sludge of the clarifiers which allowed for the omission of an expensive evaporation facility. The product water quality complies with SANS241:2006 class 1, but not with that of the regional natural water qualities.

Table 3.1.5.17.7 (c): Capital Costs Summary for Option 3

COST SUMMARY SHEET

CLIENT	JMA Consulting
TENDER NO.	P165 - Lusthof Colliery
DATE	2011/09/22
OPTION	3

General Specifications		Budget price
#	Item Description	R
	HARDWARE COST	
1	Motor Driven Equipment	R 496 807.23
2	Vessel and Auxiliary Equipment	R 1 702 862.09
3	Instrumentation	R 415 665.07
4	Manual and Control Valves	R 283 984.55
	SITE WORKS	
5	Earth and Civil Works	R 989 394.94
6	Piping and Mechanical Installation	R 1 248 394.86
7	EC&I Works	R 825 394.38
8	Commissioning	R 178 374.48
	ENGINEERING AND PROJECT MANAGEMENT	
9	Engineering and Project Management	R 0.00
	(incl in individual costs)	
	PRELIMINARIES AND GENERALS	
10	Preliminaries and Generals	R 245 634.40
	SPARES	
`11	Spares	R 170 851.55
Notes:		R 6 557 363.55

3.1.5.17.8 Estimated Operating Cost

A summary of the estimated operating cost of the effluent treatment plant for each option is shown in Table 3.1.5.17.8 (a).

- The manpower cost is the main contributor to the extremely high operating costs, making up more than 40% for all three options. Due to the small capacity of the plant the manpower cost increases the cost per cubic metre of water treated significantly.
- The small capacity of the plant also makes the further treatment of waste to possible by-products not a viable option.
- Option 1 has the highest operating cost due to the high waste removal and maintenance costs.
- Option 2 has the lowest operating cost and is also the least complicated process to operate. It has much lower chemicals and consumables cost, less waste removal cost and less maintenance cost than the other two options. This is mainly due to the softening clarifier and evaporator/crystalliser facilities being replaced by a brine pond.

3.1.5.17.9 Waste Composition and Handling

Option 1

The sludge dewatering facility receives the waste streams from the lamella clarifier, the brine softening clarifier and the crystalliser. The function of the lamella clarifier is to remove suspended solids and precipitated metals from the feed stream while the brine softening clarifier primarily removes precipitated bivalent and trivalent salts such as calcium sulphate, calcium carbonate and magnesium hydroxide. The waste from the crystalliser is the final salt crystals removed from the final treatment step and contains both monovalent and bivalent salts. Solid waste must be removed from site twice per month.

Option 2

The sludge dewatering facility receives only the underflow from the lamella clarifier. The function of the lamella clarifier is to remove suspended solids and precipitated metals from the feed stream. Solid waste must be removed from site every six months.

Option 3

The sludge dewatering facility receives the waste streams from the lamella clarifier, the brine softening clarifier and the crystalliser. The function of the lamella clarifier is to remove suspended solids and precipitated metals from the feed stream while the brine softening clarifier primarily removes precipitated bivalent and trivalent salts such as calcium sulphate, calcium carbonate and magnesium hydroxide. Solid waste must be removed from site every three weeks.
A summary of the estimated composition of the final waste to be removed from site is provided in Table 3.1.5.17.9 (a).

OPERATING COST - SUMMARY						
Availability	82%					
Operating hours per annum	7 183	hrs				
Effluent water treated	15.2	m3/hr				
	OPTION 1		OPTION 2		OPTION 3	
DESCRIPTION	Cost/annum	R/m3 water treated	Cost/annum	R/m3 water treated	Cost/annum	R/m3 water treated
CHEMICALS AND CONSUMABLES		**R 4.43**		**R 2.43**	R 0.00	**R 4.26**
Chemicals & consumables	R 484 794.57	R 4.43	R 266 299.00	R 2.43	R 466 602.01	R 4.26
Membrane replacement		**R 0.35**		**R 0.35**	R 0.00	**R 0.35**
UF	R 22 080.00	R 0.20	R 22 080.00	R 0.20	R 22 080.00	R 0.20
RO	R 16 253.64	R 0.15	R 16 253.64	R 0.15	R 16 253.64	R 0.15
Electricity		**R 2.26**		**R 1.90**	R 0.00	**R 1.90**
Pre-treatment & Reverse Osmosis	R 208 287.66	R 1.90	R 208 287.66	R 1.90	R 208 287.66	R 1.90
Evaporator and Crystallizer	R 38 753.36	R 0.35	R 0.00	R 0.00	R 0.00	R 0.00
Manpower		**R 11.82**		**R 10.94**	R 0.00	**R 11.82**
Plant manager	R 36 000.00	R 0.33	R 36 000.00	R 0.33	R 36 000.00	R 0.33
Operators	R 648 000.00	R 5.92	R 648 000.00	R 5.92	R 648 000.00	R 5.92
GA	R 288 000.00	R 2.63	R 192 000.00	R 1.75	R 288 000.00	R 2.63
Engineering assistance	R 45 000.00	R 0.41	R 45 000.00	R 0.41	R 45 000.00	R 0.41
Other (car, travel, cellphone, accommodation etc)	R 277 200.00	R 2.53	R 277 200.00	R 2.53	R 277 200.00	R 2.53
Waste removal		**R 6.92**		**R 0.27**	R 0.00	**R 4.92**
Waste removal	R 757 832.48	R 6.92	R 29 905.47	R 0.27	R 538 581.34	R 4.92
Maintenance		**R 3.24**		**R 2.68**	R 0.00	**R 1.80**
Maintenance	R 354 255.79	R 3.24	R 293 723.96	R 2.68	R 196 720.91	R 1.80
TOTAL	**R 3 176 457.51**	**R 29.01**	**R 2 034 749.72**	**R 18.58**	**R 2 742 725.56**	**R 25.05**

Table 3.1.5.17.8 (a): Summary of Operating costs for each option

Table 3.1.5.17.9 (a): Estimated Sludge Composition

	Option 1		Option 2		Option 3	
Component	**% dry basis**	**% wet basis**	**% dry basis**	**% wet basis**	**% dry basis**	**% wet basis**
Waste per month (tons)	**50.6**	**32.9**	**2**	**1.3**	**36**	**23.4**
$CaSO_4$ (Gypsum)	**39**	**25**	**-**	**-**	**60**	**38.4**
Metal hydroxides and oxides (mainly of Fe, Al and Mn)	**3**	**1.8**	**77**	**49**	**5**	**3.2**
$CaCO_3$ (Calcium carbonate)	**9**	**5.8**	**-**	**-**	**15.2**	**9.7**
$Mg(OH)_2$ (magnesium hydroxide)	**10**	**6.4**	**-**	**-**	**15.8**	**10.1**
Mixed crystallised salts of Na_2SO_4, $CaSO_4$, KCl, NaCl, $CaCl_2$, Silt	**39**	**25**	**23**	**15**	**4**	**2.6**
Water content	**-**	**36**	**-**	**36**	**-**	**36**

3.1.5.17.10 General Site Location and Utilities

Site Location

The site is located 10 km south east of Carolina in Mpumalanga province of South Africa at co-ordinates 26° 12’ 01.01” S and 30° 13’ 59.12” E. The location of Lusthof Colliery as well as the proposed effluent treatment plant is shown on the combined Figure below.

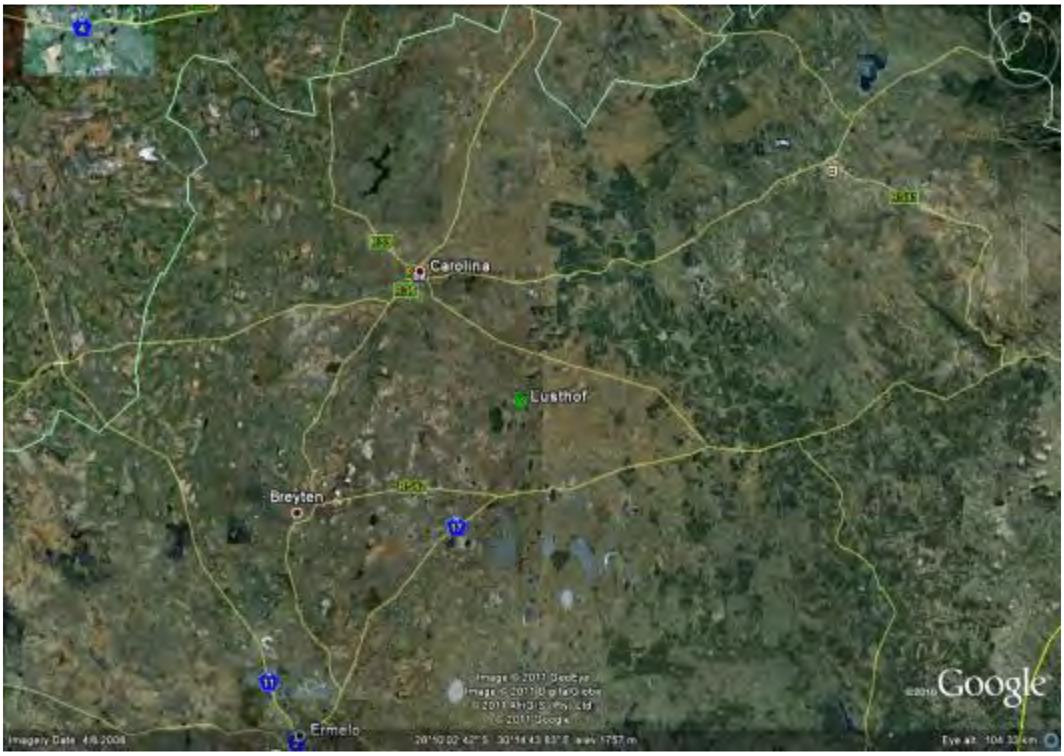


Figure 3.1.5.17.10 (a): Location of Lusthof Colliery and Proposed WTP

<u>Utilities</u>

The following infrastructure will be required for the Water Treatment Plant:

- Access roads;
- A 165m^2 flat, hard surface;
- Stormwater management;
- Electricity supply.

The WTP will have the following included on site (also included in capital costs):

- Small laboratory workspace (part of civil structure)
- Control room (part of civil structure)
- Ablutions (part of civil structure)
- Storage for chemicals and consumables (part of civil structure)
- Storage for spares and tools (part of civil structure)
- Covered/roofed area (portal frame) for membrane processes

Table 3.1.5.17.10 (a): Site Battery Limits

SUPPLY	BATTERY LIMIT	CONDITION
Feed water	Blank flange on effluent treatment plant boundary	Flowrate: 15.24m3/hr Pressure: 2 bar (g)
Electrical supply	Transformer with 3 phase/400V/50Hz power supply	Installed: 67kW Absorbed: 53kW
DISCHARGE	**BATTERY LIMIT**	**CONDITION**
Product water	Blank flange on effluent treatment plant boundary	Flowrate: 15.1 m3/hr Pressure: Ambient
Sludge and crystallised waste	Stored on site in waste skips, to be removed off site to waste disposal facility	0.71 tons dry /day 1.10 tons per day (incl moisture)
General waste	Waste skip for disposal of spent cartridges, empty containers etc.	

3.1.5.17.11 Plant Operations

The operations must provide for 24/7 operational staff based on site, including a site supervisor 4 hours a week, 3 senior fully competent and trained industrial operators (1 per shift), 3 general assistants (1 per shift) and engineering assistance of 2 hours per week.

Site operations personnel will be assisted by:

- Process engineer (2 hours per week)
- Maintenance personnel (cost included in maintenance)

Site Supervisor

The Site Supervisor will be responsible for, inter alia:

- Responsible for day to day management of the plant
- Responsible for management of site safety
- Management of site staff on day to day basis
- Preparation of shift rosters
- Compilation of daily site information for client and process staff
- Standby support
- Routine equipment and safety checks
- Routine maintenance checks on the facilities
- Strict conformance to quality control and ISO requirements
- Shutdown planning
- Providing guidance and additional hands-on training to the staff
- Conformance to all health and safety requirements
- Conformance to ISO and OHSA requirements and standards

- The overall supervision of the facilities, ensuring performance standards and availability are satisfied at all times
- Total system management, control, monitoring of plant performance
- Administrative and financial support
- Performance monitoring and control
- Mobilisation of support services
- Process support and monitoring
- Quality control and ISO conformance
- Plant Maintenance implementation
- Site HR and conducting of any required disciplinaries
- Operations budget

Some of the duties of the site supervisor may be delegated to senior operators.

Senior Plant Operators

The senior operators are responsible for day to day operation of the facility, in accordance with operational, health and safety requirements, including inter alia:

- The operation of the facilities to the required performance standards
- Control and monitoring of plant performance
- Start up and shutdown of the plant
- Reporting on plant operational data, outputs and non-conformances
- Recording and reporting of alarms and corrective action
- Strict adherence to SHEQ; HAZCHEM; HAZOP and H&S requirements
- Strict conformance to quality control and ISO requirements
- Implementing corrective actions, to avoid operational non-conformances
- Compilation of daily log books
- Sample taking
- Trouble shooting of the plant
- Reporting of all maintenance requirements
- Changing of cartridge filters
- CIP of the system

General Assistants

The general assistants will be responsible for assisting the operators, and general housekeeping, chemical loading and make-up if required.

Reporting

The management system and procedures must cover all aspects of:

- Personnel matters
- Process monitoring
- Record keeping
- Asset inventory and asset management
- Job scheduling
- Maintenance and repair control
- Procurement

- Reporting
- Plant throughput, availability, and product quality

Copies of all records and reports must be maintained at the plants for inspection and operational log sheets will be completed by plant operators on a 2 hourly basis.

Training

All staff must be properly trained and certified prior to commencing with work on site.

3.1.5.17.12 Conclusions

The following conclusions summarises the findings of this report:

- The design for an effluent treatment plant at Lusthof Colliery was based on a daily capacity of 300 m^3/day and an availability of 82%.
- The treatment plant must be a zero effluent discharge facility with all waste being removed from site.
- The required product water quality is extremely good and corresponds to the quality of the natural water sources of the region which is well below that of drinking water class 1.
- The product water from the treatment plant corresponds to that of the required water specification.
- Reverse osmosis with pre-treatment is the primary desalination process. This primary treatment phase has a recovery of 89%.
- Evaporation and crystallisation is the final salt removal step for secondary brine treatment option 1.
- An evaporation pond is the final salt removal step for secondary brine treatment option 2.
- A brine softening process and blending with product water is the final salt removal step for secondary brine treatment option 3. Thus no pond and no evaporator or crystalliser is required.
- The product water quality is within or very close to the required standard of the region's natural water sources for options 1 and 2.
- The product water quality of option 3 is within SANS 421: Class 1 standards, but outside the required standard of the region's natural water sources.
- Table 3.1.5.17.12 (a) provides a summary of the single selected primary treatment or desalination option in combination with the three different secondary brine treatment options.
- Processes that are established in the market and proven to be successful on full scale have been chosen.
- Robust processes that can handle the different qualities of feed water expected over the lifetime of the required treatment facility have been chosen.
- The capacity of the plant is too small to allow for further treatment as operations will become complex.
- Salt crystals, precipitate and all other final waste will be removed to a waste handling facility.

- The estimated capital cost of the treatment facility is R15.7 million. The evaporator and crystalliser required for the final waste treatment in order to be a ZED facility is more than 55% of the total capital cost.
- The main contributors too costs are waste disposal and manpower.

Table 3.1.5.17.12 (a): Comparative Brine Treatment Pro and Con Summary

	Option 1	Option 2	Option 3
Process	**Refer to** Error! Reference source not found.**3.1.5.17.4(e)**	**Refer to** Error! Reference source not found.**3.1.5.17.4(i)**	**Refer to** Error! Reference source not found.**3.1.5.17.4(j)**
Brine treatment	**Brine softening, evaporator and crystalliser**	**Evaporation pond**	**Brine softening**
Chemicals and consumables cost	**R484 795 per year**	**R266 299 per year**	**R466 602 per year**
Operating costs	**R3.176 million per year**	**R2.035 million per year**	**R2.743 million per year**
Advantages	**Small footprint Very good product water quality**	**Low operating cost Simpler operations Very good product water quality Low waste volumes**	**Low capital cost Small footprint Robust solution**
Disadvantages	**High operating cost High waste volumes Non-uniform waste**	**High capital cost Big footprint**	**More uniform waste High operating cost High waste volumes Product water quality only within SANS241: class 1 spec**

3.1.5.18 Overall Water Balance Diagrams for Lusthof Colliery

Overall water balance diagrams, combining both the storm water balance as well as the mine rainfall and ground water balances, and incorporating all water usage and water loss figures, have been calculated for the mine operational and post closure phases.

The operational phase water balance has been calculated for the three proposed development stages during the operational phase, and makes provision for wet season rainfall occurrences (worst case scenarios).

The overall operational phase water balance calculations are shown in Table 3.1.5.18 (a), Table 3.1.5.18 (b) and Table 3.1.5.18 (c) respectively.

The overall operational and post closure water balances are depicted as Water Balance Diagrams in Figure 3.1.5.18 (a), Figure 3.1.5.18 (b), Figure 3.1.5.18 (c) and Figure 3.1.5.18 (d) respectively.

The water balances are deemed highly accurate as all calculations have been performed subject to the mine and water management area designs.

