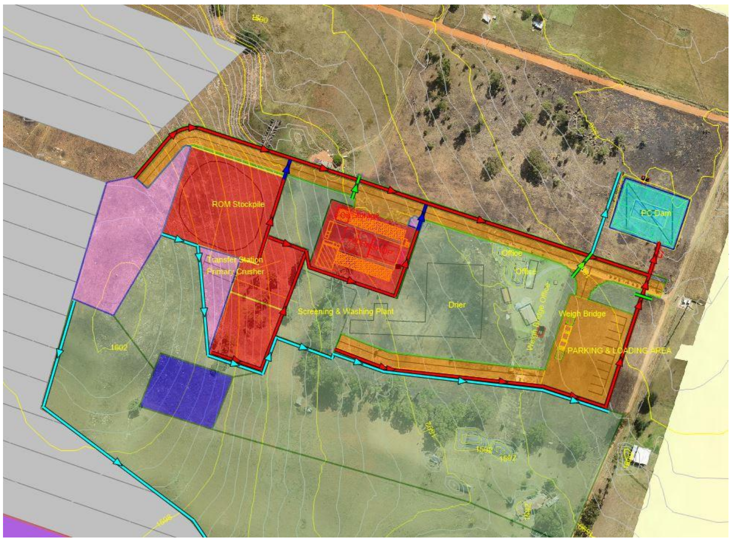
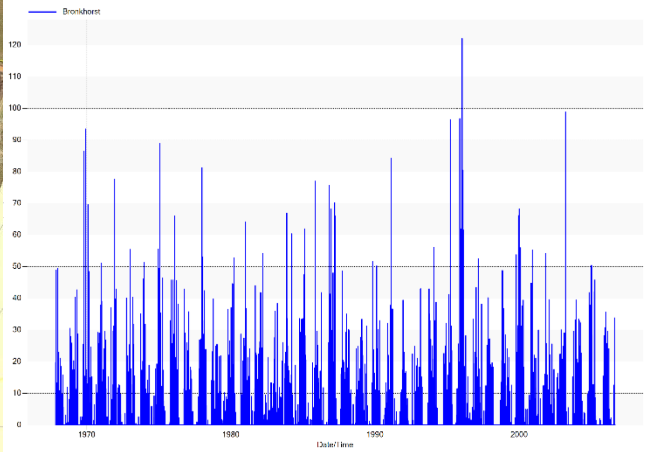
# RIETKOL SILICA

# SWMP – Design Development Report

## Detail Design Assumptions & Operational Procedures






**FINAL Report** (Revision 1)

**July 2021**

Compiled by:
**ONNO FORTUIN CONSULTING (Pty) Ltd**

28 Carrington Ave
Kimberley, 8301
Tel: (053) 831 1675
Fax: 086 699 7367

JACANA environmentals cc

Onno Fortuin Consulting TRADING AS ME² (Mining and Environmental Engineering)

# Report Specifications

| Specification | Report Details | | | |
|---|---|---|---|---|
| TITLE: | **SWMP –DESIGN DEVELOPMENT REPORT** | | | |
| REPORT STRUCTURE: | Design Assumptions & Operational Procedures | | | |
| PROJECT No: | 115/01 | | | |
| DOCUMENT TYPE: | FINAL Report | | | |
| ISSUE: | Revision 1 | | | |
| DATE: | July 2021 | | | |
| MS-WORD FILE: | 2021-07-07 RIETKOL SILICA - SWMP DESIGN DEVELOPMENT REPORT_REV 1 FINAL | | | |
| AUTHOR(S): (Compiled by) | JR FORTUIN & HO FORTUIN (Pr Eng) | | | |
| SYNOPSIS: | This report summarises the Surface Water Management Plan (SWMP) – Design Developments, Assumptions and Operational Procedures for the planned Rietkol Silica mine near Delmas. This is based on hydrological model simulations conducted for the proposed mining area. | | | |
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| Signed on behalf of Onno Fortuin Consulting (OFC) | |

# Revision History

| Revision | History | Date | Approved |
|---|---|---|---|
| 0 | Draft Report to Jacana Environmental – For WUL Application | 15/06/2018 | H O Fortuin |
| 1 | FINAL Report to Jacana Environmental – Including Waste Application requirements | 07/07/2021 | H O Fortuin |
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# 1. INTRODUCTION

Onno Fortuin Consulting (Pty) Ltd (OFC) was appointed by Jacana Environmental cc to investigate and develop a Surface-Water Management Plan (SWMP) for Rietkol Silica Mine near Delmas.

Rietkol Silica mine is located ±6km to the north-west of the town of Delmas in the Mpumalanga Province. The mine is also situated near the N12 national highway from Benoni to Emalahleni. The prospecting area entails opencast mining with associated surface infrastructure including a ROM stockpile, workshops, hard park areas, offices, general stores, and Pollution Control Dam (PCD) with silt trap. Rietkol silica mine has a projected Life of Mine (LOM) of 20 years.

The objective of the study is to develop a Surface Water Management Plan (SWMP) to mitigate the storm-water problems of the proposed new Rietkol Silica Mine to ensure compliance with industry standards and guidelines.

# 2. HYDROLOGICAL LEGISLATION

Various guideline documents and regulatory requirements were studied to ensure that the storm water measures so proposed for the Mine will in fact ensure legal compliance once these remedial actions are implemented by the Mine.

## 2.1 Regulatory and Guideline Documents

**DWS Legislation**

- ✓ National Water Act, 1998 (Act 36 of 1998)
- ✓ GN 704 of 4 June 1999
- ✓ GN R991 of 18 May 1984
- ✓ GN R1560 of 25 July 1986
- ✓ Water Quality Management Policies and Strategies in South Africa
- ✓ Minimum Requirements: Handling, Classification and disposal of Hazardous Waste 2$^{nd}$ Edition 1998

**Other Legislation**

- ✓ Articles 634, 635 & 636 of Regulation 36784 – of August 2013 – Department of Environmental Affairs (Act No. 59 of 2008) – Waste Classification and Management Regulations
- ✓ Environment Conservation Act, 1989 (Act 73 of 1989)
- ✓ Minerals and Petroleum Resources Development Act (Act 28 of 2002)
- ✓ GN R992 of 26 June 1970
- ✓ National Environmental Management Act, 1998 (Act 107 of 1998)
- ✓ Health Act 2003 (Act 61 of 2003)
- ✓ Municipal By-laws
- ✓ Conservation of Agricultural Resources Act (Act 63 of 1970)
- ✓ Nature Conservation Ordinance (No. 12 of 1983)
- ✓ Constitution of South Africa (Act 108 of 1996)

## 2.2 Legal Framework

### 2.2.1 Constitution of RSA, 1996 (Act 108 of 1996)

The Constitution of South Africa specifies the environmental right of the people of South Africa. It then more specifically states that the environment should not be harmful to the health and well-being of its citizens and for the environment to be protected for the benefit of present and future generations.

### 2.2.2 National Environmental Management Act, 1998 (Act No. 107 of 1998)

The National Environmental Management Act (NEMA) provides the guiding legislation and framework for environmental management in South Africa. The act more specifically describes a set of fundamental guiding principles governing the actions of those organs of state that may significantly affect the environment. The Department of Water Affairs & Sanitation (DWS) is thus guided by these principles in the development and implementation of various policies and strategies.

### 2.2.3 Minerals and Petroleum Resources Development Act, (Act No 28 of 2002)

The Minerals and Petroleum Resources Development Act (MPRDA) regulates the overall mining process and provides for safety and health in the mining industry. The Act supports the principles of Integrated Water Resource Management (IWRM) by promoting the goal of sustainable development in the process of developing the mineral and petroleum resources of the country.