TABLE D1: Lusthof Opencast PCD: Operational Phase Stage 1 Water Balance (wet season)

Lusthof: Run-Off Volumes m³ per month

Dam Evaporation Area (m²) — Calculated 12800

		Mine area m²	252700	Upslope Area m²	382800	Run-off Factor	7.5%
MAP=	776 mm			ROM Area m²	14400		20%
Symons pan MAE =	1583 mm			Contractor's yard m²	10000		30%

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
(days)	31	30	31	31	28	31	30	31	30	31	31	30	365
Symons pan(%MAE)	9.79	10.19	10.91	10.98	9.39	9.09	7.07	5.88	4.94	5.54	7.15	9.07	100
Symons pan (mm)	155	161	173	174	149	144	112	93	78	88	113	144	1583
pan factor	0.81	0.82	0.83	0.84	0.88	0.88	0.88	0.87	0.85	0.83	0.81	0.81	0.84
Gross Lake Evapor.(mm)	**126**	**132**	**143**	**146**	**131**	**127**	**98**	**81**	**66**	**73**	**92**	**116**	**1331**
Rainfall (% Wet)	11.92	16.94	16.74	16.33	12.32	9.76	6.23	1.87	1.08	0.80	1.59	4.41	100
Wet Rainfall (mm)	92.5	131.4	129.9	126.7	95.6	75.7	48.4	14.5	8.4	8.2	12.4	34.2	776

Interception Dam [Inflow-Outflow = Delta Storage]

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Inflow (m3)		**4539**	**6379**	**6311**	**6158**	**4671**	**3744**	**2442**	**841**	**547**	**447**	**741**	**1772**	**38593**
Direct Rain		1184	1682	1663	1621	1224	969	619	185	107	79	158	438	9931
Monthly upslope run-off		2658	3774	3729	3637	2745	2174	1389	416	241	177	355	983	22275
Washing bay (m³/day)	5	155	150	155	155	140	155	150	155	150	155	155	150	1825
ROM & Contractor's yard		544	773	764	745	562	445	284	85	49	36	73	201	4562
Outflow (m3)		**3777**	**3793**	**4005**	**4039**	**3634**	**3791**	**3361**	**3207**	**2951**	**3102**	**3343**	**3589**	**42591**
Total Evaporation		1607	1693	1835	1869	1674	1621	1261	1037	851	932	1173	1489	17041
Excess Outflow (m3)		0	0	0	0	0	0	0	0	0	0	0	0	0
Export ROM 2000t/d	0.02	1240	1200	1240	1240	1120	1240	1200	1240	1200	1240	1240	1200	14600
Dust Suppression (m3/day)	30	930	900	930	930	840	930	900	930	900	930	930	900	10950
Inflow-Outflow (m3)		762	2586	2306	2119	1037	(47)	(919)	(2365)	(2403)	(2654)	(2603)	(1817)	(3998)
Delta Storage		762	3348	5654	7773	8810	8763	7845	5479	3076	422	0	0	
Maximum month end capacity (m3)		**8810**												
		762	3348	5654	7773	8810	8763	7845	5479	3076	422	(2181)	(3998)	

1 in 50 Year 24 hour storm event:

1:50 Year storm (mm)	122
Direct Rain (m3)	1561.6
1:50 volume (m3)	19871
Storm capacity required (m3)	**21433**

Run-off factor estimated: 0.4

Capacity required for interception	**30243** m³

Iuprocon

Table 3.1.5.18 (a): Operational Phase Stage 1 Overall Water Balance Calculations

TABLE D2: Lusthof Opencast PCD: Operational Phase Stage 2 Water Balance (wet season)

Lusthof: Run-Off Volumes m³ per month

Dam Evaporation Area (m²)							Calculated		12800					
				Mine area m²		127000	Upslope Area m²		379300		Run-off Factor			7.5%
MAP=	776	mm					ROM Area m²		14400					20%
Symons pan MAE =	1583	mm					Contractor's yard m²		10000					30%
		31	30	31	31	28	31	30	31	30	31	31	30	365
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Symons pan(%MAE)		9.79	10.19	10.91	10.98	9.39	9.09	7.07	5.88	4.94	5.54	7.15	9.07	100
Symons pan (mm)		155	161	173	174	149	144	112	93	78	88	113	144	1583
pan factor		0.81	0.82	0.83	0.84	0.88	0.88	0.88	0.87	0.85	0.83	0.81	0.81	0.84
Gross Lake Evapor.(mm)		**126**	**132**	**143**	**146**	**131**	**127**	**98**	**81**	**66**	**73**	**92**	**116**	**1331**
Rainfall (% Wet)		11.92	16.94	16.74	16.33	12.32	9.76	6.23	1.87	1.08	0.80	1.59	4.41	100
Wet Rainfall (mm)		92.5	131.4	129.9	126.7	95.6	75.7	49.4	14.5	8.4	6.2	12.4	34.2	776
Interception Dam		(Inflow-Outflow = Delta Storage)												
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Inflow (m3)		**4515**	**6344**	**6277**	**6125**	**4646**	**3724**	**2429**	**837**	**545**	**446**	**737**	**1763**	**38389**
Direct Rain		1184	1682	1663	1621	1224	969	619	185	107	79	158	438	9931
Monthly upslope run-off		2632	3739	3695	3603	2720	2154	1376	412	239	175	352	974	22071
Washing bay (m³/day)	5	155	150	155	155	140	155	150	155	150	155	155	150	1825
ROM & Contractor's yard		544	773	764	745	562	445	284	85	49	36	73	201	4562
Outflow (m3)		**3777**	**3793**	**4005**	**4039**	**3634**	**3791**	**3361**	**3207**	**2951**	**3102**	**3343**	**3589**	**42591**
Total Evaporation		1607	1693	1835	1869	1674	1621	1261	1037	851	932	1173	1489	17041
Excess Outflow (m3)		0	0	0	0	0	0	0	0	0	0	0	0	0
Export ROM 2000t/d	0.02	1240	1200	1240	1240	1120	1240	1200	1240	1200	1240	1240	1200	14600
Dust Suppression (m3/day)	30	930	900	930	930	840	930	900	930	900	930	930	900	10950
Inflow-Outflow (m3)		738	2551	2272	2086	1012	(67)	(931)	(2369)	(2408)	(2656)	(2606)	(1826)	(4202)
Delta Storage		738	3290	5561	7647	8659	8592	7861	5292	2886	230	0	0	
Maximum month end capacity (m3)		**8659**												
		738	3290	5561	7647	8659	8592	7861	5292	2886	230	(2376)	(4202)	

1 in 50 Year 24 hour storm event:

1:50 Year storm (mm)	122
Direct Rain (m3)	1561.6
1:50 volume (m3)	19701
Storm capacity required (m3)	**21262**

Run-off factor estimated 0.4

Capacity required for Interception	**29921**	m³

Table 3.1.5.18 (b): Operational Phase Stage 2 Overall Water Balance Calculations

TABLE D3: Lusthof Opencast PCD: Operational Phase Stage 3 Water Balance (wet season)

Lusthof: Run-Off Volumes m³ per month

Dam Evaporation Area (m²) — Calculated: 12800

Mine area m²: 143000 | Upslope Area m²: 316800 | Run-off Factor: 7.5%

MAP= 776 mm | ROM Area m²: 14400 | 20%

Symons pan MAE = 1583 mm | Contractor's yard m²: 10000 | 30%

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
(days)	31	30	31	31	28	31	30	31	30	31	31	30	365
Symons pan(%MAE)	9.79	10.19	10.91	10.98	9.39	9.09	7.07	5.88	4.94	5.54	7.15	9.07	100
Symons pan (mm)	155	161	173	174	149	144	112	93	78	88	113	144	1583
pan factor	0.81	0.82	0.83	0.84	0.88	0.88	0.88	0.87	0.85	0.83	0.81	0.81	0.84
Gross Lake Evapor.(mm)	**126**	**132**	**143**	**146**	**131**	**127**	**98**	**81**	**66**	**73**	**92**	**116**	**1331**
Rainfall (% Wet)	11.92	16.94	16.74	16.33	12.32	9.76	6.23	1.87	1.08	0.80	1.59	4.41	100
Wet Rainfall (mm)	92.5	131.4	129.9	126.7	95.6	75.7	48.4	14.5	8.4	6.2	12.4	34.2	776

Interception Dam [Inflow-Outflow = Delta Storage]

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Inflow (m3)		**4080**	**5726**	**5666**	**5529**	**4197**	**3368**	**2202**	**769**	**506**	**417**	**679**	**1602**	**34741**
Direct Rain		1184	1682	1663	1621	1224	969	619	185	107	79	158	438	9931
Monthly upslope run-off		2197	3121	3084	3008	2271	1798	1149	344	199	146	293	813	18423
Washing bay (m³/day)	5	155	150	155	155	140	155	150	155	150	155	155	150	1825
ROM & Contractor's yard		544	773	764	745	562	445	284	85	49	36	73	201	4562
Outflow (m3)		**3777**	**3793**	**4005**	**4039**	**3634**	**3791**	**3361**	**3207**	**2951**	**3102**	**3343**	**3589**	**42591**
Total Evaporation		1607	1693	1835	1869	1674	1621	1261	1037	851	932	1173	1489	17041
Excess Outflow (m3)		0	0	0	0	0	0	0	0	0	0	0	0	0
Export ROM 2000t/d	0.02	1240	1200	1240	1240	1120	1240	1200	1240	1200	1240	1240	1200	14600
Dust Suppression (m3/day)	30	930	900	930	930	840	930	900	930	900	930	930	900	10950
Inflow-Outflow (m3)		303	1933	1661	1490	562	(423)	(1159)	(2437)	(2445)	(2685)	(2664)	(1987)	(7850)
Delta Storage		303	2236	3897	5388	5950	5527	4369	1931	0	0	0	0	
Maximum month end capacity (m3)		**5950**												
		303	2236	3897	5388	5950	5527	4369	1931	(514)	(3199)	(5863)	(7850)	

1 in 50 Year 24 hour storm event:

1:50 Year storm (mm)	122
Direct Rain (m3)	1561.6
1:50 volume (m3)	16641
Storm capacity required (m3)	**18202**

Run-off factor estimated: 0.4

Capacity required for Interception	**24152**	m³

Table 3.1.5.18 (c): Operational Phase Stage 3 Overall Water Balance Calculation

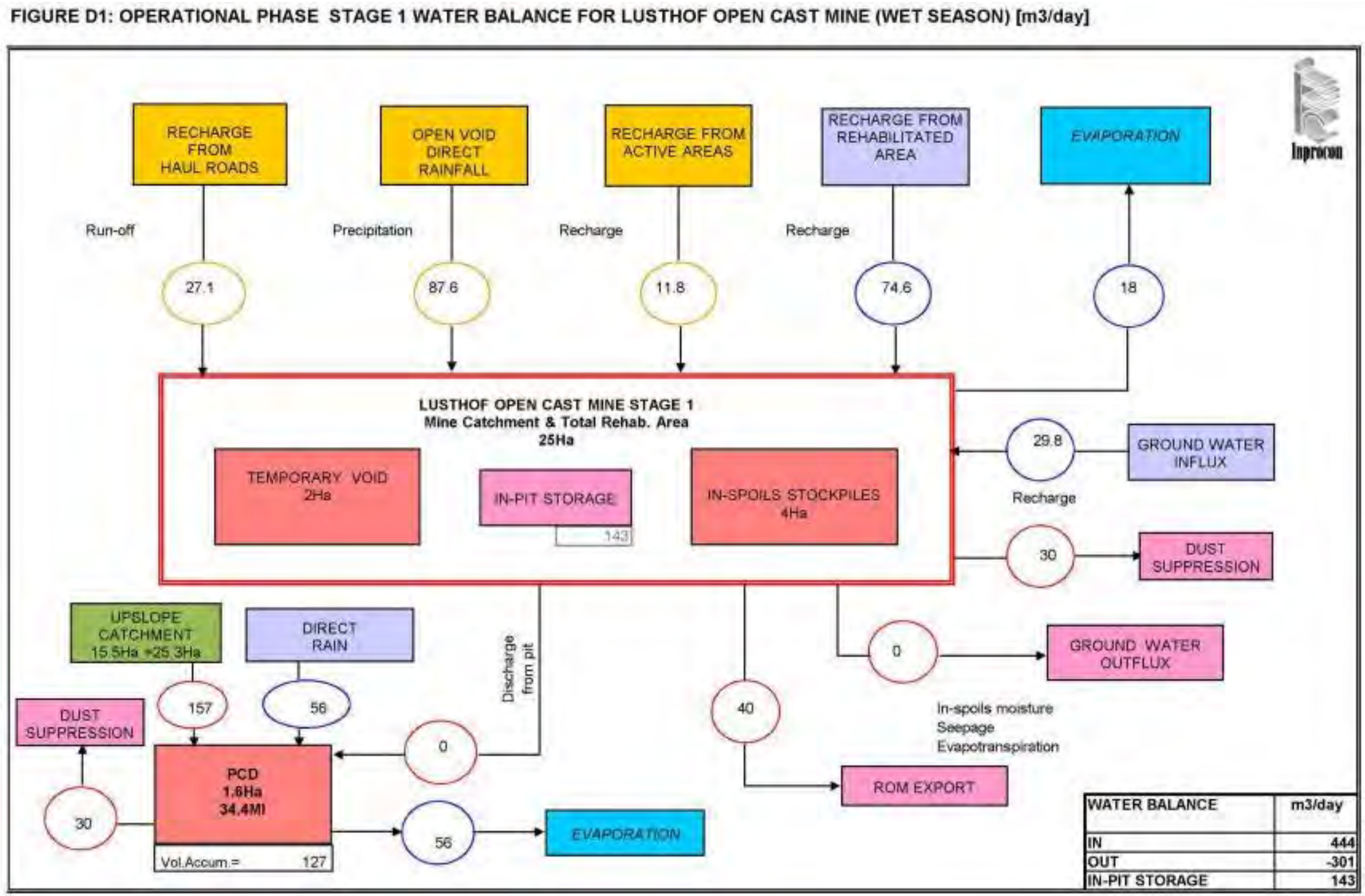
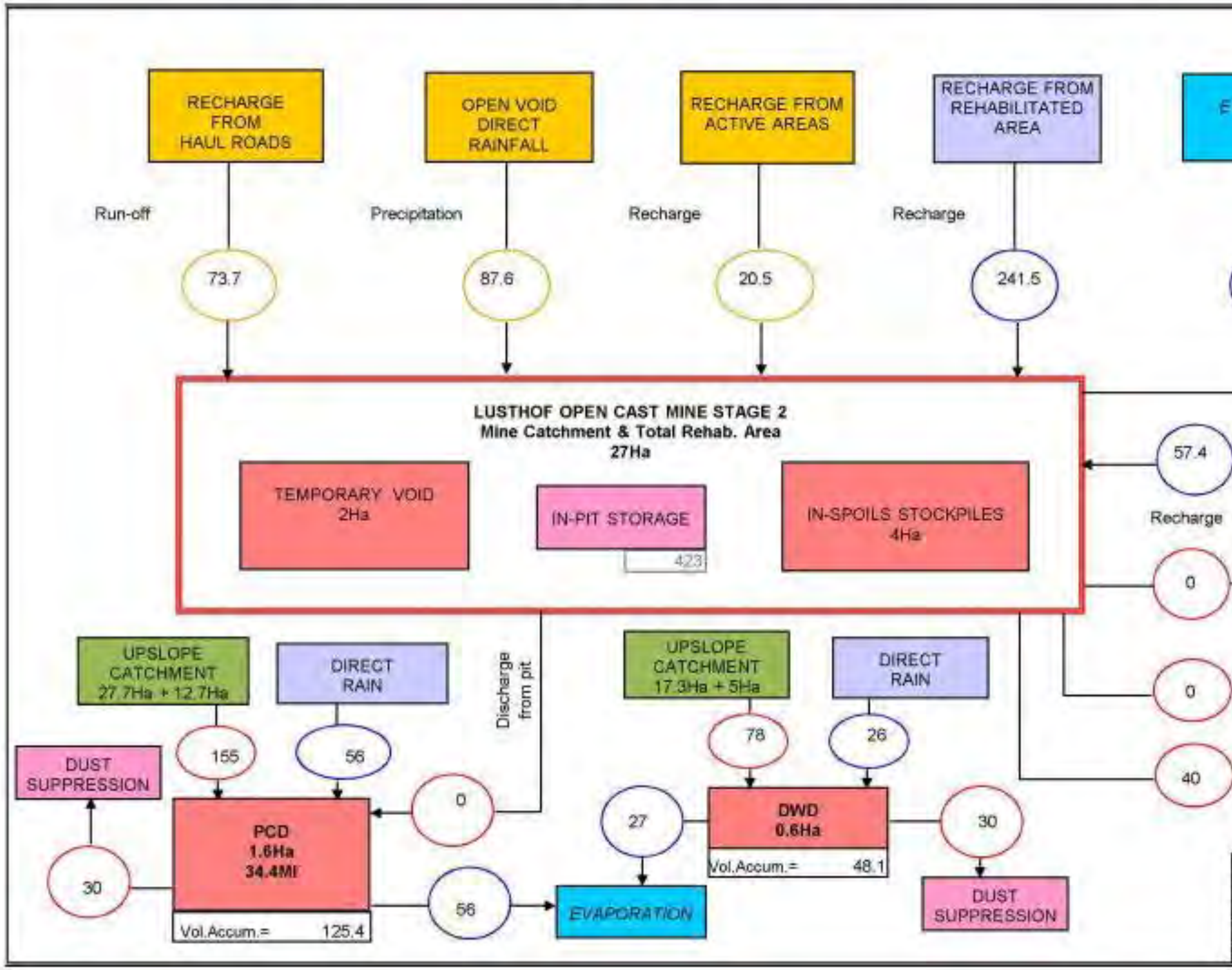