### 2.2.4 National Water Act, 1998 (Act No. 36 of 1998)

The National Water Act (NWA) emphasises the effective management of South Africa's water resources through the basic principles of Integrated Water Resources Management (IWRM).

In terms of the Act, various regulations have been developed to regulate, protect and manage water that is being used from a water resource. Section 26(4) of the Act more specifically has regulations where water users have to ensure the following:

- Promoting economic and sustainable use of water
- Conserving and protecting water resources
- Preventing wasteful water use
- Facilitate the management of water use, and
- Facilitate the monitoring of water use and water resources

### 2.2.5 DWA: Water Use Regulation, GN 704

In terms of the NWA, specific regulations were promulgated in respect of the use of water for mining aimed at protecting water resources, referred to as **Government Notice No. 704 of 4 June 1999**.

The agreement is that DWS will subscribe to the principles of co-operative governance where DMR should co-ordinate environmental management within the mining industry as part of the EMP process.

### 2.2.6 Overall Water Management Context

It is important that the development of a Storm Water Management Plan (SWMP) cannot be done in isolation where this must be guided by the overall water management context that should include the following:

- ✓ National, regional, and site-specific water management context
- ✓ Integrated mine water management in a regional context
- ✓ Mine water management requirements in terms of the life cycle phases of a mine
- ✓ Integrated regulatory and procedural guidance

### 2.2.7 DWS: Best Practice Guideline G1 - Storm Water Management (2008)

The Best Practice Guidelines (BPG) developed by DWS for Storm Water Management targets the waste management hierarchy as follows:

- ✓ Pollution Prevention
- ✓ Minimization of Impacts (re-use, reclamation & water treatment)
- ✓ Discharge or disposal of waste and/or waste water (risk based approach)

We have carefully studied the G1 BPG for Storm Water Management and can report the following:

Principle 1: Keep Clean Water Clean

The SWMP model (PCSWMM) developed clearly indicates the clean vs dirty water areas so managed for the Mine.

Principle 2: Collect and Contain Dirty Water

Dirty water areas have been limited to the smallest possible footprint. All dirty water areas are drained to the in-line silt trap and eventual PC Dam. The dirty water canals from the ROM stockpile and Workshop areas are all concrete lined and the PC Dam is lined with a leakage detection system linked to a monitoring sump with level control pumps.

Principle 3: Sustainability over Mine Life Cycle

The dirty water facilities have been planned to ensure full compliance for the Mine life cycle. Special extended time simulations (30 year rainfall records) were conducted to evaluate the sizing of the PC Dam for the 1:50 year storm event (cumulative impacts, i.e. not only the 1-day event but also cumulative over time.

The extended simulations have shown that the PC Dam has enough storage capacity during peak storm events to contain these with the necessary freeboard (GN704) requirements of 0.8m.

Principle 4: Consideration of Regulations & Stakeholders

This principle strongly supports effective liaison with the Department of Water Affairs & Sanitation (DWS) to ensure that ideas and concepts are confirmed to ensure that the statutory requirements are met. Allowance has been made for a technical presentation to DWS – National to discuss and explain the SWMP for the project. Comments and inputs from DWS will then be incorporated into the final documents that will be handed in for the IWULA.

The guideline document has eight (8) specific steps that are required when a new SWMP is designed and constructed for a Mine:

Step 1: Define the objectives of the storm water management plan

The following objectives have been taken into account in this SWMP:

- ✓ A comprehensive clean vs dirty water separation system was designed for the Mine.
- ✓ Clean water from on-surface activities are diverted away from the impacted mining activities towards the natural water courses. In total, two (2) clean water outlet positions have been identified.
- ✓ The dirty water areas have been identified as the ROM stockpile, Product Stockpiles, Hard Park and Workshop area.
- ✓ All dirty water areas have been isolated where the runoff from these areas have been routed to the centralized Pollution Control Dam (PC Dam).
- ✓ The infrastructure used to divert the clean and dirty water has been designed according to Regulation GN704 where these facilities must accommodate a 1:50 year peak storm event.

Step 2: Technical Situation Analysis

- ✓ A detailed SWMP model was developed for the Mine where we have used the well known Canadian software package called PCSWMM.
- ✓ All clean –and dirty water areas have been divided into catchments which are routed as part of the Mine's overall SWMP.
- ✓ The positions of the PC Dam, silt trap, cut-off berms and drains as well as canals have all been indicated on the layout plans.
- ✓ The latest water balance was used to simulate the return water strategies in our model.
- ✓ The biggest withdrawals from the PC Dam will be for dust suppression (0.5 liters/$m^2$/hour/day assuming a 12hr working day = 6 liters/$m^2$/day) and then evaporation from the dam surface.

Step 3: Conceptual Design and Review

- ✓ Conceptual designs were for the surface infrastructure. This was coordinated with the Mine staff where this layout was optimized and changed.
- ✓ We are of the opinion that the SWMP proposed is fully optimized and will ensure long-term compliance if implemented.

Step 4: Assess the Suitability of the Existing Infrastructure

Not applicable where this is a new mining area. Some limited impact is from opencast box-cuts where some seepage water has been incorporated in the water balance model.

Step 5: Define the Infrastructure Changes that are required

Not applicable where this is a new mining area.

Step 6: Undertake Detailed Designs of all required Infrastructure

- ✓ The PCSWMM model was used extensively to conduct scenario modelling to optimize the SWMP. The SCS Type 3 design storms have been used in our model, which is applicable for the Highveld – Mpumalanga areas.

- ✓ Three (3) rainfall scenarios were investigated to arrive at the recommended PC Dam volume. Full details will be given under the PC Dam designs section of the report.
- ✓ It can be confirmed that the PC Dams has a total storage capacity well above the 1:50 year, 1-day peak storm event to ensure that the dam will not spill.
- ✓ To accommodate Regional Maximum Floods (RMF) the PC Dam has an overflow structure designed for the 1:100 year storm event that will allow for the emergency overflows in the event of such an abnormal peak event.

<u>Step 7: Define Operational, Management & Monitoring Systems & Responsibilities</u>

- ✓ Special long-term extended time simulations were conducted to optimally size the PC Dam with sump and pumps to accommodate peak wet and dry weather periods that is foreseen at the Mine.
- ✓ Operational levels have been determined for the PC Dam during typical wet and dry periods.
- ✓ Special Environmental Activity Method Statements have been developed for this mining area where this ensures the Construction Quality Assurance (CQA) during project implementation.
- ✓ Reference is also made to the relevant SANS & Liner Industry specifications for the liner installation to ensure that the Construction Quality Procedures (CQP) are adhered to when the liners are installed.
- ✓ Where practically possible, we have limited the impacted dirty water footprint of the Mine to a minimum.
- ✓ Wetlands identified along the boundaries of this mining area have been clearly demarcated based on the classifications obtained from the Wetland Specialist. These wetlands are incorporated in the General Layout Plans.
- ✓ The environmental specialist has identified a 100m buffer zone from the edge of the wetlands. It can be confirmed that that all SWMP infrastructure fall outside this 100m wetland buffer zone.
- ✓ A security fence has been proposed all along the impacted mining infrastructure.

<u>Step 8: Document the SWMP</u>

- ✓ This SWMP is in support of an Integrated WULA that will be submitted for the Mine.
- ✓ This report summarizes the preliminary design concepts that have been incorporated into the SWMP. Due cognizance has been given to operational procedures and maintenance issues that will impact the SWMP.
- ✓ The wetland issue has been carefully analysed in our detail designs and we have noted all legislations and recommendations so made in the specialist reports.
- ✓ We have carefully considered the wetland areas and the SWMP designs and placement of stockpiles and roads have been positioned to not encroach on this 100m buffer zone.
- ✓ We have checked our SWMP and model against the BPG – G1 Storm Water Management guideline and confirm that we do comply.

### 2.2.8 DWS: Operational Guideline for GN 704, (No M6.1)

In order to come forward with more practical operational guidelines, a document was developed by DWS; Guideline Document for the Implementation of Regulations on use of water for mining and related activities aimed at the protection of water resources.

Specific guidelines were developed for these regulations and are practical recommendations to assist with the implementation and operation of these pollution control facilities. The following more specific operational guidelines have a direct impact on this project study area and involve the following:

Regulation 1: Definitions

The definition of ***"activity"*** incorporates the following:

- ✓ "Any mining related process on the mine including the operation of washing plants, mineral processing facilities, mineral refineries and extraction plants, and
- ✓ The operation and the use of mineral loading and off-loading zones, transport facilities and mineral storage yards, whether situated at the mine or not.
- ✓ In which any substance is stockpiled, stored, accumulated or transported for use in such process
- ✓ Out of which process any residue is derived, stored, stockpiled, accumulated, dumped, disposed of or transported.

The definition of *"activity"* clearly identifies the Rietkol Silica Mine as an affected mining area that needs to be managed by the mine.

The definition of ***"dam"*** incorporates the following:

- *"dam"* includes any settling dam, slurry dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of polluted water or water containing waste".

Regulation 3: Exemption from requirements and regulations

Exemption from the certain regulations can be granted by the Minister in his/ her own initiative, subject to such conditions as the Minister may determine. The approval of an exemption has been delegated to the Director: Water Quality Management where the applicant should follow the following route:

- ✓ Formal application to be forwarded to the Regional Director, containing at least the following:
  - Motivation and reason for exemption
  - Alternative proposal to the specific requirements of GN704
  - Impact assessment of alternative proposal
  - Management Plan associated with alternative proposal
  - Proposed performance assessment and monitoring techniques

Regulation 4: Restrictions on Locality

No person in control of a mine or activity may-;

- ✓ *“(a) locate or place any residue deposit, dam reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse or estuary….”*

This regulation is very clear and therefore prohibits the location of any stockpiles or pollution dam within the 1:100 flood-lines or within a 100m horizontal distance from any watercourse. The 100m buffer zone from the wetland has been used which automatically imply the adherence to the given requirements.

Regulation 5: Restrictions on use of material

No person in control of a mine or activity may-;

- ✓ “*use any residue or substance which causes or is likely to cause pollution of a water resource for the construction of any dam or other impoundment….”*

This regulation prevents the pollution of a water resource by restricting the use of certain materials for the construction of any dam or pollution control features.

Regulation 6: Capacity Requirements of Clean Water and Dirty Water Systems

- ✓ *“(a) confine any unpolluted water to a clean water system, away from any dirty area”.*

This is one of the most important best management practice principles to ensure that clean water is diverted away from any contaminated or dirty water area. This goes hand-in-hand with the principle where the dirty water area must be kept as small as possible and even further minimized to ensure the least pollution effect of the water so impacted.

- ✓ *“(c) collect the water arising within any dirty area, including water seeping from mining operations, outcrops or any other activity, into a dirty water system:”*

Make sure that all dirty water is separated from the clean water system of the Mine by channelling this to a dedicated pollution control dam.

- ✓ *“(d) design, construct, maintain and operate any dirty water system at the mine or activity so that it is not likely to spill into any clean water system more than once in 50 years, and*
- ✓ *(e) design, construct and maintain and operate any dam or tailings dam that forms part of a dirty water system to have a minimum freeboard of 0.8 metres above full supply level.”*

Regulation 6(d) specifically stipulates that the dirty water dam must **at all time** be capable to handle a 1:50 year flood event on-top of its **mean operating level** without spilling. A minimum freeboard of 0.8m above the full supply level must be maintained at all times. Evaporation of surface water has a distinct impact and an integrated evaporation model was linked to the SWMP models so developed for the Mine.

- ✓ *"(f) design, construct and maintain all water systems in such a manner as to guarantee the serviceability of such conveyances for flows up to and including those arising as a result of the maximum flood with an average period of recurrence of once in 50 years".*

Any associated channels so part of the dirty water system must also be able to convey and retain a 1:50 year flood event.

<u>Regulation 7: Protection of water Resource</u>

- ✓ *"(a) prevent water containing waste or any substance which causes or is likely to cause pollution of a water resource from entering any water resource, either by natural flow or by seepage, and must retain or collect such substance or water containing waste for use, re-use, evaporation of for purification and disposal in terms of the Act".*

The use of HDPE liners as a protective system is commonly used in the industry to prevent seepage of water from these pollution control dams into the natural environment. This condition must be read with the newly imposed waste classification where certain barrier systems are required based on the waste classification.

- ✓ *"(b) design, modify, locate, construct and maintain all water systems, including residue deposits, in any area so as to prevent the pollution of any water resource through the operation or use thereof and to restrict the possibility of damage to the riparian or in-stream habitat through erosion or sedimentation, or the disturbance of vegetation, or the alteration of flow characteristics".*

Water systems conveying dirty water such as channels must be lined to prevent any pollution entering the natural environment.

- ✓ *"(f) ensure that water used in any process at a mine or activity is recycled as far as practicable, and any facility, sump, pumping installation, catchment dam or other impoundment used for recycling water, is of adequate design and capacity to prevent the spillage, seepage or release of water containing waste at any time".*

Where possible and practicable, water must be re-used and re-cycled and every effort must be made to ensure that the dirty water so captured in the pollution control dams is re-used instead of importing clean water into the dirty water cycle of the Mine. An extended time series simulation was run (Groenfontein at Bronkhorstspruit Dam B2E001, 30-year daily rainfall data) to investigate the impact of the Mine's return water strategy and how best water must be re-cycled for operational usage.

- ✓ *"(g) at all times keep any water systems free from any matter or obstructions which may affect the efficiency thereof".*

The pollution facilities so recommended must ensure that regular maintenance can be performed and effectively operated to ensure that no spillages occur. The silting of pollution control dams is a problem and need to be looked at from a practical point of view.

Regulation 8: Security and Additional Measures

- ✓ "(a) 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".

The necessary safety measures must be put in place to ensure that the pollution dams are safe.

Regulation 9: Temporary or permanent cessation of mine or activity

- ✓ *"(a) Any person in control of a mine or activity must at either temporary or permanent cessations of operations ensure that all pollution control measures have been designed, modified, constructed and maintained so as to comply with these regulations".*

Any pollution measures so designed must still be operative after mine closure and must still comply with the regulations so mentioned herewith.

Regulation 13: General

The person in control of a mine or activity must;

- ✓ *"provide the manager with the means and afford him or her every facility required to enable the manager to comply with the provisions of these regulations."*

Compliance with the requirements of these regulations ultimately remains the responsibility of the person in control of a mining or related activity.

Regulation 14: Offences and penalties

- ✓ *"(1) Any person who contravenes or, subject to regulation 3, fails to comply with the rest of the regulations is guilty of an offence and liable on conviction to a fine or imprisonment for a period not exceeding five years"*.

This regulation clearly outlines the offences and penalties involved should these regulations are not implemented on a mine.

Regulation 16: Commencement

- ✓ *"These regulations will take effect on the date of publication".*

These regulations came into effect on **4 June 1999**. These regulations may not legally be applied retrospectively; however, they lay down certain minimum requirements that be complied with. Should a mining or related activity not comply with these requirements, a reasonable time period shall be granted for the activity to become compliant. The emphasis for existing activities should be placed on progressive improvements within a time frame stipulated by DWA.

## 2.3 Government Notice 36784 – DEA Waste Classification & Management

Previously, the mining residue management was covered under the MPRDA. This has changed when on 2 June 2014, the National Environmental Management – Waste Amendment Act (NEMWA), - Act No. 26 of 2014 was published which included residue deposits and stockpiles under the environmental waste legislation.