Figure 3.1.5.18 (a): Operational Phase Stage 1 Overall Water Balance Diagram

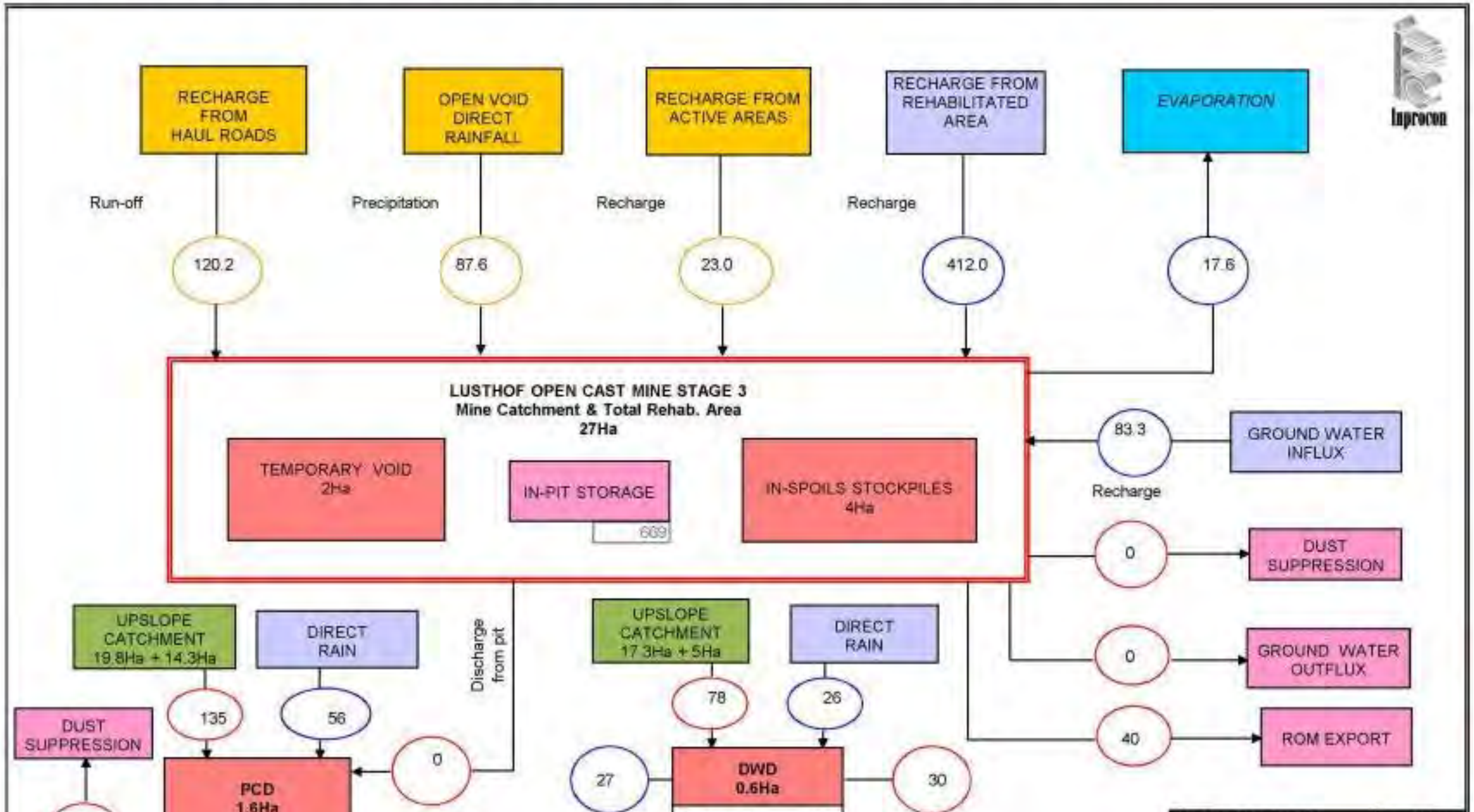
FIGURE D2: OPERATIONAL PHASE STAGE 2 WATER BALANCE FOR LUSTHOF OPEN CAST MINE (WET SEASON) [m3/day]



WATER BALANCE	m3/day
IN	797
OUT	-374
BALANCE	423

Figure 3.1.5.18 (b): Operational Phase Stage 2 Overall Water Balance Diagram

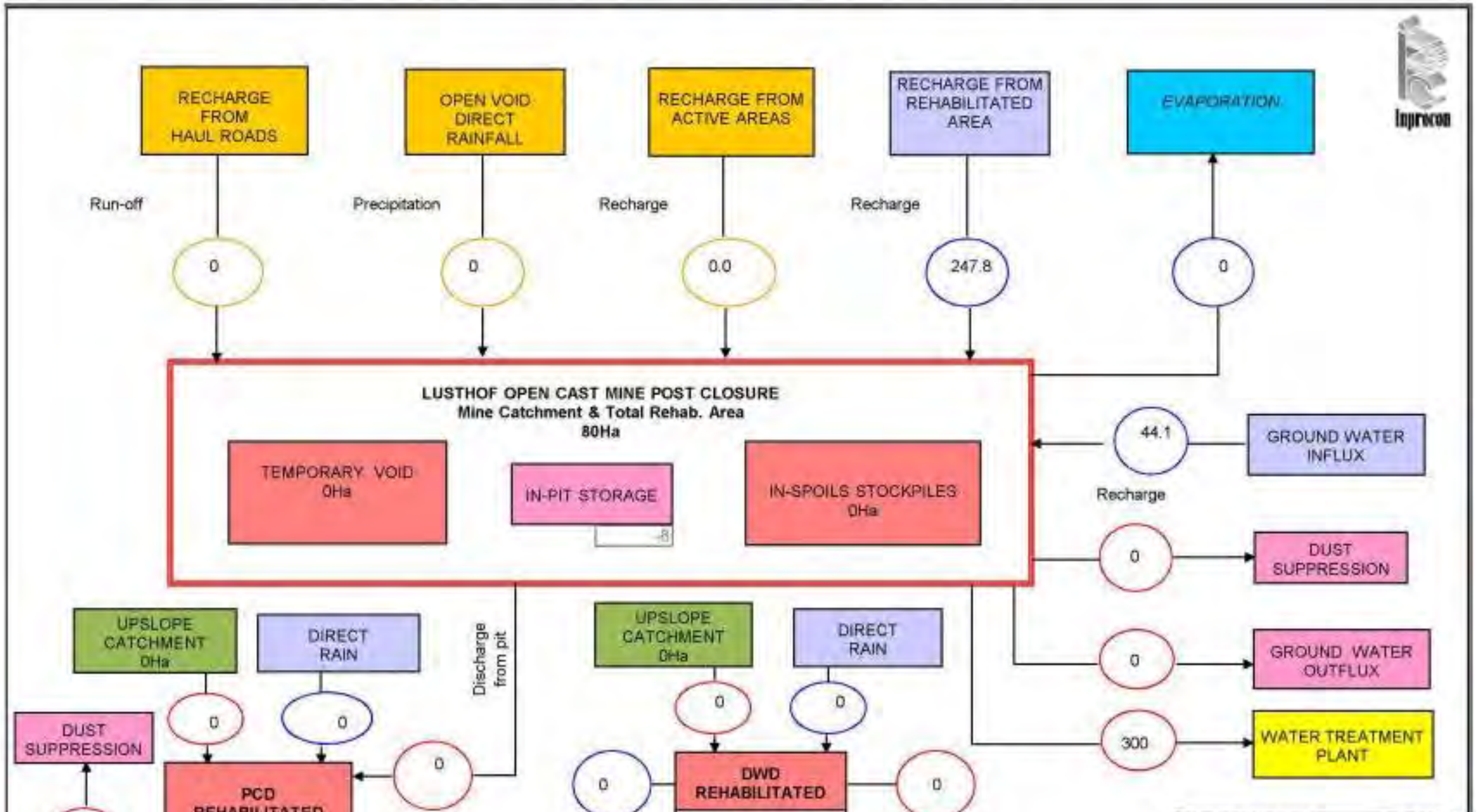
FIGURE D3: OPERATIONAL PHASE STAGE 3 WATER BALANCE FOR LUSTHOF OPEN CAST MINE (WET SEASON) [m3/day]



WATER BALANCE	m3/day
IN	1022
OUT	-353
BALANCE	669

Figure 3.1.5.18 (c): Operational Phase Stage 3 Overall Water Balance Diagram

FIGURE D4: POST CLOSURE WATER BALANCE FOR LUSTHOF OPEN CAST MINE (WET SEASON) [m3/day]



WATER BALANCE	m3/day
IN	292
OUT	-300
BALANCE	-8

Figure 3.1.5.18 (d): Post Closure Phase Overall Water Balance Diagram

3.1.5.19 Waste Management Facilities

Domestic Waste Disposal

Domestic waste will be handled by a sub-contractor that will remove waste from the site on a weekly basis. Only temporary storage in waste skip bins will take place. No permanent storage of waste will take place on site.

Spoils Disposal

The mining method will be that of continuous roll-over in the opencast pit. Only the materials excavated during the initial box cut excavation will be stored on surface. The softs and hards spoils stockpiles are delineated on Figure 3.1.5.7 (a).

Discard Disposal

No discard will be generated on site since all coal will be removed as ROM coal.

Slurry Disposal

No slurry will be generated at Lusthof Colliery.

Salvage Yard

No salvage yard will be present at Lusthof Colliery.

3.1.6 Construction Phase Activities and Time Lines

The Construction Phase will commence as soon as the required authorizations have been obtained, and will include the following items:

- Upgrading of the External Gravel Roads
- Preparation of the Road Diversions
- Moving of the Power Transmission Lines and provision of 200 kVA to the Mine
- Fencing of the Mining Area
- Construction of Security Entrance
- Preparation of Internal Access Roads
- Installation of Weighbridge
- Construction of Contractor's Yard with Infrastructure
- Installation of Diesel Storage Tanks
- Drilling and equipping of Potable Water Supply Borehole(s)
- Construction of ROM Stockpile Platform
- Construction of Mine Haul Roads
- Development of Storm Water Management Trenches, Canals and Berms
- Construction of Pollution Control Dam
- Construction of Dirty Water Dam
- Construction of Clean Water Diversion Pond
- Box-Cut Development

The full construction phase is estimated to run for 6 months.

More details of the construction activities will now be provided with reference to the details shown on Figure 3.1.5.1 (a) – see APPENDIX 3.1.5.1 (A) for large scale map.

3.1.6.1 Upgrading of External Gravel Roads

The two provincial gravel roads which connect the mine with the two tar roads to be used to transport the coal from the Mine to East Side Colliery, will be upgraded to be able to carry the coal transport trucks. An Engineering Feasibility Study, complete with geotechnical assessment, will be conducted for BGCE by the Consulting Engineers Inprocon.

3.1.6.2 Preparation of the Road Diversions

A formal application to divert the Provincial Gravel Road that currently bisects the proposed mining area has been lodged with the relevant Road Transport Authority in Nelspruit.

The Consulting Engineers Inprocon has compiled a detailed Engineering Study and Design Report, whilst the Environmental Authorization required for the road diversion forms part of the EIA Process for which this EIAR is being compiled.

The Farm Road that currently runs from the Provincial Gravel Road in a southerly direction through the proposed mining area and which provides access to farm land to the south of Lusthof, will also be diverted.

This road will be diverted by upgrading the western farm road which currently runs along the western Lusthof farm boundary, with a new take off south of the mining area in a south-easterly direction to meet up with the original Farm Road running through the centre of the proposed mining area.

3.1.6.3 Moving of Power Lines and Provision of Power to Lusthof Colliery

An 22 kV Eskom overhead power line currently supplies a dwelling on Lusthof from where it diverts south across the mining area towards the farm steads in the south. The dwelling on Lusthof will be mined out and power will no longer be required here.

However, in order to sustain power supply to the south, the line will be diverted along the eastern boundary of Lusthof, with a take of point to the west to supply 200 kVA to Lusthof Colliery. All diversions and new installations will be handled by ESKOM.

3.1.6.4 Fencing of the Mining Area

A 5 strand barbed wire fence will be established around the perimeter of the mining area and will take place right at the beginning of the construction phase.

3.1.6.5 Construction of Security Entrance

A boom gate and a pre-fabricated security house will be erected in the western central part of the mining area where the main access road to the mine enters the mining area.

3.1.6.6 Preparation of Internal Access Roads

Internal access roads will be developed to provide for coal transport and mining vehicles to enter and leave the mine, as well as to provide access for water bowsers to the Existing Lusthof Northern Surface Water Dam. The main internal access road will be 10 m wide and all other access roads will be 4 m wide. The roads will be scraped, shaped to optimize run-off drainage, covered with a suitable gravel and compacted.

3.1.6.7 Installation of Weighbridge

A weighbridge will be installed by an external supplier between the ROM Stockpile and the Main Access Road.

3.1.6.8 Construction of Contractors Yard and Infrastructure

The area will be levelled and all concrete floors and bunds, as well as the workshop will be constructed. Pre-fabricated facilities will be supplied and erected by an outside contractor. The potable water storage tank will be installed and water reticulated to the offices, change house and toilets. The French drain will be constructed, and the area will be fenced.

3.1.6.9 Installation of Diesel Storage Tanks

Two diesel storage tanks will be installed within either bunds or with spillage bowls within the Contractors Yard.

3.1.6.10 Drilling and Equipping of Potable Water Supply Borehole

It is foreseen that only one potable water supply borehole will be required. However, in the event that a yield of 0.28 l/s cannot be secured additional holes will be drilled until sufficient supplies are secured. The boreholes will be 165 mm in diameter and will be between 50 m and 80 m deep. Boreholes will be fitted with submersible pumps and flow meters to record the abstracted volumes.

The water will be pumped to the potable water storage tank located in the Contractor’s Yard.

3.1.6.11 Construction of ROM Stockpile Platform

The ROM Stockpile Platform will be constructed in accordance with a Detailed Civil Engineering Design as approved by DWA. The consulting engineers Inprocon have performed a concept design for approval by DWA. Once the Platform has been constructed, the as built drawings will be submitted to DWA.

3.1.6.12 Construction of Mine Haul Roads

Permanent haul roads are to be constructed between the ROM Stockpile and the Open Pit. The roads will be constructed of suitable material and will conform to minimum safety requirements in terms of slopes and widths etc. The haul roads will terminate in the south at the ROM stockpile and in the north at the current strip being mined.

3.1.6.13 Development of Storm Water Management Trenches, Canals and Berms

The principle of keeping clean water out of the mining operation and retaining dirty water shall apply to the proposed mine. A series of local diversion berms and clean water drains are to be constructed adjacent to the pit boundary to divert clean water away from the opencast pit. All water that falls on the outside of the berms is considered clean water and will be allowed to discharge into the environment.

Surface water within the extent of the berms is considered to be dirty water and will be required to be managed. The trenches, canals and berms will be constructed in accordance with a formal civil engineering design performed by Inprocon and as approved by DWA.

3.1.6.14 Construction of Pollution Control Dam

The Pollution Control Dam will be constructed in accordance with a Detailed Civil Engineering Design as approved by DWA. The consulting engineers Inprocon have performed a concept design for approval by DWA. Once the PCD has been constructed, the as built drawings will be submitted to DWA.

3.1.6.15 Construction of Dirty Water Dam

The Dirty Water Dam will be constructed in accordance with a Detailed Civil Engineering Design as approved by DWA. The consulting engineers Inprocon have performed a concept design for approval by DWA. Once the DWD has been constructed, the as built drawings will be submitted to DWA.

3.1.6.16 Construction of Clean Water Diversion Pond

A Clean Water Diversion Pond will be constructed near to the saddle on the western side of the pit area. The pond will intercept and store clean surface water run-off to be used for dust suppression. The pond will have a surface area of 5 000 m^2 and maximum depth of 3 m for a maximum storage capacity of 4 000 m^3. The Clean Water Diversion pond will be constructed in accordance with a Detailed Civil Engineering Design as approved by DWA. The consulting engineers Inprocon have performed a concept design for approval by DWA. Once the CWD has been constructed, the as built drawings will be submitted to DWA.

3.1.6.17 Box-Cut Development

The box-cut has been planned for the southern extent of the pit boundary. A double box cut has been planned for the first strip, after which single box cut roll over mining will take place in a northerly direction. The overburden of the initial box-cuts will be loaded and hauled to the allocated stockpile areas and will be used for rehabilitation of the final box-cut in the north of the pit boundary.

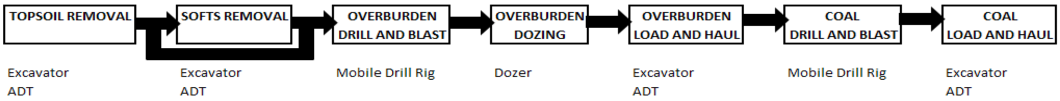
3.1.6.18 Water Treatment Plant

Current indications are that a WTP will only be constructed during Year 6 of mining. The WTP will be constructed in accordance with a DWAE approved Detailed Civil Engineering design. A Conceptual design has been performed for the purpose of this EIAR and also to support the Waste License Application which has to be lodged to authorize the WTP in terms of the provisions of the NEMWA.

3.1.7 Operational Phase Activities and Time Lines

The operational phase, known as the steady state mining phase, will commence after the completion of the initial box cut. A conventional strip mining (roll-over) method will be employed.

Steady-state mining includes the following processes and will be conducted by a sub-contractor:



To conduct the above process the planned mining equipment to be utilized is as follows –

- 1 X Komatsu D375 Bulldozer
- 3 X Volvo EC700 Hydraulic Excavators
- 12 X Volvo A35E Articulated 6X6 Dump trucks
- 2 X Komatsu D65 Bulldozer
- 1 X Volvo G940 Motor Grader
- 2 X 12 000 litre Water Bowser
- 1 X 12 000 litre Diesel Browser
- 1 X Mobile Percussion Drilling Rig
- 1 X Service Truck

The actual production rates for the proposed mine will be calculated based on the proposed equipment match to the mining layout. The payloads and loads/hour assumptions are based on actual performance by mining subcontractors at other sites. The calculation assumes two 10.5 hour shifts working 5.5 days a week. Based on the above calculation, the average monthly production capacity of coal is 38,970 m^3 or 58,455 tons. A monthly production of 55,000 t is therefore assumed for steady-state mining.

The stockpiled coal will be loaded onto 30 ton coal transport trucks which will transport the coal to the beneficiation plant at East-Side Colliery just outside Carolina on the Badplaas road.

Rehabilitation of the mine will comprise an on-going material roll over activity during the operational phase.

In addition to all the above, the overall environmental management (including water management and the treatment of water from Year 7 onwards) and monitoring program represents an important operational phase activity.

Throughout all three operational phase development stages clean water diversion berms will be constructed on the northern side of the advancing mining area to divert clean surface water run-off into the natural environment on the eastern side of the mine.
At the same time dirty water isolating berms will be constructed progressively along the southern and eastern perimeter of the mining area to intercept and

discharge contaminated surface water via a silt trap into to PCD. Several clean storm water cross-over culverts will be constructed at appropriate locations in the dirty water diversion berms for the passing of clean surface water run-off into the natural environment during stages 2 and 3.

It is clear that the clean and dirty water diversion/isolating berms need to be constructed in a planned manner and in accordance with the mine development plan in order to be effective and to achieve the surface water management goals. The order, sequence and timing of implementing these berms are critical for the prevention of dirty water spills and will need to be monitored and adapted, if necessary, on a continuous basis.

3.1.7.1 Topsoil Removal

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. The topsoil removed from the initial box cuts will be used to construct the berm alongside the northern road diversion and will be planted with grass. Topsoil will be removed using excavators and hauled with Articulated Dump Trucks (ADT's).

Figure 3.1.7.1 (a): Removal of Topsoil within demarcated Block

3.1.7.2 Softs Removal

Soft subsoil/overburden 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 ADT's.

Figure 3.1.7.2 (a): Removal of Soft Overburden (Softs) using an Excavator and ADT

Figure 3.1.7.2 (b): Removal of Softs within demarcated Block

3.1.7.3 Overburden Drill and Blast

Overburden blasting will only occur once every two weeks, on a weekly alternating basis with coal blasting.
Drilling of the blast holes will be done with a mobile drill rig, dedicated to this activity.