Under schedule 3 of the Act, mine waste is categorised under the Hazardous Waste sector. The understanding being that mine waste is considered hazardous unless proven differently by the mine. This new waste classification act therefore regards residue deposits and residue stockpiles as waste which was promulgated on 23 August 2013 and is regulated as follows:

- ✓ Regulation R635 - National Norms and Standards for the assessment of waste for landfill disposal
- ✓ Regulation R636 – National Norms and Standards for the disposal of waste to landfill

According to SANS 10234, all waste generators must ensure that the waste they generate is classified within 180 days of generation. The norms and standards specify how the waste can be classified and what barrier systems are required for a specific waste stream. The waste is classified according to the National Norms and Standards for Disposal to Landfill according to the following waste classification criteria **(Table 1 below).**

**Table 1: Waste Classification Criteria (SANS 10234)**

| Waste Type | Total Concentrations (TC) | Leachable Concentrations (LC) | Disposal to Landfill |
|---|---|---|---|
| 0 | TC > TCT2 | LC > LCT3 | Not Allowed |
| 1 | TCT1 < TC < TCT2 | LCT2 < LC < LCT3 | Class A (Hh :HH) |
| 2 | TC < TCT1 | LCT1 < LC < LCT2 | Class B (GLB+) |
| 3 | TC < TCT1 | LCT0 < LC < LCT1 | Class C (GLB+) |
| 4 | TC < TCT0 | LC < LCT0 | Class D (GLB-) |

TCT = Total Concentration Threshold
LCT = Leachable Concentration Threshold

**Table 2** below is the landfill classification (Class A to D) for the waste types so identified in **Table 1** above.

**Table 2: Disposal to Landfill Class according to Waste Type**

| Waste Type | Landfill Disposal Requirements |
|---|---|
| **Type 0 Waste** | The disposal of Type 0 waste to landfill is not allowed. The waste must be treated and re-assessed in terms of the *Norms and Standards for Assessment of Waste for Landfill Disposal.* |
| **Type 1 Waste** | Type 1 waste may only be disposed of at a Class A landfill designed in accordance with section 3(1) and (2) of these Norms and Standards, or, subject to section 3(4) of these Norms and Standards, may be disposed of at a landfill site designed in accordance with the requirements for a Hh/HH landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., Department of Water Affairs and Forestry, 1998). |
| **Type 2 Waste** | Type 2 waste may only be disposed of at a Class B landfill designed in accordance with section 3(1) and (2) of these Norms and Standards, or, subject to section 3(4) of these Norms and Standards, may be disposed of at a landfill site designed in accordance with the requirements for a GLB+ landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998). |
| **Type 3 Waste** | Type 3 waste may only be disposed of at a Class C landfill designed in accordance with section 3(1) and (2) of these Norms and Standards, or, subject to section 3(4) of these Norms and Standards, may be disposed of at a landfill site designed in accordance with the requirements for a GLB+ landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998). |
| **Type 4 Waste** | Type 4 waste may only be disposed of at a Class D landfill designed in accordance with section 3(1) and (2) of these Norms and Standards, or, subject to section 3(4) of these Norms and Standards, may be disposed of at a landfill site designed in accordance with the requirements for a GLB· landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998). |

# 3. WASTE ASSESSMENT

A detailed waste assessment and classification was conducted by Groundwater Complete, referred to as: "Report on Geohydrological Investigation as part of the Environmental Impact Assessment and Environmental Management Programme", dated May 2021. This report is included in the overall EAP application for this project.

## 3.1 Acid Base Accounting

From the exploration drilling in the project area, it was concluded that the Rietkol quartzite deposit is exceptionally pure. No Acid Base Accounting (ABA) was therefore deemed necessary for this investigation as the targeted quartzite is predominantly composed of inert silica (i.e., amount of metal sulphide minerals is negligible, if any).

## 3.2 Waste Characterisation

A waste classification was conducted by Aquatico Scientific during April of 2021. The aim was to chemically characterise the waste material that will be generated and stockpiled during the operational phase of the project. Mining is yet to commence, meaning that no silica ore or waste material was available for sampling and testing purposes. Two composite samples (i.e. tailings material and waste rock) were consequently collected from the operational Thaba Chueu mine (previously known as SamQuarz) situated approximately 17 kilometres east/north-east of the Rietkol MRA area. The ore deposit currently being mined at Thaba Chueu is chemically very similar to the Rietkol deposit, meaning that the results of the waste classification would be applicable to Rietkol.

Two types of tests or analyses were conducted, namely total concentration (TC) and leachable concentration (LC). The waste classification concluded the following results:

- ✓ Both the tailings material and waste rock can be regarded as a Type 4 or inert waste.
- ✓ It is concluded that a Class D (or GSB-) disposal facility would suffice for both the tailings material and waste rock.

The PC Dam has been designed as a Type 3 waste with a Class C barrier design. All impacted water from the Mine will be directed and managed at the Pollution Control Dam (PC Dam).

# 4. ENVIRONMENTAL IMPACTS INFLUENCING DESIGN DEVELOPMENTS

Various specialist studies have been conducted in support of this EIA/ WUL application. The environmental risks impacting the integrated SWMP have been incorporated into the civil design development process.

The following specialist studies have been studied; -

- ✓ Geotechnical Assessment
- ✓ Soil and Land Capability
- ✓ Wetland Delineation & Hydropedological Buffer Zones

## 4.1 Geotechnical Investigation

A detailed geotechnical investigation was conducted by JD Geotechnical Services (JD) in support of the civil designs, and is attached as **Appendix A**.

Nine test pits were dug on the site, as shown below in **Figure 1**.

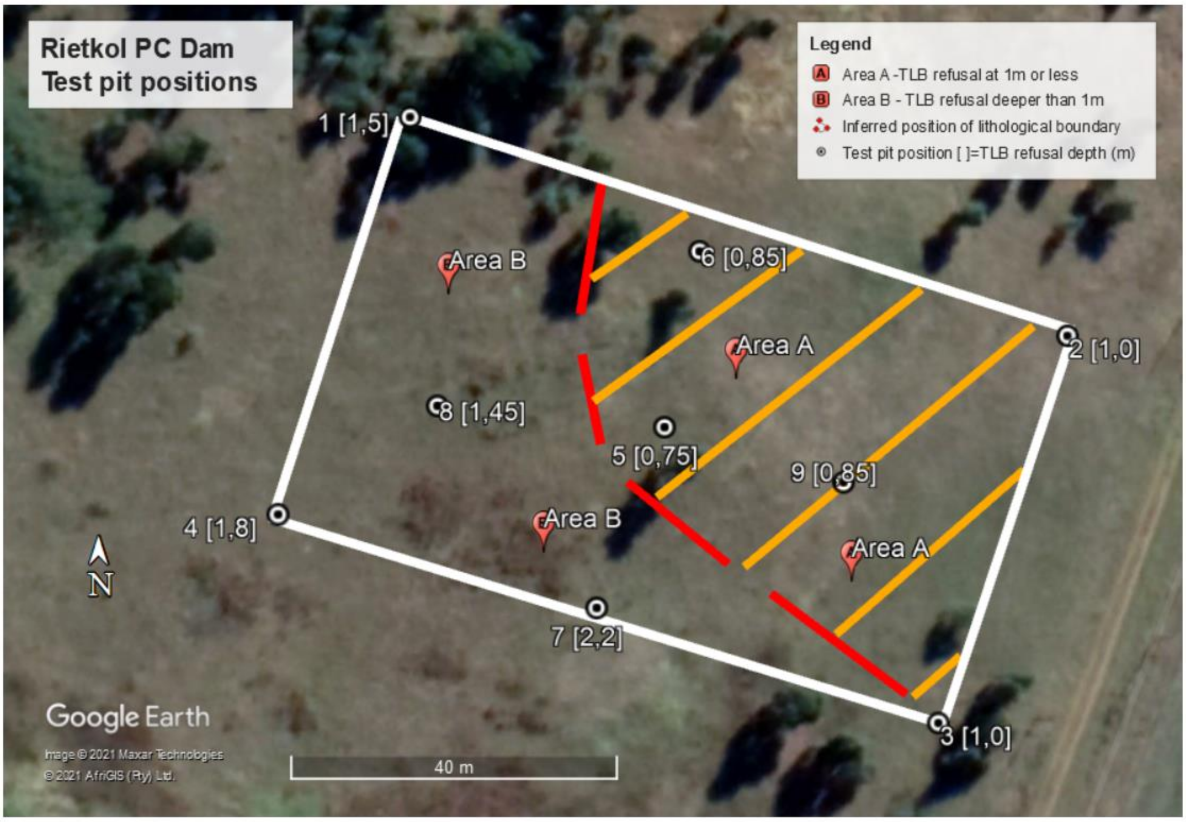


**Figure 1: Geotechnical Investigation showing the 9 x Test-Pit Positions impacting the PC Dam**

The test pits were dug by means of a Cat 428B backactor. The test pits were dug to refusal, the depths ranging from 0,75m to 2,2m, and were fully profiled.

The following are the more important findings from this investigation:

1) The test-pitting investigation indicated that the site could be subdivided into two areas referred to as Areas A and B.
2) The Pollution Control Dam site is covered by transported, very loose to medium dense silty sands in the order of 0,5m in thickness which generally have an estimated bearing capacity in the order of 30kPa.
3) These materials are underlain by residual silty sandstone in the form of a medium dense to dense clayey sand, which generally has an estimated bearing capacity in the order of 80kPa to 100kPa.
4) With depth the residual silty sandstone becomes very dense and is sometimes ferruginised, causing backactor refusal at depths ranging from 0,75m to 1,0m in Area A, and 1,45m to 2,2m in Area B, respectively.
5) The excavatability should generally be possible to depths of at least 3,0m beneath the site providing use is made of large excavating equipment equipped with ripper teeth.
6) It is possible that silty sandstone rock could be encountered with depth, and it would therefore be advisable to make provision for the possible use of power tools and/or explosives in the deeper parts of the excavation.
7) The sides of excavations may tend to be unstable and should either be shored or else battered back.
8) The test-pitting investigation did not indicate the presence of clay that could have a low permeability.
9) The materials that were encountered were generally clayey sands, having a Unified Soil (US) classification of SC. Such materials characteristically have permeabilities in the order of $10\text{-}^{-5}$ cm/sec, which indicates that the soils should probably be slightly permeable.
10) It should be noted that the indications of the laboratory test results on representative samples taken from the soil profile underlying the site indicate that, according to the COLTO classification, the materials are slightly poorer than G9 in quality.
11) It is anticipated that, if a mixture of the material layers that underlie the site is compacted in layers 150mm in thickness at -1% + 2% of optimum moisture content, to a density greater than 95% Mod AASHTO, then a CBR value of at least 7 should be attainable, and it is anticipated that the material could be used in the proposed dam embankments.
12) Seepage of groundwater did not occur in any of the test pits that were dug on the site, which were dug to depths ranging from 0,75m to 2,2m.
13) It should be borne in mind that the investigation took place during the dry season (May 2021), and it is possible that seepage could take place at shallower depths during the rainy season. It is therefore recommended that provision should be made for the removal of groundwater from excavations.
14) pH and conductivity tests carried out on representative samples of the materials underlying the site indicate that the materials should be neutral and should have a low corrosivity as regards underground services.

## 4.2 Soil & Land Capability

The dominant soil types within the Mining Right Area (MRA) area include Hutton/Clovelly (Hu)/(Cv), Rocky Outcrop, Westleigh/Avalon (We)/(Av) and Mispah/Glenrosa/Dresden (Ms/Gs/Dr). The remainder of the MRA area is occupied by Witbank (Wb) (Anthrosols), Pinedene (Pn), as well as residential properties.

Sandstone outcrops were observed where the bedrock is exposed on the ground surface around the crest (hilltop) landscape position. This is indicative of intense erosion likely attributed to historic land uses, particularly overgrazing.

The soil map with associated land capability is shown below in **Figure 2**.


**Figure 2: Soil Map showing Land Capability (Courtesy Jacana Environmental)**

## 4.3 Wetlands & Hydropedology

Two hydrogeomorphic (HGM) units were identified within the proposed MRA area, classified as depression (pan) and hillslope seep wetlands. These wetlands have been considerably modified and have an intermediate level of ecoservice provision with relatively good water quality.

The identified wetlands were classified as Inland systems falling within the Highveld Ecoregion and within the Mesic Highveld Grassland Group 4 wetland vegetation group.  The wetland systems with associated buffers are shown below in **Figure 3**.

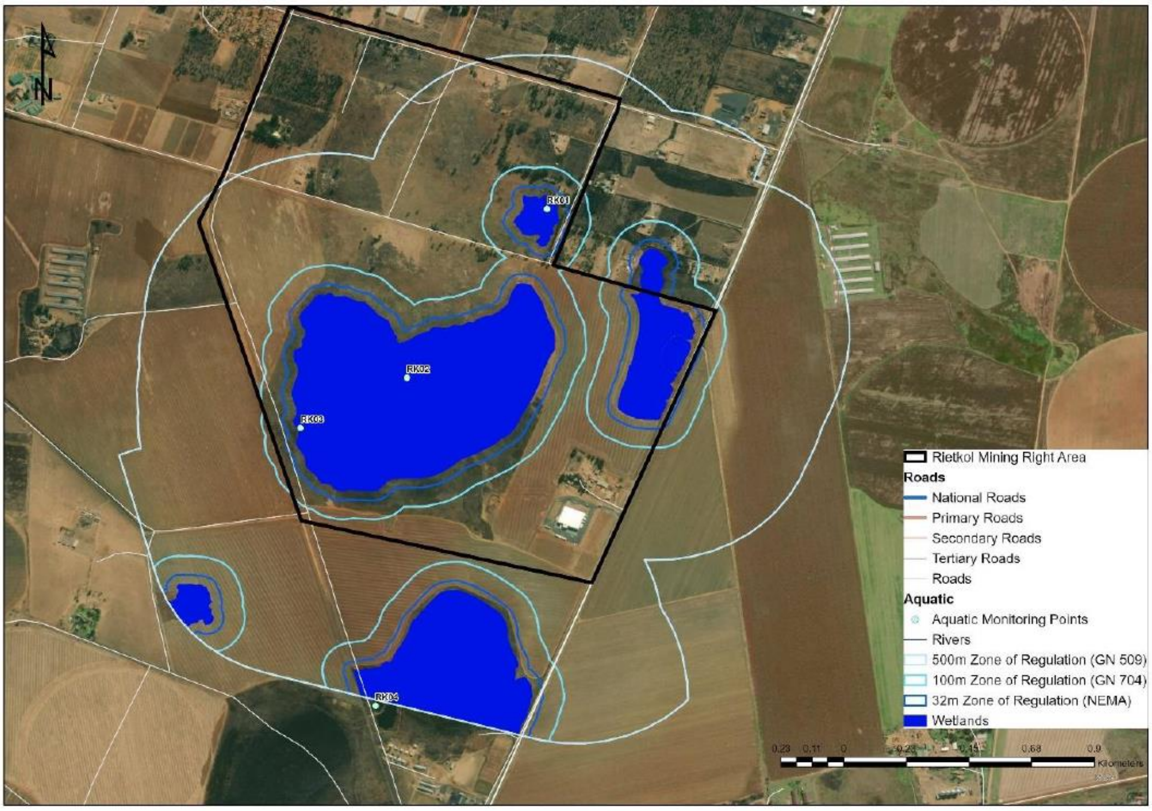


**Figure 3: Wetland Delineation & Buffer Zones**

The hillslope seep wetlands are hydrologically isolated and not connected to other surface water resources, as inferred from the local micro-topography. The hillslope seeps within the MRA area are recharged by surface water from seasonal rainfall as well as via the interflow soils (SAS, 2021). The soils are not driven significantly by groundwater.