All blasting will be done according to a formal Code of Practice to be developed for the mine prior to any blasting being done.

A Code of Practice is a comprehensive document prepared by specialists for the benefit and use of operatives, supervisors and managers concerned with a particular operation – such as blasting. Comprehension and adherence to the Code of Practice will ensure that the operations are carried out safely and effectively. It is necessary for every person engaged in carrying out and supervising operations to be conversant with and fully understand every aspect of the Code of Practice.

The main objectives of the COP are to firstly establish safe working practices for work on explosive equipment and secondly to minimize environmental impacts associated with blasting, by the establishment of rules and guidelines including the engineering, administrative controls as well as use and wearing of suitable safety equipment.

At Lusthof Colliery blasting operations will be conducted by an externally appointed blasting contractor. Explosives and explosive accessories will be a bench delivery. These explosives are delivered via road, by the supplier.

A collection of technical data (including geology) relating to the block of ground, containing waste rock and coal seams, which is to be fragmented will be considered in drawing up a '**Drill and Blast Plan'**

<u>Drill and Blast Plan</u>

The drill and blast plan will address aspects related to:

1. A Drill and Blast Request Form shall be completed by the Superintendent Drill & Blast and submitted to the Mining Contractor to design the blast. The request form shall contain all the data that the superintendent deems relevant.
2. Before commencing the design the technician shall refer to the special area plan in order to determine whether planned blast block has any influence on previously designated or currently designated special areas.
3. The technician shall refer to the geological maps in order to identify any slips, faults, dykes or other geological anomalies, which will have a bearing on the design.
4. The technician shall take account of the surface water drainage and ground water table as they might affect the blast block.
5. The technician shall refer to the available geological borehole logs and any other data from the field as supplied in the request form, in order to determine the planned depth of the blast hole.

6. When the drill and blast plan (Scale 1:500) is completed for the overburden or interburden blasts, the technician shall ensure that certain data is clearly shown.
7. Overall information should include:
   - The drill and blast plan number.
   - The north direction arrow.
   - A 500m radius circle highlighting;
   - Any other working excavation
   - Any accumulation of surface water.
   - Any boundary line encompassing property beyond Klipspruit Colliery.
   - A 50m wide boundary pillar between the blast block and boundary of adjacent mine.
8. Blast hole information should include:
   - The surveyed high wall crest position and toe positions of No.4 and / or No. 2 Seams.
   - The blast hole grid numbered by an alphanumeric system to define rows and columns of holes.
   - The burden, spacing and standoff distance between holes.
   - The position of any test holes drilled.
   - An information block quartered at each hole position.
   - The designed depth from the collar elevation to the top of the coal seam for each hole.
9. In the event of the blast taking place in the proximity of sensitive areas or structures, it is necessary to limit the intensity of ground vibrations. This is accompanied by limiting the mass of explosives that is initiated each delay interval, the mass being dependent on the distance between blast hole and structure.
10. Charging information including:
    - The type of explosives to be used.
    - The powder factor per blast hole.
    - The planned mass of explosives charge per blast hole.
    - The number of boosters, the size and position of each relative to the top and / or bottom of the blast hole.
    - The number and position of decking, if any.
11. The technician shall issue a copy of the completed Drill and Blast Plan to the Blasting Foreman and to the manager – Bulk Explosives Contractor. One copy of the plan shall be filed for reference and record purposes.
12. Before charging operations commence, the blaster shall ensure that warning signs are erected at the entrance to the blast area. The warning sign has to read as follows:

“NO ENTRY - BLASTING AREA”
“GEEN TOEGANG - SKIETGEBIED”

13. The blaster shall announce on the three radio channels (walkie talkie), that a blast is to take place, the location of a blast block, and the estimated time of the blast. He shall warn all persons to keep clear of the area.
14. The blaster shall warn all guards and radio users if there is to be more than a single blast.

15. The blaster shall ensure that all trailing cables at or near the blast block that could be damaged by blasting, are removed to a safe position.
16. The blaster shall ensure that all machines and equipment that could be damaged are removed to a safe position, prior to the blast.
17. The blaster shall ensure that all persons are moved to a safe position, at least 500 metres, from the blast block, prior to the blast. Persons who are in a downward position should be moved further away on a windy day.
18. The blaster shall select and appoint a sufficient number of persons to act as blast guards.
19. The blast guard shall ensure that no persons are within the danger zone, or re-enters the danger zone until after the all clear has been given.

Ground vibrations, emanating from a blast, could be sufficiently intense so as to cause rock falls from high wall faces or failure of spoil piles in cuts and other excavations in the proximity of a blast block, even though those working lie beyond the 500 metre radius of the blast block.

20. The blaster shall decide whether or not persons working in cuts and excavations in proximity of the blast block are at risk, from the effects of ground vibrations.
21. In the event of the blaster deciding that persons working in the proximate excavations are at risk, he shall ensure that the machinery is moved to the middle of the cut and the persons are moved to a position of safety under the direction of the blast guard.

The blast may be initiated with different accessories and different systems, to suit each application. The systems may comprise of using capped safety fuse, electric detonators or electric delay detonators connected to shock tubes. The blaster shall choose to use electric detonation with shock tube and electric lead in wire combinations when:

22. The blasting restrictions apply because blasting operations are less than 500 metres away from buildings, railway lines, power lines, public roads and telephone lines.
23. The blast is to be monitored for VOD recordings or MPH speed photography.
24. The blaster shall cause a blasting siren to be sounded continuously for at least three minutes prior to setting of the blast.
25. After the blast has successfully been completed, the blaster shall wait for the dust and blasting fumes to clear before he re-enters the blast area.

Blasting in Close Proximity to Structures

From time to time, it is necessary to conduct blasting operations in the proximity of public structures such as roads, railways and power lines. Because the danger does exist that such structures may be damaged, particular precautionary measures must be adopted. Also, the co-operation of the public authorities must be obtained to deal with any ramifications, which may result from blasting operations.

Blasting near Power Lines

1. When a blast is planned within a distance of 500 metres of an ESKOM power line, the local management staff of the utility shall be notified.

2. The open pit manager shall notify the Regional Manager of ESKOM that a blast will take place near the overhead power lines at least 48 hours before the blast is to occur.
3. The Regional Manager shall acknowledge receipt of the communication. It shall lie in his discretion whether or not to send an observer to the blast area.
4. A technician of ESKOM shall accompany the blast foreman to conduct an in-site inspection of the portion of the power line at risk, prior to the blast.
5. The ESKOM technician and blast foreman shall examine the power line after the blast to determine the presence of structural damage to the power line and the extent thereof.
6. In the event of a blast taking place within 100metres of a power line pylon, a portable seismograph shall be set at the pylon to record the ground vibrations emanating from the blast.
7. The operation of the seismograph shall be under the control of the blast monitoring technician.
8. The seismograph charts shall be made available to the ESKOM technician.

Blasting near Provincial Roads

There are provincial roads that run near the boundaries of the colliery lease area. When blasting operations are undertaken close to such roads, traffic travelling on the road is at risk from fly-rock. The Regional Traffic Authority is responsible for safety on such roads.

1. When a blast is planned within s distance of 500 metres of a provincial road, the manager of the regional traffic authority shall be notified.
2. The open pit manager shall notify the regional chief traffic officer that a blast will take place near the provincial road at least 24 hours before the blast.
3. The notification shall show the position of the blast on a plan and the expected time of the blast.
4. The regional chief traffic officer shall acknowledge receipt of the communication. It shall lie in his discretion whether or not to send his personnel to be present at the blast.
5. The blaster shall be responsible for closing off the road and placing both signage and blast guards on the road.
6. Warning notices “STOP - BLASTING IN PROGRESS” shall be placed on the road facing traffic approaching the danger area.
7. Mine personnel, designated by the blast foreman, shall man the roadblocks. A vehicle shall be parked on the right hand side of the road facing approaching traffic. The headlights shall be switched on and hazard lights flashing.
8. When the blaster has closed off the blast area, he shall notify the blast foreman by radio.
9. The blast foreman shall then proceed to close the road, by placing the signs, the guards and the vehicle at the roadblock.
10. Flagmen shall be stationed at suitable points approximately 200 metres from the roadblock to flag down approaching traffic to warn of the presence of the roadblock.
11. When the road has been closed, the blast foreman, who may be accompanied by traffic officials, will drive through from one road block to the other, to ensure that the road is clear of traffic and people.
12. When the area between the roadblocks has been proved to be clear, the blast foreman shall notify the blaster by radio, that the blasting may proceed.

13. The blaster shall sound the warning sirens in accordance with normal blasting practice.
14. After completion of the blast, the blast foreman shall drive through from one roadblock to the other, to check that there is no fly-rock on the road as an impediment to traffic.
15. In the event of blast debris lying on the road, the blast foreman shall arrange for the debris to be removed. If necessary the fire master shall be summoned by radio to come and wash the debris from the road using the fire engine. The roadway shall be cleared before the blast foreman allows traffic flow to resume.
16. Flagmen deployed on the road to warn approaching traffic at the roadblock, shall be strategically placed so as to give adequate warning. Special consideration needs to be given to build rises and curves in the roads.

Blasting near Workshops, Washing Plant and Stockpile

It does not often happen that blasting operations take place in the proximity of workshops, coal washing plants, stockpiles or the likes. However, such operations do take place.

1. The blast foreman shall notify the plant foreman early in the morning that a blast is planned to take place in the afternoon and the estimated time of the blast.
2. The plant foreman shall carry out an inspection of the plant area and order the removal of all machines and other mobile equipment that could be damaged by the blast to a safe location.
3. The plant foreman shall ensure that all personnel are vacated from the plant to a point beyond the blast guards prior to the time of the blast.
4. The plant foreman may appoint personnel to assist in closing off the plant area for the blast and to act as blast guards. Such appointments shall be entered in the plant foreman’s logbook and shall be co-signed by the blaster.
5. When blasting operations are complete, the plant foreman shall inspect the plant area for damage. If he deems the area to be safe, he shall give the all clear and permit personnel to re-enter their workstations.

Blasting near Telkom Lines

Telkom’s phone lines usually run along main roadways and may be exposed to blast damage.

1. When a blast is planned within a distance of 500 metres of a Telkom phone line, the regional manager of Telkom shall be notified.
2. The open pit manager shall notify the regional Telkom manager that a blast will take place near Telkom lines at least 24 hours before the blast.
3. The regional Telkom manager shall acknowledge receipt of the communication. It shall be in his discretion whether or not to send an observer to the blast area.
4. The blast foreman, who may be accompanied by Telkom personnel, shall examine the Telkom phone lines after the blast for any damage and there extend thereof.

Monitoring of Blasts

Monitoring of blasts is carried out from time, mainly for analytical purposes and to record blast effects for protection purposes. Specialist's personnel conduct the monitoring, but must work in close co-operation with blasting personnel.

Velocity of Detonation (VOD) Recording

1. The open pit manager shall, in good time, request the high wall manager / technical department to arrange for VOD recordings to be made for a particular blast as indicated on the D&B Plan.
2. The open pit manager shall notify the blaster that VOD recordings are to be made for a particular blast as indicated on the D&B Plan.
3. The blaster shall notify the manager, Bulk Explosives Contractor, that blast holes in a particular blast are to be instrumented for VOD recordings.
4. It is usual to place instruments into holes in successive rows, starting at the high wall and working back to the A-line.
5. The blaster shall notify the blast monitoring technician by radio when priming of the blast holes is to begin.

It is not practical to record the velocity of detonation in a blast hole, which is primed with detonating cord. The detonating cord initiated the primer and boosters so that the detonating cord VOD corrupts the VOD of the explosives column. The VOD recording cable could also be damaged. Hence instrumented blast holes are initiated with shock tube and instantaneous electric detonators.

6. The blast-monitoring technician shall ensure that the VOD recording cable is looped down each successive hole. The loop in each hole shall be attached to the lower most booster.
7. The blast monitoring technician shall suspend the VOD recording cable by hand whilst the blast hole is being carefully charged with explosives.
8. The blast monitoring technician shall connect up the VOD recording cable between holes and set up the recorder during morning of the blast. Normally, at the same time as the blast is being connected up.
9. When the detonating cord has been connected and the VOD recording cable has been connected, the blast monitoring technician shall examine the assembly. He shall protect the VOD recording cable from blast damage by lifting the detonating cord and placing suitable flat rock between the cord and the cable. The cable shall be covered with drill cuttings 5cm deep for a distance of 1 metre on either side of the crossing point.
10. The blaster shall ensure that no vehicle on site shall ride over the VOD recording cable either during the blast hole charging process or after conclusion of the blast because the cable could be damaged.
11. The blast monitoring technician shall test the VOD recording circuits for continuity only after the blast area has been cleared and the blast guards have taken up their positions.
12. When the circuits are satisfactorily tested, the blast monitoring technician shall arm the VOD recorder, which is automatically triggered by the blast.
13. After the blaster gives the all clear, the blast monitoring technician shall retrieve the cables and instruments. This shall be done before rock cleaning operations are commenced.

Seismography

A seismograph is an instrument, which is used to measure ground vibrations. Ground vibrations emanating from blasts are capable of causing structural damage. By means of staggering the timing of blast holes, the intensity of ground vibrations can be controlled. By natural delay, the ground vibration waves alleviate with distance from the blast. Hence, seismometers are placed a strategic points around the site of blasting. A seismometer is a self triggering and discreet device. It is the colliery management's policy to make seismographic recordings of as many blasts as is practical, for record purposes.

1. Permanent seismograph stations are located at particular points on the colliery. These are locked and can be left unattended.
2. Portable seismographs are set up by the blast monitoring technician at points around the blast as is designated by the blaster on the D&B Plan.
3. The blast monitoring technician shall place each portable seismograph in the charge of a blast guard where such a location lies within the blast danger zone; the seismograph shall be left unattended during the blast.
4. After the blast, the blast monitoring technician shall collect all seismographic monitoring instruments, cables and accessories.
5. When returning seismographic monitoring equipment to the store, the blast monitoring technician shall conduct an inventory check to ensure that all drawn equipment has been safely returned.
6. The blast monitoring technician shall transport all instruments in a service vehicle belonging to the technical department.
7. In the case of it being impractical to transport monitoring cables and accessories in the technical departments vehicle, the technical services manager shall permit another suitable service vehicle to be used for the purpose.

High Speed Photography

The technique of high speed photography is used to record features of over burden and inter burden blasts. The important features are timing the blast holes, ejection of the stemming, movement of the broken rock, throw of the burden and occurrence of fly rock. Such information is most useful for blast analytical purposes. Only selected blasts are photographed. It is possible to use more than one high speed camera to record a blast. The high speed camera is very sophisticated equipment. The person operating the equipment must have been specially trained in its use.

1. The open pit manager shall, in good time, request the technical department to photograph a particular blast.
2. The open pit manager shall notify the blaster that a high speed photographic record will be made of a particular blast.
3. The blaster shall notify the blast monitoring technician by radio when drilling of a blast block is completed.

Successful photographing of a blast depends on the placement of white markers. Empty 200 litres oil or tar drums are usually used for this purpose.

4. The blast monitoring technician in co-operation either the blaster shall set the marker barrels. A number of sets of barrels shall be placed.

5. The anchor marker barrel shall be placed at the crest of the high wall, perpendicular to the wall. A line of marker barrels shall be suspended on the high wall face by means of wire rope.
6. The set of suspended marker barrels shall be placed as follows:
    - At the depth of stemming.
    - At the top of the coal seam contact.
    - Midway between the above two markers.
    - At the toe of the blast hole, as close as possible to the high wall.
    - At the middle of the cut, at floor elevation.
7. The blast monitoring technician shall arrange for the position of the marker barrels to be surveyed and clearly marked on a plan and front elevation of the blast block for reference purposes.
8. The blast monitoring technician shall select the site positioning of the high speed cameras. The position shall be at a safe distance from the blast and be on firm ground. The technician should consider the elevation of the position, the view angle and the point of initiation of the blast.
9. The point of initiation should be at a point furtherst from the camera so that dust from the initiation should not cloud the blast from the camera view.
10. The technician, in choosing the camera site, shall take account of the wind direction on the day of the blast.
11. The blaster and the blast monitoring technician shall device a system fir initiating the blast and triggering the cameras so as to satisfactorily photograph the blast.
12. Immediately prior to the blast, the blaster and blast monitoring technician shall have dry runs of the count down to set off the blast. If possible the blaster and blast-monitoring technician shall be together when initiating the blast.
13. If practical, a conventional video camera shall be used also to photograph the blast from a different location.

3.1.7.4 Overburden Dozing

The first overburden removal process will be to doze overburden material to the spoil side. For modelling purposes it is assumed that 40% of the overburden can be dozed. The assumption is based on current mining practice at similar sites where the contractor is employed.

Figure 3.1.7.4 (a): Dozing of Overburden towards the Spoils

3.1.7.5 Overburden Load and Haul

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

Figure 3.1.7.5 (a): Removal of Hard Overburden directly above Coal Seam

Figure 3.1.7.5 (b): Removal and Dozing of Hard Overburden within designated Block

Figure 3.1.7.5 (c): Block almost ready to be Drilled, Blasted and Stripped of Coal

3.1.7.6 Coal Drill and Blast

Drilling of the coal will be done using a mobile drill rig. Drilling and blasting will be conducted to achieve required fragmentation. Drilling and charging will be done to expected powder factors for coal in the order of 0.15 to 0.30 kg/m^3. This may be adjusted once mining has commenced.

The blasting protocol will be similar as for blasting of the overburden as discussed in section 3.1.7.3.

3.1.7.7 Coal Load and Haul

The coal will be loaded, hauled and dumped on the Run of Mine (ROM) Stockpile. The loading and hauling of the coal will be conducted using excavators and ADT's as well.

3.1.7.8 Coal Transport to Eastside

The **Coal Transport Plan** has been designed with due consideration of safety, dust, noise and road carry capability aspects. The current estimate is that 4 coal transport trucks will complete the return trip from the mine to Carolina and back every hour.

Coal will be transported from the Lusthof ROM Stockpile with 30 tonne coal haulers to the East Side Colliery located 6 km out of Carolina on the Badplaas road. The loaded coal trucks will be covered with tarpaulins before leaving the Lusthof Mine boundary. Thereafter they will travel in a westerly direction towards Carolina. The first 1860 meters (magenta line on map in Figure 3.1.7.8 (a)) after leaving the mine, will be along a gravel section that will carry two-way Lusthof traffic. The loaded trucks will turn right at the T junction and continue along the gravel road until they reach the 30 tonne limit tar road, where they will turn left towards Carolina. This stretch which is some 14 560 m long (yellow line on map) will carry only one-way traffic from Lusthof.

The last section of tar road (magenta line) is 10 810 m long and goes through Carolina towards East Side Coal. This section will again carry two-way Lusthof traffic as the empty coal haulers will return along the same route from East Side Coal on their way back to Lusthof. However, on the return and once through Carolina, the empty trucks will turn right onto the 10 tonne Chrissiesmeer tar road and travel along this road for some 17 543 m before turning left onto the gravel road back to Lusthof. The green section will again only carry one-way Lusthof traffic. Once the empty trucks have turned right on the final stretch, traffic will again be in two directions.

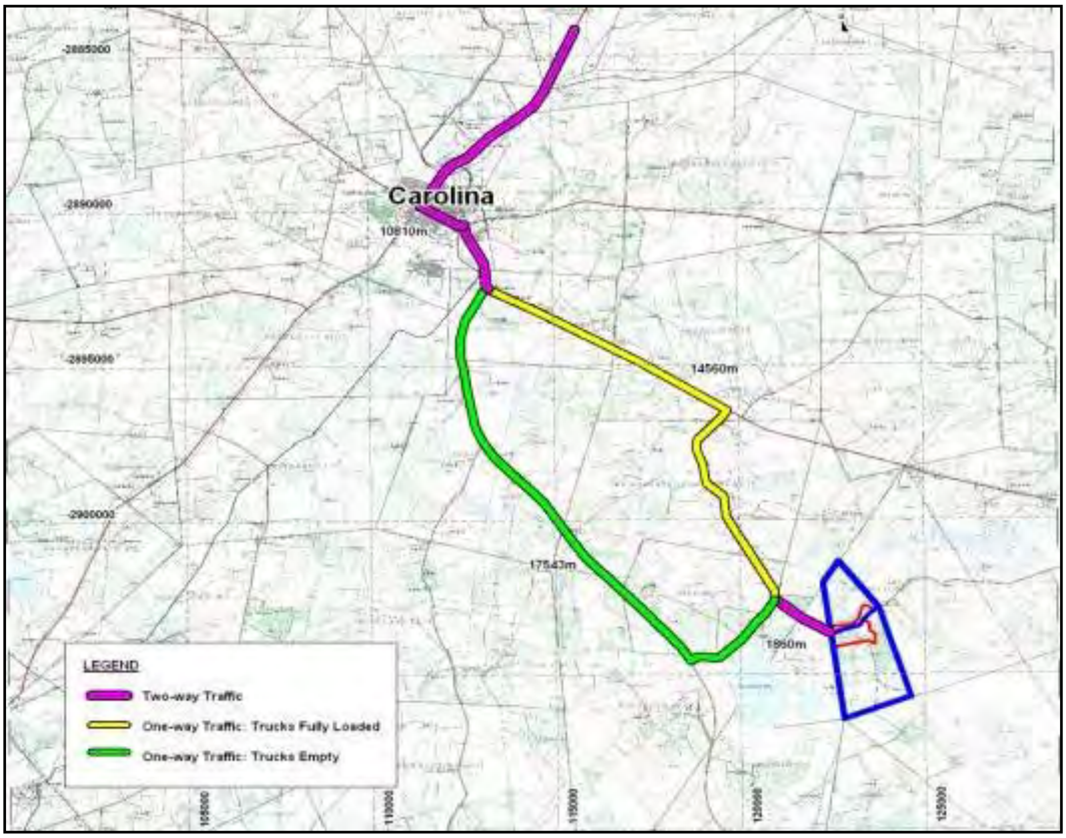


Figure 3.1.7.8 (a): Coal Transport from Lusthof to East Side Colliery

3.1.7.9 On-going Rehabilitation

Rehabilitation of the opencast mining area will be done concurrently with the opencast mining according to the stated mining sequence and subject to this formal rehabilitation plan.

Figure 3.1.7.9 (a): Rehabilitation taking place on mined-out Blocks

Materials will be placed back into the void in the former strata graphical sequence i.e. topsoil on the surface, subsoil directly below the topsoil and all hard material [sandstone and shale] in the bottom of the void. However the existing surface drainage pattern will remain unchanged and the total disturbed area will be free draining. The estimated post surface profile has been calculated by bulking the overburden (Softs 15% and Hards 30%) and deducting the volume of coal that has been removed for that area. Excess material will result in a higher surface elevation after mining, whereas insufficient material will result in a depression in the surface elevation after mining. It is envisaged that the final reinstated surface level at Lusthof will be approximately1.58 m above the original surface level.

On completion of surface reinstatement, the area will be re-vegetated with suitable pasture grass species.

An alternative to re-vegetation with grass is the establishment of a tree plantation. This option is attractive in that the enhanced evapotranspiration from trees will reduce the water make to the voids. There are published estimates of the water use by trees, and in particular *Eucalyptus grandis,* with estimates of between 30 and 90 ℓ/tree.day^{-1} (Dye 1996). Working with the lower figure, it implies that a plantation of 10 ha (1000 trees /ha) would be sufficient to handle the estimated post closure mine water balance of 300 m^3/day. This option represents obvious long term cost saving implications.

Whether trees can be established in the rehabilitated areas would need to be established, as well as their water use, through monitoring to determine the value of this suggestion.

Dye PJ., 1996., Response of Eucalyptus grandis *trees to soil water deficits. Tree Physiology 16, 233--238*

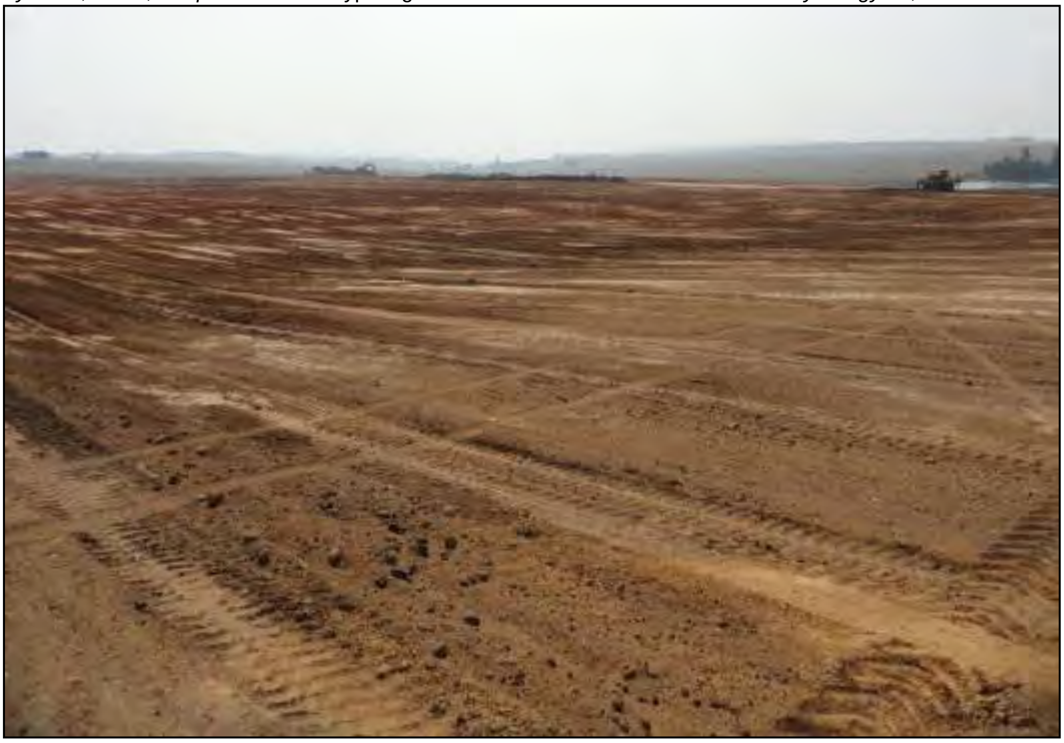


Figure 3.1.7.9 (b): Free Draining Rehabilitated Area. Topsoil is ready to be Re-vegetated

Figure 3.1.7.9 (c): Vegetation growing on Rehabilitated Area

3.1.7.10 On-going Environmental Management and Monitoring

Apart from the on-going rehabilitation discussed in section 3.1.7.9, all aspects related to water management discussed in sections 3.5.1.10 through 3.5.1.15, as well as the blasting plan discussed in section 3.1.7.3, environmental management and monitoring of other environmental components will also occur during the operational phase. The site specific details of the proposed environmental management measures for Lusthof Colliery for all its Life Cycle Phases, as well as the detailed Environmental Monitoring Plan for the Mine, are contained in Chapters 6 and 7 of this EIAR respectively.

3.1.8 Decommissioning & Closure Phase Activities and Time Lines

Final decommissioning and closure of the Mine will commence as soon as the final coal has been mined from within the demarcated open pit mining area.

The **final voi**ds will be back filled with overburden materials specially stockpiled for this purpose during the construction phase of the box-cut and the first mining strips. After compaction, the **top soil stockpiles** used as the earth berm along the northern perimeter will be pickup up and used for re-soiling prior to re-vegetation. The final open pit rehabilitation will be done in compliance with the details as specified in the Rehabilitation Plan detailed in section 3.1.7.9.

Once the final pit rehabilitation has been completed, demolition and removal of all non-water management infra-structure will commence.

All **buildings (temporary and permanent)** with the exception of the security gate house and the Water Treatment Plant will be removed/demolished, their footprints cleaned and rehabilitated and the areas re-vegetated.

All **internal roads**, with the exception of the road giving access to the Northern Surface Water Dam (this road will be retained for post mining use), will stripped of their base layers, the soil underneath will be remediated and the areas will be re-vegetated.

All coal on the footprint of the **ROM Stockpile** area will be cleaned, the platform will be picked up and the sub-soil will be tested for contamination and remediated if necessary, after which the area will be re-soiled and re-vegetated. The **dirty water canals and berms** around this area will remain in place until it can be confirmed that no dirty surface water run-off is generated from the rehabilitated site.

The **Storm Water PCD** will therefore also remain until it can be proven that all surface run-off from the site complies with the Target Water Quality Objectives for the site. The Storm Water PCD will be the last facility to be removed from site. The liner will be picked up and the sub-soil in the walls and floor will be tested for contamination and remediated if necessary, after which the walls will be dozed in and the area will be re-soiled and re-vegetated.

The footprints of the **overburden stockpiles** will be cleaned and the sub-soil will be tested for contamination and remediated if necessary, after which the area will be re-soiled and re-vegetated. The **dirty water canals and berms** around this area will remain in place until it can be confirmed that no dirty surface water run-off is generated from the rehabilitated site.

Only after the rehabilitated footprint areas of the overburden stockpiles have been given a clean bill of health with respect to surface water run-off quality, will the **Dirty Water Dam** be de-commissioned. The sub-soil of the walls and floor will be tested for contamination and remediated if necessary, the walls will be dozed in and the area will be re-soiled and re-vegetated.

The **Clean Water Dam** will be retained to intercept clean storm water run-off from the west and to divert it along the western pit perimeter. The **clean water canals** constructed around the perimeter of the open pit will remain in so far as they are required to divert storm water run-off across the rehabilitated mine area. This is required to prevent erosion as well as to minimize possible infiltration into the pit post closure.

The **Water Treatment Plant** will remain post closure.

3.1.9 Post Closure Phase Activities and Time Lines

A total period of 5 years post closure is proposed to ensure that re-vegetation is successfully implemented and to conduct adequate aftercare and monitoring. Monitoring will be conducted specifically to assess whether the closure objectives for the site are being achieved on a sustainable basis.

Post Closure Management and Monitoring are detailed in Chapter 7 and Chapter 8 of the EIAR respectively.

Two critical activities that will remain post closure relate to abstraction of mine water from the rehabilitated pit for treatment in the WTP, as well as the abstraction of ground water seepage from the pit along its eastern and southern perimeters for recirculation into the pit.

3.2 LISTED ACTIVITIES OCCURRING IN PROJECT

Due to the nature and extent of the proposed Lusthof Colliery operations Environmental Authorizations as provided for in several sets of legislation other are required for various activities. In addition to activities identified as mining related actions in terms of the MPRDA, other activities include *inter alia*:

- Listed Activities in terms of the National Environmental Management Act (NEMA) as listed in Regulations GNR 544, GNR 545 and GNR 546,
- Listed Waste Management Activities in terms of the National Environmental Management Watse Act (NEMWA) as listed in Regulation GNR 718,
- Water Uses as defined in section 21 of the National Water Act (NWA) as well as Mine Water Management activities as provided for in Regulation GN 704.

3.2.1 MPRDA Mining Related Activities

Mining as such is listed as an activity in the NEMA EIA Regulations. However, mining as a NEMA activity has not been activated and as such the EIA for mining related activities is conducted in terms of the MPRDA Regulations. In order to support the EIA for mining, JMA has identified the following activities for assessment under the MPRDA Regulations:

- Coal Transportation on Tar Roads from Carolina to Lusthof Colliery and back
- Coal Transportation along Gravel Roads from Carolina to Lusthof Colliery and back
- Security fence around Lusthof Colliery Mining Area
- Security Office at Main Gate
- Coal Transportation along Main Mine Access Road between main gate and ROM Stockpile
- Coal Transportation along Mine Haul Roads between Open pit and ROM Stockpile
- Weighbridge
- Contractors Yard
- Storm Water Management Berms and Canals
- Mining Soil Stripping
- Soil Stockpiles
- Mining Soft Overburden Stripping
- Soft Overburden Stockpiles
- Mining Hard Overburden Stripping
- Hard Overburden Stockpiles
- Mining Blasting
- Mining Coal Excavation
- Mining Hauling
- Mining Spoiling
- Mining Levelling, Compacting and Shaping
- Mining Top soiling
- Mining Re-vegetating

3.2.2 NEMA Listed Activities

In addition to the actions identified in terms of the MPRDA, the following activities related to the proposed Lusthof Colliery operations were identified as NEMA listed activities.

- Storm Water Management System around Mine and Marsh Area immediately south of the Open Pit
- Clean Water Diversion Pond (9 800m3)
- Pollution Control Dam (19 000m3)
- Dirty Water Dam (37 000m3)
- WTP Brine Dam (30 000m3)
- Mining of Marsh Area in the centre of the Open Pit
- Construction of internal Mine Access Road and Haul Roads from Open Pit to ROM Stockpile Area
- Construction of Dirty Water Dam
- Construction of Pollution Control Dam
- Construction of WTP Brine Dam
- Road diversion of Provincial Road to the north of mine
- Road diversion of Farm Road currently running north to south across the mining area to a new alignment to the west and south of the mining area;
- Construction of a new Farm Road to the Lusthof Northern Surface Water Dam
- Construction of Diesel Storage Tanks within the Contractors Yard at the mine (capacity 46m3)
- Construction of Water Treatment Plant
- Clean Water Diversion Pond
- Construction of Dirty Water Dam
- Contractors Yard
- Soil Stockpile / Berms
- Overburden Stockpiles
- ROM Stockpile
- Pollution Control Dam
- Clearance of vegetation for all Mining Related Activities including the Haul Roads and Open Pit

3.2.3 NEMWA – Listed Waste Management Activities

NEMWA listed waste management acivities for Lusthof Colliiery are associated with the proposed Water Treatment Plant to be commissioned during year 7 of the planned mining operations. Although the Waste License Application will not be lodged as part of this project, the listed waste management activities will be dealt with in the EIA and EMP in support of the EMPR Addendum Application.

- The temporary storage of brine prior to removal and disposal elsewhere, originating from the Water Treatment Plant to be constructed and operated on-site
- Water Treatment Plant to treat contaminated mine water
- Construction of Water Treatment Plant and associated Brine Disposal Facility

3.2.4 NWA Water Uses

The Lusthof Colliery project will require the authorization of a number of Water Uses. The following water uses will be applied for as part of this project:

Section 21(a)

- Abstraction of ground water from two (2) boreholes for potable use
- Abstraction of contaminated ground water from five (5) boreholes to intercept ground water seepage from the open pit
- Abstraction of mine water contained in the spoils of the open pit from three (3) boreholes to manage mine water decant and for treatment in the water treatment plant
- Abstraction of water from the Lusthof Northern Surface Water Dam for dust suppression.
- General Authorisations in terms of Section 39: Abstraction of ground water from two (2) boreholes for potable use form quaternary catchment W55A (Table 1.2 – Zone C)

Section 21(b)

- Lusthof Colliery Clean Water Diversion Pond
- Lusthof Colliery Northern Surface Water Dam

Section 21(c) & 21(i)

- Diverting of clean storm water originating from the marsh area south of the open pit, through a road culvert underneath the main mine access road
- Lusthof Mining Activities including the Road Diversion within 500 m up gradient from a wetland
- Diverting of clean storm water originating from the marsh area south of the open pit, through a road culvert underneath the main mine access road
- Lusthof Mining Activities including the Road Diversion within 500 m upgradient from a wetland

Section 21(e)

- Dust suppression of all gravel roads within the mining area with clean water
- Dust suppression of gravel roads used for coal transportation from the mine to the coal beneficiation plant at East Side Colliery with clean water
- Dust suppression of open pit haul roads with mine water

Section 21(g)

- Lusthof Colliery Dirty Water Dam
- Lusthof Colliery Pollution Control Dam
- Lusthof Colliery Overburden Stockpiles
- Lusthof Colliery ROM Stockpile
- Brine Disposal Facility at Water Treatment Plant

Section 21(j)

- Abstraction of mine water contained in the spoils of the open pit from three (3) boreholes to manage mine water decant and for treatment in the water treatment plant

3.2.5 NWA GNR 704

GNR 704 of 4 June 1999 deals with the Regulation on Use of Water for Mining and related Activities aimed at the Protection of Water Resources. BGCE intends to apply (with full motivation) for exemption for the following activities as listed in GNR 704:

4. Restrictions on Locality - 4a

- Location of Storm Water Berms in proximity to the marsh area immediately south of the mine.
- Location of ROM Pad in proximity to the marsh area immediately south of the mine.
- Location of Contractors' Yard in proximity to the marsh area immediately south of the mine.
- Location of Mine Access Road in proximity to the marsh area immediately south of the mine.

4. Restrictions on Locality – 4b

- Opencast Mining Operations at Lusthof Colliery in proximity immediately south of the mine
- Opencast Mining Operations at Lusthof Colliery in the marsh area in the centre of the mine.

4. Restrictions on Locality – 4c

- Placement of spoils in the Open Pit in a continuous manner during mining at Lusthof Colliery.