The depression (pan) is hydrologically isolated from other surface water resources, as inferred from the local micro-topography in its vicinity. This pan is recharged by surface water from seasonal rainfall as well as subsurface flow (SAS, 2021). Groundwater is not anticipated to have a direct significant interaction with the surface and shallow sub-surface hydrogeological processes which drive this pan (SAS, 2021).

The surrounding agricultural activities is up to the edge of this pan and have already reduced the catchment yield that enters the pan. Nevertheless, the pan is sustained by hydropedological interflow (subsurface water within the vadose zone of the pan).

The classification of the wetlands is shown below in **Table 3**.

**Table 3: Wetland Classification**

| Wetland System | PES | Ecological function and service provision | EIS | REC |
|---|---|---|---|---|
| Hillslope seeps | D (Largely modified) | Intermediate | D (Largely modified) | D (Largely modified) |
| Pan | C (Moderately modified) | Moderately low/ Intermediate | C (Moderately modified) | C (Moderately modified) |


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# 5. HYDROLOGICAL BACKGROUND INFORMATION

## 5.1 Location

The proposed Rietkol Silica Mine is shown below in **Figure 4**. The Mine is accessible from the N12 from Benoni to Emalahleni and is located approximately 6km due west of the town of Delmas.

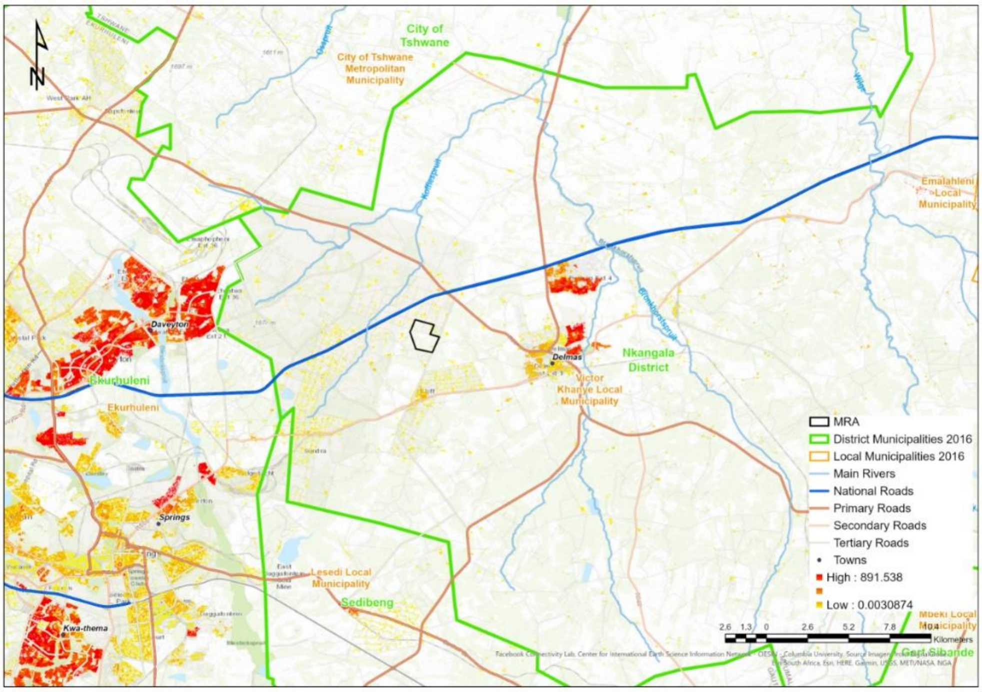


**Figure 4: Rietkol Silica Mine – Showing the MRA, surrounding Towns & Major Roads. Courtesy (Jacana)**

The coordinates of the surface infrastructure for the project is as follows:

- Longitude: 26°07’36” S
- Latitude: 28°36’27” E

## 5.2 Climate

According to the Water Research Commission (WRC) study of the Water Resources of South Africa (WR 2012), the Rietkol Silica Mine falls within the Olifants River Water Management Area (WMA 4) and more specifically within Quaternary Catchment B20B, with the following catchment characteristics:

- Mean Annual Precipitation (MAP) : 699mm
- Mean Annual Evaporation (MAE) : 1 677mm
- Mean Annual Runoff (MAR) : 14.4 mil $m^3$
- Rain Zone : B2A
- Evaporation Zone : 4A

The site has three wetland resources (Hillslope Seep, Artificial Impoundment & a Pan) to the South-East of the on-surface.

### 5.2.1 Rainfall

Design storm data was obtained from the Design Rainfall Estimation Software for SA, as developed by Smithers & Schulze, University of Natal 2002.

According to the Design Rainfall Estimator, the two closest rainfall stations to the mine are as follows:

- Droogefontein rainfall station (SAWS Nr: 0477191_W)
- Delmas rainfall station (SAWS Nr: 0477309_W)

The Droogefontein rainfall station has a MAP of 664mm and the Delmas rainfall station has a MAP of 661mm. It was decided to use the Delmas rainfall station as it has a rainfall record of 92 years and is the closest to the site.

For the 1-day 1:50 year flood event, we have used the Delmas rainfall data (131.9mm in 24hr) to size the canals and other site infrastructure required such as culverts and silt traps.

An extended time series was used to specifically test and size the pollution control dam where the Groenfontein rainfall Station at the Bronkhorstspruit Dam (B2E001) was used with daily rainfall data that was available for a period of 30 years (1967 to 2006).

### 5.2.2 Evaporation

As stated, the Rietkol Silica Mine falls in Quaternary Catchment B20B, which falls within Evaporation Zone 4A. The Mean Annual Evaporation (MAE) for this catchment is 1 677 mm per year.

The monthly distribution of the MAE for Evaporation Zone 4A is as follows:

- Jan = 184 mm
- Feb = 154 mm
- Mar = 152 mm
- Apr = 117 mm
- May = 98 mm
- Jun = 80 mm
- Jul = 87 mm
- Aug = 116 mm
- Sept = 150 mm
- Oct = 181 mm
- Nov = 170 mm
- Dec = 188 mm

# 6. DETAILED SWMP MODEL

A detailed Surface Water Management Plan (SWMP) was developed for the Rietkol Silica Mine with the Canadian software package PCSWMM. The SWMP model was used to simulate various design storms and to run extended time simulations based on a 30-year daily rainfall record that was obtained from the nearby Groenfontein Rainfall Station at the Bronkhorstspruit Dam.

To ensure compliance for the Mine, these rain events were used during the preliminary designs for the sizing of stormwater infrastructure where a complete clean-vs dirty water management system was designed for the Mine. The model layout for Rietkol Silica Mine is shown below in **Figure 5**.