8. Security and Additional Measures - 8a

- Dirty Water Dams and PCDs are located within the mine fenced area and will not be provided with security fences around the individual facilities

3.3 I&AP CONFIRMATION OF CONSULTED POTENTIAL IMPACTS

I&AP's were presented with baseline information regarding the existing Socio-Cultural Environment, Heritage Environment, Current Land Use, Socio-Economic Conditions, Existing Infrastructure, the Existing Biophysical Environment, Meteorology, Topography, Soils, Land Capability, Geology, Ground Water, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals, Blasting and Vibration.

After they received it, they were duly consulted by JMA Consulting (Pty) Ltd by means of two Scoping Phase Public Meetings which was held on the 17 February 2010 and on 14 November 2012. Focus Group Meetings were held on 22 August 2009, 20 January 2011, 16 May 2012 and 21 June 2012. During the given time frame, JMA Consulting requested the I&AP's to review this information (review period of 30 days) and to submit any comments that they may have to the EAP (JMA Consulting). All comments received were reviewed and included in the Public Participation Comments and Response Register.

See Appendix 6.2.5 (A) of the Public Participation Report for an example of the customised JMA comment form and feedback/ comments received from I&AP's.

3.3.1 Confirmation of Impacts on the Socio-Cultural Environment

JMA Consulting received comments with regards to the Socio-Cultural Environment of the area. Local Tourism especially Eco-Tourism is a major concern and the effects that mining will have on the area relating to Eco-Tourism. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.2 Confirmation of Impacts on the Heritage Environment

No additional impacts on the Heritage conditions were emphasised by any of the I&AP's other than the potential impacts compiled by the EAP; refer to section 3.4.2.

3.3.3 Confirmation of Impacts on the Current Land Use

JMA Consulting received comments with regards to the Current Land Use of the area. Eco-Tourism is a major concern and the effects that mining will have on the area regarding Eco-Tourism. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.4 Confirmation of Impacts on the Socio-Economic Environment

JMA Consulting received comments with regards to the Socio-Economic Environment of the area. Eco-Tourism is a major concern and the effects that mining will have on the area regarding Eco-Tourism. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX

6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.5 Confirmation of Impacts on the Existing Infrastructure

JMA Consulting received comments with regards to the Existing Infrastructure. Roads are a major concern. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.6 Confirmation of Impacts on the Meteorology

No additional impacts on the Meteorological conditions were emphasised by any of the I&AP's other than the potential impacts compiled by the EAP; refer to section 3.4.6.

3.3.7 Confirmation of Impacts on the Topography

No additional impacts on the Topographical conditions were emphasised by any of the I&AP's other than the potential impacts compiled by the EAP; refer to section 3.4.7.

3.3.8 Confirmation of Impacts on the Soils

No additional impacts on the Soil conditions were emphasised by any of the I&AP's other than the potential impacts compiled by the EAP; refer to section 3.4.8.

3.3.9 Confirmation of Impacts on the Land Capability

Several comments were received in terms of the Land Capability in terms of the Plant Life, Animal Life and Aquatic Systems that occurs within the area of study. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.10 Confirmation of Impacts on the Geology

No additional impacts on the Geological conditions were emphasised by any of the I&AP's other than the potential impacts compiled by the EAP; refer to section 3.4.10.

3.3.11 Confirmation of Impacts on the Ground Water

Several comments were received in terms of the Ground Water. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.12 Confirmation of Impacts on the Surface Water

Several comments were received in terms of the Surface Water. These comments and issues are fully noted and addressed in the Issues and Response Register

(APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.13 Confirmation of Impacts on the Plant Life

Several comments were received in terms of the Plant Life. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.14 Confirmation of Impacts on the Animal Life

Several comments were received in terms of the Animal life. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.15 Confirmation of Impacts on the Aquatic Ecosystems

Several comments were received in terms of the Aquatic Ecosystems. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.16 Confirmation of Impacts on the Air Quality

Some comments were received in terms of the Air Quality. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.17 Confirmation of Impacts on the Noise

Some comments were received in terms of the Noise. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.18 Confirmation of Impacts on the Visuals

Some comments were received in terms of the Visual Impact that mining activities will and can have on Eco-Tourism in the area. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.19 Confirmation of Impacts on the Blasting and Vibration

Several comments were received in terms of the Blasting and Vibration regarding the impact that it can have on amphibians and livestock in the area as well as boreholes and historical buildings in the nearby town of Chrissiesmeer. These comments and issues are fully noted and addressed in the Issues and Response

Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

3.3.20 Confirmation of Cumulative Impacts

No additional cumulative impacts were identified by any of the I&AP's other than the cumulative impacts compiled by the EAP; refer to section 3.4.20.

3.4 POTENTIAL IMPACTS RELATED TO MINING AT LUSTHOF

Specialists involved in the compilation of the base line studies and impact assessments for this Lusthof Colliery project, provisionally compiled lists of potential impacts which they believe could be associated with the proposed coal mining activities. Interested and Affected Parties are requested to review the lists provided below and to add any impacts which they are concerned with and which they believe may occur as a result of the proposed mining activities. A final list for inclusion into the Impact Assessment Phase of this project will then be compiled after the Scoping Phase to ensure that all concerns are addressed in the Impact Assessment Phase of this project.

3.4.1 Potential Impacts on the Socio-Cultural Environment

- Outflux of indigenous people from the area.
- Influx of other people into the area.
- Urbanization of previously rural area due to increased mining activities.
- Potential increase in respiratory diseases due to air quality impacts.
- Potential traffic accidents.
- Potential water pollution.
- Potential increase in noise levels.
- Potential visual impacts (infrastructure, lights, dust).
- Potential blasting related vibration damage to property.

3.4.2 Potential Impacts on the Heritage Environment

- Restriction of access to heritage sites due to access control around the mining area.
- Destruction of heritage sites resulting from physical mining activities.

3.4.3 Potential Impacts on the Current Land Use

- Destruction of agricultural land within mining footprint.
- Urbanization and / or industrialization of rural areas.

3.4.4 Potential Impacts on the Socio-Economic Environment

- Creation of employment opportunities.
- Increased income levels.
- Increased provision of infrastructure, services and social facilities.
- Skills development.

3.4.5 Potential Impacts on the Existing Infrastructure

- The generation of vibrations due to blasting at the mine could damage buidlings and other structures and infrastructure.
- Increased traffic due to deliveries and personnel and product transport could impact on road conditions as well as road safety.

3.4.6 Potential Impacts on the Meteorology

- The mine will have no impact on the meteorology.

3.4.7 Potential Impacts on the Topography

- Extensive alterations to the topography are caused by mining (open pit excavation and stockpiling of soil and overburden).
- The construction of the mine and its associated infrastructure, as well as waste management and water management facilities, also cause modifications to the topography.

3.4.8 Potential Impacts on the Soils

- Total destruction of the soil profile due to open cast mining.
- Over saturation of soils due to spillages and/or leakages from tanks, ponds and dams.
- Contamination of soils due to spillages in the plant and from vehicles, storage tanks, ponds and dams.
- Contaminated surface water run-off not properly managed can also cause soil pollution.

3.4.9 Potential Impacts on the Land Capability

- The capability of the land for agricultural and ecotourism land uses will be fully compromised during the operational phase of the Lusthof operations.

3.4.10 Potential Impacts on the Geology

- The main geological impact relates of course to the mining of the coal seams.
- The geological profile all the way down to and including the bottom coal seam is removed during mining.
- The mine will employ the roll-over method which means that spoils will be placed back in the open cast workings.
- Overburden and soil is stockpiled next to the open pit for use during final rehabilitation.
- The disturbed geological materials will be prone to geochemical alteration.

3.4.11 Potential Impacts on the Ground Water

- The open pit mining will result in the formation of a localized cone of depression in the shallow weathered zone aquifer which could impact on ground water availability in boreholes, springs and seeps.
- Waste management, water management and operational activities could have an impact on ground water quality at Lusthof, both witin and around the open pit.
- The potential for the generation of Acid Mine Drainage exists for the spoils, overburden and at the ROM Stockpile.
- Post closure decant (ground water and surface water) could occur from the open pit.

3.4.12 Potential Impacts on the Surface Water

- The open pit mining as well as the surrounding mining activities will result in modification of the storm water run-off profile of the Lusthof site.

- This will impact on the availability of storm water run-off in the surface water resources down-gradient from the Lusthof site.
- Waste management and operational activities could have an impact on surface water quality at, and down–gradient from Lusthof.

3.4.13 Potential Impacts on the Plant Life

- Floral habitat modification and destruction due to the mining and coal transport activities.
- Impact on plant life diversity – destruction of species and introduction of invader species.

3.4.14 Potential Impacts on the Animal Life

- Faunal habitat modification and destruction due to the mining and coal transport activities.
- Impact on animal life diversity – destruction of species and introduction of foreign species.

3.4.15 Potential Impacts on the Aquatic Ecosystems

- Physical destruction of wetlands due to mining activities.
- Impact on the hydraulic characteristics of wetlands due to water flow modifications – interception of water or discharge of water.
- Aquatic habitat modification and destruction due to the physical mining activities.
- Impact on aquatic habitat due to surface water pollution resulting from the mining and coal transport activities.
- Impact on aquatic diversity – destruction/inhibition of species and introduction of foreign species.

3.4.16 Potential Impacts on the Air Quality

- Introduction of gaseous emissions into the atmosphere from blasting and motorized vehicles and its subsequent dispersion away from the site.
- The generation of dust into the atmosphere by mining and transport of coal and its subsequent dispersion away from the site.

3.4.17 Potential Noise Impacts

- The generation of noise by blasting, mining and transport of coal and the subsequent alteration of the ambient noise profile.

3.4.18 Potential Visual Impacts

- Visual alterations due to the construction and presence of mining infrastructure and equipment (roads, fences, buildings, stockpiles, lights, etc.).
- Visual impacts related to air quality impacts (dust).
- Visual impacts related to changes in vegetation.

3.4.19 Potential Blasting and Vibration Impacts

- The generation of vibrations due to blasting at the mine could damage buildings and other structures and infrastructure.
- Blasting and vibration could impact on animal behaviour.

3.4.20 Potential Cumulative Impacts

The following description on Potential Cumulative Impacts was compiled by the EAP for consideration during the EIA phase. I&AP's are requested to add to this description. Section 3.4.20 of the Final Scoping Report and Plan of Study will reflect the combined discussion on Potential Cumulative Impacts.

In areas where extensive mining and industrial activities occur, impacts experienced at individual sites may combine, and whereas they may be of acceptable magnitude and significance on individual site scale, could after they have accumulated, be fully un-acceptable on a regional scale. Most of the identified cultural, heritage, socio-economic and biophysical impacts have the potential to accumulate and therefore have to be considered. In this regard, however, it is important to separate those that would accumulate linearly and those that would accumulate exponentially.

Linear accumulation is defined for impacts for which the aerial extent and zone of influence is directly related to the extent of the surface area where the impact is generated and occurs, or impacts for which the time duration is short. Examples of environmental attributes for which this is the case are:

- Heritage
- Topography
- Soils
- Land Capability
- Geology
- Plant Life

Exponential accumulation is defined for impacts for which the aerial extent and zone of influence exist beyond the extent of the surface area where the impact is generated and which could therefore increase in significance as it combines with the manifestations of other external impacts generated by neighbouring or down-gradient/down-stream sources.

Examples of environmental attributes for which this is the case are:

- Cultural
- Socio-Economics
- Land Use
- Ground Water
- Surface Water
- Animal Life
- Wetlands
- Aquatic Ecosystems
- Air Quality

- Noise
- Visual Aspects
- Vibration Aspects
- Traffic Impacts

Each of the Specialist Impact Assessment Studies commissioned for this EIA, will address the cumulative impacts related to the exponential accumulation attributes listed above. The information will be collated under a single heading for Cumulative Impacts in the EIA.

4. CONSIDERATION OF ALTERNATIVES

4.1 ALTERNATIVE LAND USES

The current land use for the two portions of Lusthof on which the mine will be located is that of low intensity grazing, requiring only the natural grassland and limited amounts of water, of which more than sufficient is available as either ground water or else within the existing surface water dam located on the northern portion of the farm.

Alternative land uses in addition to the current land and identified for the site includes basically high intensity farming and ecotourism. A specialist study will be commissioned for the EIA Phase to conduct a comparative assessment between the propsed mining land use and the other potential land uses described above.

4.2 ALTERNATIVE LAND DEVELOPMENTS

The following alternative land developments will be assessed in the comparative assessment to be conducted for the EIA phase:

- Low intensity agriculture (grazing).
- High intensity agriculture.
- Ecotourism.
- Coal Mining.

4.3 ALTERNATIVE OPERATIONAL ASPECTS

JMA Consulting was given the opportunity to influence the Lusthof Colleiry mine design process with the objective of optimizing the mining programme with regard to specifically water management but also environmental management in gerenal.

4.3.1 Mining Method

The depth and size of the reserve dictates the preferred mining method, namely opencast mining. Safe underground mining activities cannot take place at Lusthof Colliery. Due to the small size of the reserve (82 ha) a single pit operation with a central box cut makes the most sense from a practical mining and financial perspective.

4.3.2 Mining Plan

Several alternatives were investigated as far as the mining plan is concerned, both in terms of the actual extent of mining as well as with respect to the direction and sequencing of mining.

The available mineable reserve at Lusthof Colliery covers a surface area 97 ha. The original mining layout for this area has a lowest surface elevation of 1760 mamsl. During the design of the mine water management plan it was found that this mining layout would result in a surface decant elevation of 1760 mamsl and a safe environmental elevation of 1655 mamsl for the pit.

Working at these low elevations would have meant that in-pit management and storage of mine water would not be a possibility. However, by cutting the mining layout back to a surface elevation of 1770, would raise all the critical management elevations by 10 m which would enable the handling of the full operational phase mine water balance within the bounds of the mining pit.

Furthermore the original plan was to mine the reserve from a central box cut. A centralized box cut will allow for mining operations to continue in both a northerly and southerly direction.

A single box cut entry point with only one directional coal face can lead to continuous production issues due to the relative short high wall face (<500m). However, a central box-cut will not allow the optimization of in-pit water management and storage. In order to optimize in-pit water management and storage, the mining layout and sequence was reversed to start in the south with two box cuts, thereby firstly mining the "deepest" part of the coal seam, and then mining upslope towards the shallowest parts of the mine in the north.

This reversal in mining direction means that the roll over section(s) behind mining would immediately become available for in-pit water management and storage, in fact enabling in-pit mine water management for the entire operational Life of Mine and thereby postponing the requirement for a WTP by 6 years.

4.3.3 Mineral Processing

Since no mineral processing will take place at Lusthof Colliery no alternatives were considered.

4.3.4 Transport Methods & Routes

No other transport methods than road hauling is possible due to the lack of rail sidings in the immediate area. However, three alternatives exist for road transport from the site. These alternatives were considered with due consideration of technical, economical, safety, environmental and social aspects.

The proposed road transport plan is discussed in section 3.1.7.8 and represents a combination of two alternatives. The third alternative is to use a different outgoing route from the mine, in the sense that instead of turning west wards on the provincial gravel road on leaving the mine, to in fact turn right and travel in an easterly direction along the gravel road until the northern tar road is intersected, before turning left towards Carolina. This alternative adds 10 km to the transport distance and also moves past more farm residences on its way to the tar road than the other outgoing route. This alternative was discarded.

The motivation for the combination of the two other alternatives is discussed in section 3.1.7.8.

4.3.5 Road Diversion Alternatives & Routes

There is no alternative to the requirement for the diversion of the two roads that intersect the mining area.

However two alternatives routes exist for both road diversions.

The first road to be diverted is the provincial gravel road that runs west to east through the proposed mining area. This road can be diverted either to the north or the south of the mining area.
The northern option was selected as the preferred alternative, as it represented the best alternative from a number of critical aspects such as:

- length of diversion
- gradient of road alignment
- number of properties affected
- visibility of the mine

The second road to be diverted is the farm road running off the provincial gravel road from north to south through the proposed mining area. This road could be diverted west or east of the mine. The western option was selected as the preferred alternative, as it represented the best alternative from a number of critical aspects such as:

- a western road already exist over a distance of more than half the required diversion
- The entire diversion would be on the property belong to the mine

4.3.6 Stream Diversion Alternatives

No streams will be diverted, so no alternatives were considered.

4.3.7 Electrical Power Supply

The current practice for mining operations similar in size to the proposed Lusthof Colliery is to use diesel power generator sets for electrical power supply.

However, there is an existing ESKOM power line that will be diverted along the eastern side of the mine which will provide the opportunity to tap ESKOM power.

In view of the fact that power will be required post closure for the WTP and ground water interception boreholes, it is logical to establish ESKOM power for the mine.

It is therefore proposed that a 200 kVA ESKOM power point be used to supply:

- The Contractor's Yard
- The Potable Supply Borehole(s)
- The Water Treatment Plant
- The Mine Water Abstraction Boreholes in the Pit
- The Ground Water Abstraction Boreholes outside the Pit
- Lighting at the ROM Stockpile

It is proposed that diesel generator sets be used for lighting inside the pit.

4.3.8 Water Supply

Although several options exist for water supply, the proposed water supply sources as discussed in section 3.1.5.9 are deemed to represent the best combination with the smallest environmental footprint.

The primary objective in selecting the different sources was to optimize the utilization of "dirty" water and to restrict the abstraction of clean water from the environment to a minimum.

As soon as the WTP comes into operation, all clean water requirements will be sourced from this facility to minimize impacts on the catchment yield.

4.3.9 Topsoil Stockpile Sites

Topsoil is usually stockpiled in a location close to the final cuts in order to minimize the transport distances during final rehabilitation. Originally the optimal sites for topsoil stockpiling were located in the south-west and south-east as the final voids would have been in these areas.

The main environmental impacts associated with soil stockpiling relate to erosion from the soil dump sides, as well as the potential for the soils to become infertile if stacked to thicknesses in excess of 1.5 m.

The change in mining sequence and direction, however now dictated that the soil stockpiles would have to be close to the north-eastern tip of the mine. This new development presented an opportunity for the soil stockpiles to be rather deposited as 2.5 m high berms along the northern and eastern perimeter of the mine, next to the proposed road diversion. Whilst still satisfying the requirement of being close to the final rehabilitation area, several environmental benefits are derived from this alternative:

- Due to the lower stacking height, soil infertility, as well as erosion, will be minimized
- The berms will play a significant part in surface water management
- The berms will provide a visual barrier to the mine
- The berms will assist in noise abatement
- The berms will play a small role in security and access control

4.3.10 ROM/Product Stockpile Sites

Two options existed as far as locating the ROM Stockpile.

The first option for ROM stockpile placement was to have the footprint(s) in areas that will be mined or was already mined, so as to prevent the migration of possible pollution away from these facilities. To achieve this, the placement of the ROM stockpile would have to be confined to within the open cast mining area. This option would have meant that a low permeability liner to protect the subsurface soils and water resources would not be required, but storm water management would still have been required.

On the down side, it implies that the ROM stockpile, together with the haul roads as well as the PCD to capture the storm water run-off, would have to be moved sometime during the operational phase, once the original site had to be mined.

The second option was to select a ROM Stockpile site beyond the open pit perimeter in an area easily accessible by the haul roads and also a site where storm water management could be achieved effectively. Once the decision was taken to reverse the mining direction, the potential site for the off-pit ROM Stockpile actually selected itself.

The down side from a financial perspective is to now provide the ROM Stockpile with an engineered platform to optimize storm water management and to minimize contamination of the subsurface. However, the financial down side is countered by the fact that neither the haul roads, nor the PCD or the storm water canals and berms now have to be moved.

All aspects being considered, JMA proposes Option 2 as the preferred alternative.

4.3.11 Domestic and Industrial Waste Disposal

All domestic and industrial waste generated at Lusthof Colliery will be removed by sub-contractors. No on-site alternatives were considered, since the removal of all waste will be the most environmentally friendly option.

4.3.12 Sewage Treatment

The small volumes of sewage at the site indicate a French drain system to be the best option (versus chemical toilets or small sewage plant).

4.4 CONSEQUENCES OF THE NO-GO OPTION

The mining of export quality and steam coal will generate a turnover of some R2 Billion over the Life of Mine. The no-go option will sterilize this opportunity.

5. PROJECT PLANNING AND DEVELOPMENT

5.1 PLANNING OPTIONS STEMMING FROM CONSULTATION

The entire mine planning and design reflected in Chapter 3 of this report, stemmed from consultation over a period of more than 2 years with members of the Mpumalanga Lakes District Protection Group (MLDPG) as well as the land owners of Lusthof Portions 4 and 6 (represented by Mr Hannes Botha) and surrounding land owners. Other I&AP's were also consulted during this period.

The consultation process was documented in detail and is available as a Draft Public Participation Programme Report.

5.2 DYNAMIC PLANNING AND DEVELOPMENT PROCEDURE

The planning and development procedure used during the mine planning and design phase was an iterative one within the consultative approach discussed above. It should be noted that the full mine design, including the design of environmental management measures and infrastructure, was based on current best practice as prescribed by various relevant governing authorities. A list of the guidelines considered, some of which were used, is given in Chapter 1 of this report.

6. SCOPING PUBLIC ENGAGEMENT PROCESS

6.1 DESCRIPTION OF INFORMATION PROVIDED TO I&AP's

In addition to information pertaining to the EIA process provided to I&AP's via e-mails, faxes, newspaper advertisements, site notices and sms's, two BID Documents as well as 2 Draft Scoping Reports and Plans of Study were provided to I&AP's since the project commenced in 2009.

Furthermore a number of specialist investigations were conducted, the outcomes of which were also communicated to the I&AP's. These included *inter alia*:

- Civil Engineering Design Reports for water management infrastructure.
- Water Treatment Plant Feasibility Report.
- Closure Cost Assessment Financial Report.
- Base Line Information
- Updated Project Description

The first round of formal public participation was conducted during 2009/2010, which included *inter alia* a Scoping Phase Public meeting during February 2012. Several focus group meetings were also conducted during 2010, 2011 and 2012, during which a wealth of relevant information was shared with the I&AP's.

During the second Scoping Phase Public meeting scheduled for 14 November 2012, more information in the form of a second BID, as well as presentations on the most recent Draft Scoping Report and Plan of Study will be given to I&AP's.

The most recent Draft Scoping Rerport and Plan of Study will be made available for I&AP review within a week after the public meeting. This report was structured in strict compliance with the latest DMR guidelines for Scoping Reports (2012).

Full details on the Public Participation Programme (PPP) conducted to date, with proof of all notifications and documents provided, is attached as a Draft PPP Report as APPENDIX 6 (A) to this report.

6.2 LIST OF I&AP's ACTIVELY CONSULTED

A comprehensive I&AP Data Base for the BGCE Lusthof Colliery Project was developed since 2009. The Data Base was verified again during October 2012 and information was provided to all I&AP's registered on the data base.

The formal I&AP Data Base for this project, listing all I&AP's which are actively consulted to date is attached in the Draft PPP Report as APPENDIX 6 (A) to this report. The PPP Report also contains the proof of consultation with all parties.

6.3 I&AP VIEWS ON EXISTING ENVIRONMENT

I&AP's were presented with baseline information regarding the existing Socio-Cultural Environment, Heritage Environment, Current Land Use, Socio-Economic Conditions, Existing Infrastructure, the Existing Biophysical Environment, Meteorology, Topography, Soils, Land Capability, Geology, Ground Water, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals, Blasting and Vibration.

After they received it, they were duly consulted by JMA Consulting (Pty) Ltd by means of two Scoping Phase Public Meetings which was held on the 17 February 2010 and on 14 November 2012. Focus Group Meetings were held on 22 August 2009, 20 January 2011, 16 May 2012 and 21 June 2012. During the given time frame, JMA Consulting requested the I&AP's to review this information (review period of 30 days) and to submit any comments that they may have to the EAP (JMA Consulting). All comments received were reviewed and included in the Public Participation Comments and Response Register.

See Appendix 6.2.5 (A) of the Public Participation Report for an example of the customised JMA comment form and feedback/ comments received from I&AP's.

6.3.1 I&AP Views on Existing Socio-Cultural Environment

JMA Consulting received comments with regards to the Socio-Cultural Environment of the area. Local Tourism especially Eco-Tourism is a major concern and the effects that mining will have on the area relating to Eco-Tourism. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.2 I&AP Views on Existing Heritage Environment

JMA Consulting received no comments with regards to the Heritage Environment; therefore it was assumed the current status of the Heritage Environment was confirmed.

6.3.3 I&AP Views on Existing Land Use Environment

JMA Consulting received comments with regards to the Current Land Use of the area. Eco-Tourism is a major concern and the effects that mining will have on the area regarding Eco-Tourism. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.4 I&AP Views on Existing Socio-Economic Environment

JMA Consulting received comments with regards to the Socio-Economic Environment of the area. Eco-Tourism is a major concern and the effects that mining will have on the area regarding Eco-Tourism. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.5 I&AP Views on Existing Infrastructure

JMA Consulting received comments with regards to the Existing Infrastructure. Roads are a major concern. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.6 I&AP Views on Existing Meteorology

JMA Consulting received no comments with regards to the Meteorology of the area. Therefore it was assumed the current status of the Meteorology was confirmed.

6.3.7 I&AP Views on Existing Topography

JMA Consulting received no comments with regards to the Topography of the area. Therefore it was assumed the current status of the Topography was confirmed.

6.3.8 I&AP Views on Existing Soils

JMA Consulting received no comments with regards to the Soils within the area. Therefore it was assumed the current status of the Soils was confirmed.

6.3.9 I&AP Views on Existing Land Capability

Several comments were received in terms of the Land Capability in terms of the Plant Life, Animal Life and Aquatic Systems that occurs within the area of study. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.10 I&AP Views on Existing Geology Environment

JMA Consulting received no comments with regards to the Geology of the area. Therefore it was assumed the current status of the Geology was confirmed.

6.3.11 I&AP Views on Existing Ground Water Environment

Several comments were received in terms of the Ground Water. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.12 I&AP Views on Existing Surface Water Environment

Several comments were received in terms of the Surface Water. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.13 I&AP Views on Existing Plant Life Environment

Several comments were received in terms of the Plant Life. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.14 I&AP Views on Existing Animal Life Environment

Several comments were received in terms of the Animal life. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.15 I&AP Views on Existing Aquatic Ecosystems

Several comments were received in terms of the Aquatic Ecosystems. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.16 I&AP Views on Existing Air Quality Environment

Some comments were received in terms of the Air Quality. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.17 I&AP Views on Existing Noise Profile

Some comments were received in terms of the Noise. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.18 I&AP Views on Existing Visual Aspects\

Some comments were received in terms of the Visual Impact that mining activities will and can have on Eco-Tourism in the area. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.3.19 I&AP Views on Existing Blasting and Vibration Environment

Several comments were received in terms of the Blasting and Vibration regarding the impact that it can have on amphibians and livestock in the area as well as boreholes and historical buildings in the nearby town of Chrissiesmeer. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4 I&AP VIEWS ON IMPACTS

I&AP's were presented with baseline information regarding the existing Socio-Cultural Environment, Heritage Environment, Current Land Use, Socio-Economic Conditions, Existing Infrastructure, the Existing Biophysical Environment, Meteorology, Topography, Soils, Land Capability, Geology, Ground Water, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals, Blasting and Vibration.

After they received it, they were duly consulted by JMA Consulting (Pty) Ltd by means of two Scoping Phase Public Meetings which was held on the 17 February 2010 and on 14 November 2012. Focus Group Meetings were held on 22 August 2009, 20 January 2011, 16 May 2012 and 21 June 2012. During the given time frame, JMA Consulting requested the I&AP's to review this information (review period of 30 days) and to submit any comments that they may have to the EAP (JMA Consulting). All comments received were reviewed and included in the Public Participation Comments and Response Register.

See Appendix 6.2.5 (A) of the Public Participation Report for an example of the customised JMA comment form and feedback/ comments received from I&AP's.

6.4.1 I&AP Views on Impacts on the Socio-Cultural Environment

JMA Consulting received comments with regards to the Socio-Cultural Environment of the area. Local Tourism especially Eco-Tourism is a major concern and the effects that mining will have on the area relating to Eco-Tourism. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.2 I&AP Views on Impacts on the Heritage Environment

JMA Consulting received no comments with regards to the Heritage Environment; therefore it was assumed the current status of the Heritage Environment was confirmed.

6.4.3 I&AP Views on Impacts on the Current Land Use

JMA Consulting received comments with regards to the Current Land Use of the area. Eco-Tourism is a major concern and the effects that mining will have on the area regarding Eco-Tourism. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.6.4 I&AP Views on Impacts on the Socio-Economic Environment

JMA Consulting received comments with regards to the Socio-Economic Environment of the area. Eco-Tourism is a major concern and the effects that mining will have on the area regarding Eco-Tourism. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.5 I&AP Views on Impacts on the Existing Infrastructure

JMA Consulting received comments with regards to the Existing Infrastructure. Roads are a major concern. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.6 I&AP Views on Impacts on the Meteorology

JMA Consulting received no comments with regards to the Meteorology of the area. Therefore it was assumed the current status of the Meteorology was confirmed.

6.4.7 I&AP Views on Impacts on the Topography

JMA Consulting received no comments with regards to the Topography of the area. Therefore it was assumed the current status of the Topography was confirmed.

6.4.8 I&AP Views on Impacts on the Soils

JMA Consulting received no comments with regards to the Soils within the area. Therefore it was assumed the current status of the Soils was confirmed.

6.4.9 I&AP Views on Impacts on the Land Capability

Several comments were received in terms of the Land Capability in terms of the Plant Life, Animal Life and Aquatic Systems that occurs within the area of study. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.10 I&AP Views on Impacts on the Geology

JMA Consulting received no comments with regards to the Geology of the area. Therefore it was assumed the current status of the Geology was confirmed.

6.4.11 I&AP Views on Impacts on the Ground Water

Several comments were received in terms of the Ground Water. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.12 I&AP Views on Impacts on the Surface Water

Several comments were received in terms of the Surface Water. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.13 I&AP Views on Impacts on the Plant Life

Several comments were received in terms of the Plant Life. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.14 I&AP Views on Impacts on the Animal Life

Several comments were received in terms of the Animal life. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.15 I&AP Views on Impacts on the Aquatic Ecosystems

Several comments were received in terms of the Aquatic Ecosystems. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.16 I&AP Views on Impacts on the Air Quality

Some comments were received in terms of the Air Quality. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.17 I&AP Views on Noise Impacts

Some comments were received in terms of the Noise. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.18 I&AP Views on Visual Impacts

Some comments were received in terms of the Visual Impact that mining activities will and can have on Eco-Tourism in the area. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.19 I&AP Views on Blasting and Vibration Impacts

Several comments were received in terms of the Blasting and Vibration regarding the impact that it can have on amphibians and livestock in the area as well as boreholes and historical buildings in the nearby town of Chrissiesmeer. These comments and issues are fully noted and addressed in the Issues and Response Register (APPENDIX 6.2.14(A)) of the Public Participation Report (APPENDIX 6(A) of the Final Scoping Report).

6.4.20 I&AP Views on Cumulative Impacts

No additional cumulative impacts were identified by any of the I&AP's other than the cumulative impacts compiled by the EAP; refer to section 3.4.20.

6.5 OTHER I&AP CONCERNS RAISED

Throughout the Public Participation Programme conducted for this BGCE Lusthof Colliery Project, a comprehensive Issues and Response Register has been kept to document all concerns and issues raised by the I&AP's as well as the responses of the EAP and the Applicant to these issues and concerns.

The detailed Issues and Response Register, completed up to date, is attached as an Annexure to the Draft Public Participation Programme Report attached as APPENDIX 6 (A) to this Draft Scoping Report.

6.6 MINUTES OF CONSULTATION MEETINGS

Minutes of all consultation meetings conducted with Authorities, Focus Groups and I&AP's, including the first Scoping Phase Public Meeting of 17 February 2010, as well as the most recent Scoping Phase Public Meeting of 14 November 2012, are attached in the Draft Public Participation Programme Report attached as APPENDIX 6 (A) to this report.

6.7 OBJECTIONS RECEIVED

Serious objections related to the mining of coal on Lusthof were raised since the original EMPR was approved and the initial mining right was granted to BCGE in June 2006. The following parties were involved in rasing the objections and in discussions ever since to resolve the differences:

- The Mpumalanga Lakes District Protection Group
- The Land Owners Messrs Johan and Hannes Botha
- Surrounding Land Owners Messrs Pierre du Hain and Koos Davel
- The Mpumalanga Tourism and Parks Agency
- Other I&AP's

Although it is deemed that good progress has been made in dealing with a variety of issues, finalization of certain outstanding issues still has to be achieved. The amicable resolving of these issues will be pursued through the formal Public Participation Programme conducted in support of this Scoping and EIA process.

Full details of the consultation with all the above mentioned parties are contained in the Issues and Response Register - APPENDIX 6 (A).

7. PLAN OF STUDY

7.1 COMPLETING THE EIA PROCESS

In order to complete the EIA process after the Scoping Phase (EIA Stage 2) has been concluded, the following actions will receive attention:

EIA Stage 3: Environmental Impact Assessment

- Commence to Implement Plan of Study
- Continue Public Participation Process
- Conduct Specialist Studies
- Prepare EIA Report (EIAR comprising EIA, EMPr as per Regulations and Guidelines
- EIA/EMP Public Meeting
- Make EIAR available for Review
- Capture and Consider Comments from I&AP's and Relevant Authorities
- Finalize and Submit EIAR to I&AP's and Authorities

EIA Stage 4: Consideration and Decision

- Authority Review & Decision
- Notification of Decision on the EIAR
- Granting of Environmental Authorization
- Inform I&AP's of Decision/Approval and of Opportunity to Appeal

EIA Stage 5: Appeal

- Appellant to give notice of intention to Appeal to Authority and Applicant
- Consultation between Applicant and Appellant to Resolve Issues
- Submission of appeal to Authority and Applicant
- Submission of Responding Statement from Respondent/Applicant to Authority and Appellant
- Submission of Answering Statement by Appellant to Authority and Applicant
- Acknowledgment of all by Authority within 10 days
- Processing of Appeal
- Decision on Appeal
- Notification of Decision on Appeal to Appellant and Respondents by Authority

7.2 PROPOSED SPECIALIST STUDIES OR SPECIALIZED PROCESSES

The current version of the Scoping Report contains detailed base line studies for a number of Environmental Components. The scope and content of these studies were determined in consultation with the authorities, as well as during a prolonged public consultation process of more than 2 years with I&AP's, as well as with specific focus groups.