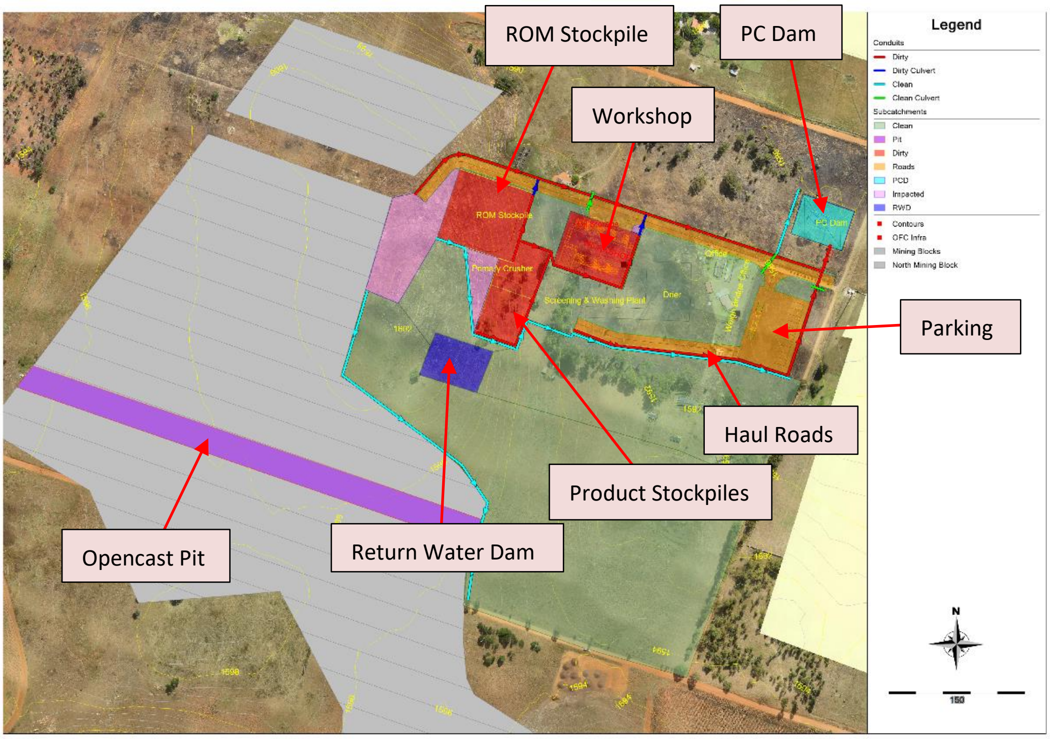


**Figure 5: Detailed SWMP Model for Rietkol Silica Mine - Showing clean vs dirty water separation**

The clean areas are clearly indicated as the green sub-catchments. The water from these clean areas is diverted away from the impacted dirty water areas of the mine shown in red and orange. The position of the Pollution Control Dam is shown to North-Eastern corner of the mine. The model is based on the simulated groundwater influx & water balance calculations received from the mine.

We have used the groundwater & water balance data in our SWMP model where this was then used in the extended 30-year rainfall model for the final sizing of the PC Dam.

# 7. SWMP INFRASTRUCTURE – DESIGN DEVELOPMENTS

The following is a summary of the SWMP infrastructure proposed for Rietkol Silica Mine.

Preliminary designs were conducted covering the overall scope for the SWMP that will be submitted in support of the Water Use Licence (WUL) application. All the signed preliminary design drawings for the SWMP are included in **Appendix B**.

## 7.1 General Layout Plan

The expected life of mine for Rietkol Silica Mine has been estimated at 20 years. The infrastructure and engineering designs must therefore withstand this life of mine period.

The General Layout Plan for the Mine is shown on Drawing **P115-RS-G-01** (Overall area) in **Appendix B**. The following can be reported:

- The drawing is done to a scale of 1: 1 500 showing the terrain contours (major 2m intervals & minor contours 0.5m interval).
- The clean vs dirty water areas have been clearly indicated where the red shaded areas depict the dirty water areas.
- The Dirty Water System comprise the following:
    - Hard Park area is located to the east of the Infrastructure area. This hard park area will be a sloped engineering platform (Class D barrier).
    - The ROM Stockpile and Primary Crusher areas will be a sloped engineering platform (Class D barrier).
    - The Product Stockpile area will be a sloped engineering platform (Class D barrier).
    - PC Dam in itself is seen as dirty water area footprint where any surface water will also impact the overall dirty water system of the Mine. All the dirty water areas identified in the SWMP model has been routed to the PC Dam.
    - Haul Roads are shown where these roads are considered part of the dirty water system. These roads are 12m wide. Surface water collected form the haul roads will be captured in trapezoidal canals and routed to the main PC Dam.
    - All dirty water canals are lined (concrete) and have been designed for the 1:50 year, 1-day storm event. All the water so captured in the dirty water canals are routed to the PC Dam.
- Screening & Washing Plant The screening & washing plant will be beneath a corrugated roof structure thereby preventing pollution of the rainfall water. The water within the plant will be self-contained and will be diverted to the PC Dam via the dirty canal system running next to the workshop. The water falling on the roof and draining via the down pipes will form part of the clean water system.
- The Clean Water System is the remainder of the mining area where the clean-water areas in-between are diverted with gravel drains and side berms away from the impacted mining areas. The following is of importance for the clean water system:
    - Clean water diversion canals/ berms have been placed strategically throughout the mining area (light-blue) where the clean water is diverted to the natural environment.
    - Return Water Dam – The dam is classified as a Class D barrier design.

- Wetland Delineation has identified two (2) hillslope seepage wetlands and two (2) artificial impoundments to the South of the surface infrastructure. The wetlands have been colour coded on the General Layout Plan. The 100m buffer zone is indicated for the wetlands identified. All activities have been placed outside of this 100m buffer zone.
- Clean Water Storm Water Discharge from the mining area has been allowed for at two (2) strategic placed outlet positions as indicated, one to the north of the PC Dam and the second to the south of the Return Water Dam. No flood attenuation will be required for the clean water systems. However, special erosion outlet chutes have been designed at these outlets to limit erosion damage and high flows into the surrounding environment. The velocity in the diversion berms are designed to be below 1.5m/s (maximum for grass lined canals but above the minimum of 0.3m/s (minimum to prevent siltation of the grass canal).
- A Security Fence with Guardhouse have been shown all along the boundary of this infrastructure area.
- Access Road to the Mine is from an existing gravel road.

## 7.2 PC Dam & Return Water Dam

The water in the PC Dam will be mainly surface water accumulated from the dirty water areas identified for Rietkol Silica Mine. The PC Dam will therefore receive dirty water runoff from the ROM Stockpile, Product stockpiles, Workshop, Haul Roads & Parking Area.

The groundwater influx into the opencast pit as well as the run-off from the opencast pit will be dewatered to a silt trap that feeds into the Return Water Dam. The Return Water Dam will act as additional clean water storage that can be used as make-up water for the Mine.

The water captured in the Return Water Dam & the PC Dam will be reclaimed back to the Mine's operations for the washing and screening plant. A complete water balance was modelled for the Return Water Dam & PC Dam to ensure the optimal use of the water so captured in the facilities.

### 7.2.1 Sizing of the PC Dam & Return Water Dam

The sizing of the Main PC Dam was carefully analysed where three (3) model scenarios were investigated, as follows:

1:50 Year – 1 Day maximum storm event (131.9 mm): This gives a good indication of what infrastructure is required to manage a big storm event on the Mine. All clean -and dirty water infrastructure must be able to withstand this event. The minimum dam size to accommodate this 1-day event:

- PC Dam: 3600 $m^3$
- Return Water Dam: 2500 $m^3$

Simulate the Average wettest month (January 140 mm) + 1:50 Storm: The levels in the dams during an average wettest month period give a good indication of the possible operation levels of both dams and serve as a baseline before introducing a 1:50 storm. The highest water level during an average wettest month is taken as the baseline water level in each dam before introducing a 1:50 storm. This is a possible worst-case scenario. The minimum dam sizes required to contain this situation:

- PC Dam: 4 500 $m^3$
- Return Water Dam: 3 500 $m^3$

Simulate an Extended Time Series Model: Accurate daily rainfall data was available from the Groenfontein rainfall station at the Bronkhorstspruit Dam for a period of 30 years (1967 – 2006). This is a long-term test to simulate seasonal fluctuations, especially the dry vs wet period impacts. Spillages vs periods when the PC Dam runs dry were evaluated.