Detailed base line descriptions are therefore available for the following Environmental Components:

- Socio-Cultural Aspects
- Heritage Aspects
- Land Use
- Socio-Economic Aspects
- Current Infrastructure
- Meteorology
- Topography
- Soils
- Land Capability
- Geology
- Ground Water
- Surface Water
- Plant Life
- Animal Life
- Aquatic Ecosystems
- Air Quality
- Noise
- Visuals
- Blasting and Vibration

Each of the specialists involved in the compilation of the above, will now finalize Specialist Reports for each of the above. The Specialist Reports will be compiled in strict accordance with Regulatory Specifications and will comprise the following chapters:

1. Introduction
2. Details of Specialist
3. Declaration of Independence
4. Scope of Work
5. Legal Framework
6. Investigative Methodology
7. Assumptions
8. Base Line Description
9. Impact Assessment
10. Management Objectives
11. Management Measures and Costing
12. Monitoring Plan

The Specialist Studies, together with specific specialist inputs related to specialized processes, already commissioned for the BGCE Lusthof Project, include the following:

Environmental Component	**Specialist Consultant**	**Specialist Studies and Specialized Processes**
Socio-Cultural Aspects	RS Risk Solutions	Socio-Cultural Base Line Assessment Socio-Cultural Impact Assessment Socio-Cultural Management Plan
Heritage Aspects	JMA	Heritage Base Line Assessment Heritage Impact Assessment Heritage Management Plan
Socio-Economic Aspects	An Kritzinger	Socio-Economic Base Line Assessment Socio-Economic Impact Assessment Socio-Economic Management Plan
Infrastructure Aspects Roads	Inprocon Engineers	Road Diversion Report Gravel Road Upgrade Report
Topography	JMA Consulting	Current Topography Topography Impact Assessment Topography Management Plan Topography Monitoring Plan
Soils, Land Capability & Land Use	Wetland Consulting Services	Soil/Land Type Distribution Assessment Land Capability Assessment Current Land Use Assessment Soil, Land Capability and Land Use Impact Assessment Soil Utilization and Rehabilitation Plan
Geology/Geochemistry	JMA Consulting	Geological Base Line Description including aspects pertinent to Mineralogy, Lithology, Stratigraphy, Ore Body Description, Structural Aspects and Geochemistry Overburden Geochemical Classification AMD Characterization
Ground Water	JMA Consulting	Aquifer Physical, Hydraulic, Dynamic and Hydrochemical Assessment Ground Water Use Assessment Aquifer Classification Ground Water Balance Ground Water Salt Balance Ground Water Impact Assessment Ground Water Management Plan Ground Water Monitoring Plan
Surface Water	Inprocon CC	Meteorological Assessment (Rainfall and Evaporation) Flood Lines Surface Water Quality Surface Water Use Surface Water Balance Surface Water Salt Balance Overall Mine Water Balance Overall Mine Salt Balance Surface Water Impact Assessment Design of Storm Water Management Infrastructure Surface Water Monitoring Plan
Plant Life	Wetland Consulting Services	Floral Habitat Assessment Floral Diversity Assessment Identification of Red Data Species Identification of Protected/Endangered Species Floral Sensitivity Assessment Floral Impact Assessment Floral Management Plan
Animal Life	Wetland Consulting Services	Faunal Habitat Assessment Faunal Diversity Assessment

Environmental Component	Specialist Consultant	Specialist Studies and Specialized Processes
		Identification of Red Data Species Identification of Protected/Endangered Species Faunal Sensitivity Assessment Faunal Impact Assessment Faunal Management Plan
Aquatic Ecosystems	Wetland Consulting Services	Wetland Delineation Wetland Classification Wetland Functional Assessment Present Ecological State (PES) Assessment Ecological Importance & Sensitivity (EIS) Assessment Wetland Impact Assessment Wetland Management Plan Water Quality Assessment Aquatic Macro-invertrebates Assessment (SASS5) Habitat Integrity Assessment (HIA) Aquatic Impact Assessment Aquatic Management Plan Bio-monitoring Plan
Air Quality	Airshed Planning Professionals	Meteorological Assessment (Wind Fields) Ambient Air Quality Assessment Air Quality Dispersion Assessment Air Quality Management Plan Air Quality Monitoring Plan
Noise	ACUSOLV	Ambient Noise Assessment Noise Source Assessment Sensitive Receptor Identification Noise Propagation Assessment Noise Management Plan Noise Monitoring Plan
Visual	Zeli Design	Topopgraphical Assessment View Shed Analyses Contextual Analyses Photographic Visibility Assessment Visual Impact Assessment (VIA) Visual Management Plan
Infrastructure Aspects Vibration	Blast Management & Consulting	Blasting & Vibration Base Line Assessment Identification of Structures potentially to be affected Condition of such structures Blasting & Vibration Impact Assessment Blasting & Vibration Management Plan
Draft EMP	JMA Consulting	Management Objectives Management Measures Monitoring Plan Financial Provisioning Compliance/Performance Auditing
Public Participation Program	JMA Consulting	Pre-Application Phase Application Phase Scoping Phase EIA Phase Public Participation Programme Report ROD Information Phase Appeal Phase
Civil Engineering Designs	Inprocon Engineers	Preliminary Civil Engineering Designs for all Water Management Infrastructure
Water Treatment Plant	Proxa	Feasibility Study for Water Treatment Plant
Financial Provisions	Independent Economic Researchers	Estimation of Financial Provisions and Associated Funding Model for the Post Closure Operation of a Water Treatment Plant
Land Use and Developments	An Kritzinger	Economic Comparative Study

7.3 COMPILE EIA REPORTS

An EIA report will be compiled by JMA for DMR and DEDET respectively. The reports will be structured and compiled to give compliance with the MPRDA Regulations and the NEMA EIA Regulations respectively. Draft reports will be made available to the relevant authorities and I&AP's for comment prior to finalization for submission the lead authorities for consideration and approval.

The following Impact Significance Rating Protocol developed by JMA Consulting will be used for compilation of the Environmental Impact Assessment:

The assessment matrix contains all the critical elements for Environmental Impact Assessment as proposed in the formal DEAT Protocol for Environmental Impact Assessment – *DEAT (2002) Impact Significance, Information Series 5, Department of Environmental Affairs and Tourism (DEAT), Pretoria.*

The protocol comprises a series of steps in order to systematically go through a process of:

1. Identifying and Quantifying the **Significance** of an impact. **Step 1**.
2. Determining the **Probability** of an impact happening. **Step 2.**
3. Determine the **Risk Level** attached to the impact. **Step 3.**

The identification process is conducted by each individual specialist and then the Step 1 Significance Assessment is completed based on the specialist's interpretation. The interpretation is converted into the numerical rating contained in Table 7.3(a), and an Impact Significance Total is calculated. The Significance Total is converted into a Significance S Number, for population of the overall Risk Matrix. The components considered to arrive at the Significance Rating (S Number) are as follows:

- Spatial extent of the impact
- Intensity or Severity of the impact
- Duration of the impact
- Unacceptability of the impact
- Mitigatory difficulty of the impact

The sum of the numerical ratings for the above components represents the Significance Total.

Table 7.3 (a): Impact Significance Assessment Criteria

CRITERIA FOR DETERMINING SIGNIFICANCE		
Criteria	**Definition**	**Points**
Spatial Extent		
High	Widespread. Far beyond site boundary. Regional/national/international scale.	3
Medium	Beyond site boundary. Local area.	2
Low	Within site boundary.	1
Intensity or Severity		
High	Disturbance of pristine areas that have important conservation value. Destruction of rare or endangered species.	3
Medium	Disturbance of areas that have potential conservation value or are of use as a resource. Complete change in species occurrence or variety.	2
Low	Disturbance of degraded areas that have little conservation value. Minor change in species occurrence or variety.	1
Duration		
High (Long term)	Permanent. Long Term (more than 20 years). Beyond decommissioning.	3
Medium (Medium term)	Reversible over time. Lifespan of the project. Medium Term (3-20 years). Operational Phase	2
Low (Short term)	Quickly reversible. Less than the project lifespan. Short Term (0 – 3 years). Construction Phase	1
Un-Acceptability		
High (Unacceptable)	Abandon project in part or in its entirety. Redesign project to remove impact or avoid impact.	3
Medium (Manageable)	With regulatory controls. With project proponent's commitments.	2
Low (Acceptable)	No risk to public health.	1
Mitigatory Difficulty		
High:	Little or no mechanism to mitigate negative impacts.	3
Medium:	Potential to mitigate negative impacts. However, the implementation of mitigation measures may still not prevent some negative effects.	2
Low:	High potential to mitigate negative impacts to the level of insignificant effects.	1

Once a Significance Total has been calculated for a specific impact, an Impact Significance Number is determined (S-number) as completion of **Step 1**, based on the Table below:

Table 7.3 (b): Assignment of Impact Significance S-Number

Significance Total	Significance S-Number
15	S5
12 - 14	S4
9 - 11	S3
6 - 8	S2
5	S1

Table 7.3 (c): Explanation for Impact Significance Rating

EXPLANATION FOR IMPACT SIGNIFICANCE RATING		
Impact Significance	**Explanation**	**Points**
Very High	Of the highest order possible within the bounds of impacts that could occur. In the case of adverse impacts, there is no possible mitigation that could counteract the impact, or mitigation is difficult, expensive, time-consuming or a combination of these. Social, cultural and economic activities of communities are disrupted to such an extent that these come to a halt. In the case of beneficial impacts, the impact is of a substantial order within the bounds of impacts that could occur.	**>14**
High	Impact is high and substantial in relation to other impacts that might take effect within the bounds of those that could occur. In the case of adverse impacts, mitigation is possible but expensive. Social, cultural and economic activities of communities are changed, but can be continued (albeit in a different form). Modification of the project design or alternative action will be required. In the case of beneficial impacts, the project out performs other alternatives in terms of time, cost and effort.	**12-14**
Medium	Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. In the case of adverse impacts, mitigation is both feasible and fairly easily possible. Social, cultural and economic activities of communities are changed, but can be continued (albeit in a different form). Modification of the project design or alternative action may be required. In the case of beneficial impacts, other means of achieving this benefit are about equal in time, cost and effort.	**9-11**
Low	Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts, mitigation is either easily achieved or little will be required, or both. Social, cultural and economic activities of communities can continue unchanged. In the case of beneficial impacts, alternative means of achieving this benefit are likely to be easier, cheaper, more effective and less time-consuming.	**6-8**
Insignificant	Although an impact may exist it is rated as insignificant and is not deemed to warrant any specific management measures or even monitoring.	**<6**

During **Step 2** the Probability of an impact occurring/re-occurring is assessed.

Table 7.3 (d): Probability of an Impact Occurring (P-Value)

Likelihood Descriptors		Probability Intervals	Likelihood Definitions
P1	Unlikely	0 - 25%	Less than 25% probability that a specific impact will occur.
P2	Possible	25 - 50%	25% - 50% probability that a specific impact will occur.
P3	Probable	50 - 75%	50% - 75% probability that a specific impact will occur.
P4	Highly Probable	75 - 100%	More than 75% probability that a specific impact will occur.

Finally, the overall impact is quantified in a Risk Matrix, by combining the S-Number (determined in **Step 1**) with the P-Value (determined in **Step 2**) in the Risk Matrix provided below (**Step 3**). The Risk Matrix also provides and Action Table to indicate and allocate responsibility. The matrices shown above make use of generic criteria in order to systematically identify, predict, evaluate and determine the significance of impacts resulting from project construction, operation and decommissioning. In order to enhance the accuracy and integrity of the outcome of the Impact Assessment, the suite of potential environmental impacts (to both the natural and human environments) identified in the EIA, were as far as possible **quantified during the various specialist studies conducted.**

Table 7.3 (e): Risk Classification Table

RISK MATRIX					
	Significance S1	Significance S2	Significance S3	Significance S4	Significance S5
Probability P4	Low Risk	Low Risk	Moderate Risk	High Risk	High Risk
Probability P3	Very Low Risk	Low Risk	Moderate Risk	Moderate Risk	High Risk
Probability P2	Very Low Risk	Very Low Risk	Low Risk	Low Risk	Moderate Risk
Probability P1	Very Low Risk	Very Low Risk	Very Low Risk	Very Low Risk	Low Risk

7.4 COMPILE DRAFT EMP's

EMP reports will be compiled by JMA for DMR and DEDET respectively. The reports will be structured and compiled to give compliance with the MPRDA Regulations and the NEMA EIA Regulations respectively. Draft EMP reports will be made available to the relevant authorities and I&AP's for comment prior to finalization for submission the lead authorities for consideration and approval.

7.5 CONSULTATION TIME LINE WITH COMPETENT AUTHORITY

DEDET was consulted when the EIA application form was submitted. They will be consulted again with submission of the Final Scoping Report. This is proposed to happen in January 2013, after which the authority will a set time period to review the report and to notify the applicant of their decision.

DMR will be consulted at the same time (January 2013), with the submission of the Scoping Report for review.

DWA will be consulted in March 2013, when the relevant water use application forms will be submitted.

If approval of the scoping report is granted from DEDET the EIA/EMP phase will commence during which specialist studies proposed in the Plan of Study will be conducted.

Public Participation Phase 2 will also take place; the proposed date thereof is in May 2013. The draft EIA and EMP reports will be finalized and be made available for review by the I&AP's. Once the review period has expired, and the comments raised by I&AP's have been addressed, the reports will be finalized and be submitted to the relevant authorities.

The proposed date for the submission of the EIA and EMP to DEDET and DMR respectively, is end June 2013.

The Final IWWMP will be submitted to the DWA in June 2013.

Once all documentation has been submitted the competent authorities must review the documentation and grant the relevant approvals, ROD (record of decision) and Water Use License.

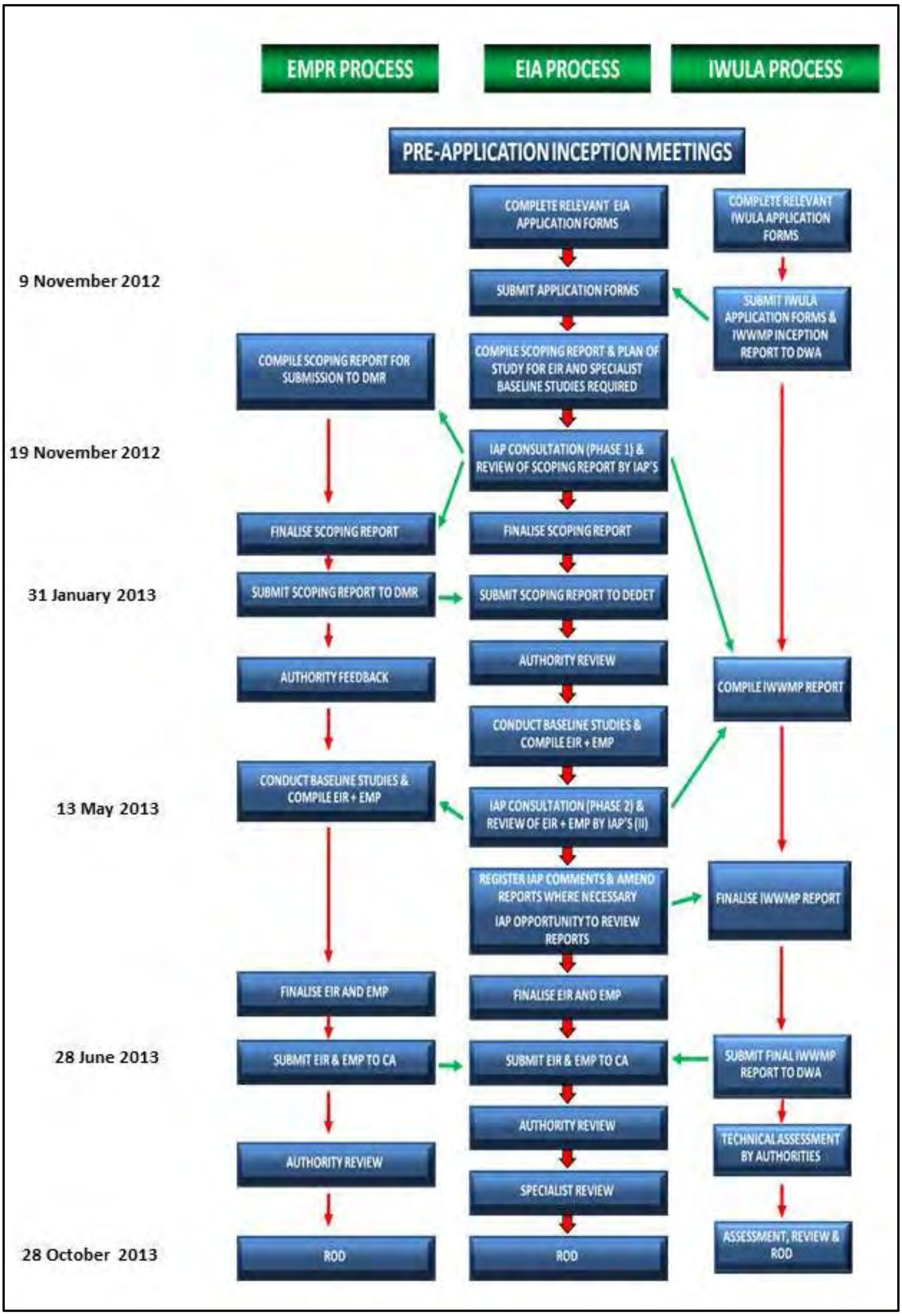


Figure 7.5(a): Process and Authority Consultation Time Line

7.6 PROPOSED PLAN FOR EIA PHASE PUBLIC PARTICIPATION

7.6.1 The Scope of the Public Participation Programme (EIA Phase)

The scope of the Public Participation Programme during the EIA phase of the project will be along the same dimensions and considerations as the one that was conducted during the Scoping Phase of the EIA.

7.6.2 Identification/Registration of Authorities and I&AP's

An extensive list/register of I&AP's and authorities will have been compiled by this phase and the same database will be used for communication with I&AP's during the EIA phase.

However should any person identified, or should any person request to be registered as an I&AP to the project, at any stage of the project, he/she will be given the opportunity to do so and be notified of the project accordingly.

7.6.3 Notification of Authorities and I&AP's

Notification of I&APs and authorities on the progress of the project will be done according to the regulations 54 – 57 as set out in GNR 543 which includes notification letters, press advertisements, and site notices. These notices and advertisements will inform the I&AP's on details of the Public Meeting during the EIA phase.

7.6.4 Information to Authorities and I&AP's

Information included in the correspondence and consultation with I&AP's and authorities will include updated information generated for the proposed project. Also it will include information and details of the EIA phase public participation process.

7.6.5 Meetings with Authorities and I&AP's

Meetings with authorities during the EIA phase will be organized on request. The I&AP's will be invited to attend a Public Meeting during which the results of the environmental impact assessment and proposed management and mitigation measures will be communicated to them. Should some of the I&AP's wish to be consulted in a Focus Group format, such meetings will be scheduled and conducted.

7.6.6 Obtaining Comments from Authorities and I&AP's

All I&APs will receive the opportunity to comment on any of the information generated during the EIA/EMP Process, in the review periods of the various documentation, which will be submitted to the relevant authorities. This includes the Draft EIA Report and Draft EMP which will be submitted to DMR and DEDET.

The IWWMP which will be submitted to the DWA is not usually presented for formal public review due to the complex and technical nature of the report, but should any I&AP wish to view this report, it will be made available to them. Irrespective of this fact the results of the IWWMP will be discussed with the I&AP's during the EIA Phase Public Meeting and possible Focus Group Meetings.

7.6.7 Responding to Comments from Authorities and I&AP's

All comments that are raised by I&AP's will be incorporated into an I&AP Comments Register. JMA will then address each and every issue or comment raised. Once this is completed the I&AP's will be notified of how their issue or comment have been addressed and the finalized report will be submitted to the relevant authorities.

7.6.8 Public Participation Report

A detailed Public Participation Report, containing information of all the actions that were undertaken with regard to the Public Participation Process (for both phases, Scoping and EIA), will be compiled for this project and be submitted along with the final reports to the relevant competent authorities.

8. IDENTIFICATION OF THE REPORT

Herewith I, the person whose name and identity number is stated below, confirm that I am the person authorized to act as representative of the applicant in terms of the resolution submitted with the application, and confirm that the above report comprises the results of consultation as contemplated in Section 16(4)(b) or 27(5)(b) of the Act, as the case may be.	
Full Names and Surname	Jasper Lodewyk Muller (Pr.Sci.Nat.)
Identity Number	571116 5104 081
Signature	