Global warming trends have shown a more drastic disparity between dry and wet periods where the wet periods result in mush higher volumes that must be managed. This extended 30-year model has shown that the minimum dam sizes needed to prevent spillages are:

- PC Dam: 6 000m³
- Return Water Dam: 5 000 m³

The final sizing of the dams is thus:

- PC Dam: 6 000 m³
- Return Water Dam: 5 000 m³

## 7.3 Dam Associated Structures

Two structures have been provided to manage the inflows and outflows of the Dams.

### 7.3.1 In-Line Silt Trap

All dirty water collected from the Mine is discharged via canals into the Silt Trap located at the inlet to the PC Dam. The silt trap is a concrete lined structure where we recommend that a double chamber system is incorporated. Additionally, the Return Water Dam will also have a Silt Trap to improve the turbidity of the water as well as prevent the return water dam from silting up. The basic design principles are the following:

- Design flow through the sedimentation/ silt trap must cater for the 1:10-year – 24 hour recurrence interval.
- The silt trap must allow for easy access to allow for the regular cleaning of the silt trap.
- A rectangular silt trap is proposed with two parallel chambers (PC Dam) and one chamber (Return Water Dam) which will increase the retention period through the silt trap to allow for settlement.
- A splitter canal will serve the silt trap where the option to exist to either close-off one silt trap for drying and cleaning whilst the second silt trap can be operational.
- The first receiving silt trap accumulates the coarsest silt whilst the second parallel chamber allows for the finer silt deposition as the speed through the silt trap decreases significantly.
- The detention time for the 1:10 year, 24-hour storm event through the silt trap should not be less than 20 hours.
- Small weeping holes (20mm diameter) are provided to ensure that the water in the silt traps can be drained over time during dry periods. This will help with the regular cleaning of the silt trap once the water levels in the silt trap have subsided.
- A special sloping drying slab is provided adjacent to the silt trap where the seepage water is then drained back into the silt trap.
- A special waste storage facility has been provided alongside the drying slab which the Mine can use for any contaminated waste storage area that is bunded.
- Special rails are proposed in the floor –and wall section of the silt trap which will allow for the protection of the concrete when loaders and heavy equipment are used to remove the silt from the silt trap.

Design details of the silt trap are provided in Drawing: **P115-RS-D-01** attached.

### 7.3.2 Emergency Overflow Structures

Concrete emergency overflow structures have been designed at the outlet of the PC Dam & Return Water Dam. This is required to protect the safety of the dam for extreme storm events bigger than the 1:50 year event.

The following details can be observed for the emergency overflow structures:

- The structure is built in concrete to ensure the integrity of the structure during extreme storm events.
- The overflow structure makes provision for the mandatory 800mm freeboard to be maintained for the PC Dam.
- The overflow structure is sized to easily accommodate the 1:100-year storm event through this opening.
- A special sump section is provided in the overflow structure for the Mine to install a return pump that can completely draw-down the volume of water in the PC Dam after an extreme storm event.
- The overflow structure makes provision for special protection with gabion boxes and mattresses at the outlet to the natural environment to limit the damage when the dam is overflowing.
- This overflow concrete structure is included in the overall sealing and water proofing of the Main PC Dam when the HDPE liner is installed.

Design details of the overflow structures are provided in Drawing: P115-RS-D-02 attached.

## 7.4 Dirty Canals

The dirty canals have been sized to convey the 1:50 storm without spilling. The dirty canals are concrete lined trapezoidal canals that have a depth ranging from 0.3m to 1m and a bottom width ranging from 0.5m to 1m. Shown below in **Figure 6** is the trapezoidal canal section.

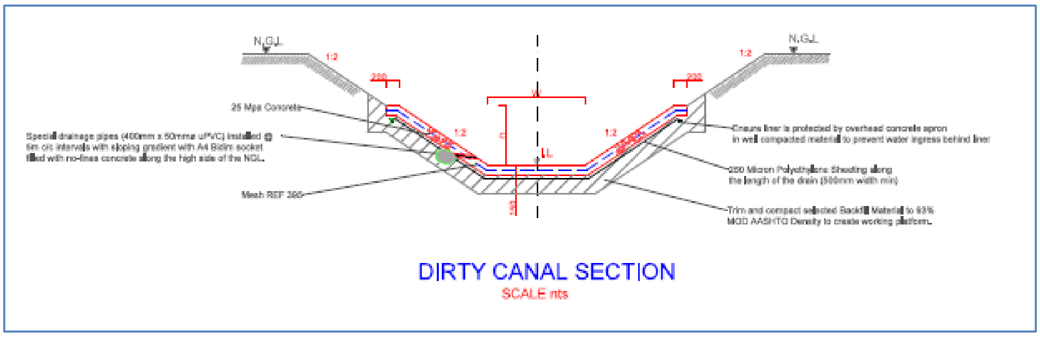


**Figure 6: Dirty Water Canals - Trapezoidal Canal Section**

## 7.5 Culverts

The clean and dirty canals must be designed to convey the 1:50 storm. Two dirty water & two clean water culverts are needed to pass underneath the northern Haul Road. The dirty water culverts will tie into the dirty water canal running parallel to the haul road whilst the clean water culvert will pass beneath the haul road and the dirty canal before draining into the natural environment.

This means that the haul road will need to be elevated for the culverts to pass beneath the road and still drain to their respective systems. The Haul roads can be built up with the softs material from the opencast mining operations. The clean water culverts will be concrete circular interlocking stormwater pipes, whereas the dirty water culverts will be concrete spigot & socket stormwater pipes. The clean water culverts as well as the dirty culverts will be between Ø300mm – Ø450mm at a slope of 2%. The clean water culverts will have wingwalls at both the inlet & outlet, whereas the dirty water culverts will have a smooth tapered inlet & outlet to the trapezoidal dirty canal.

## 7.6 Workshop, Washbay & Refuelling Station

The workshop and refuelling station area will be shaped to drain into two v-drain canals that run next to the workshop. The v-drains will run into a small silt trap from where it will overflow to an oil separator. The oil separator will sperate the water and oil in a 3-chamber structure from where the water will flow to the dirty water canal that ultimately flows into the PC Dam.

The Wash-Bay will be bunded but will be shaped so as to be able to drain towards a v-drain running next to the workshop via a small sluice gate in the wall.

## 7.7 Haul Road Construction & Management

The haul roads are 12m wide and have been designed with a single cross-fall of 3%. The haul roads are classified dirty water areas and surface water draining from the road surface must be captured and managed as part of the Mine's dirty water system. Trapezoidal canals are proposed at the downstream edge of the road surface. Refer Drawing: **P115-RS-D-06** is attached**.**

## 7.8 Clean Water Diversion Berms

The clean diversion berms are designed at gradients in the order of 1:200 slope to limit the design velocity between 0.8m/s (maximum) and 0.3m/s (minimum). For a gravel drain, the standard is that velocities higher than 0.8m/s limit will result in erosion of the diversion berm, whereas velocities lower than 0.3m/s will result in the silting of the diversion berm.

To ensure compliance to Regulation GN704, the clean water berms must be able to drain the 1:50 year storm event for the area.

The diversion berms details are as follows:

- Trapezoidal earth canal with dimensions that will accommodate the flood events from the receiving catchment.
- The diversion berm will be built in a cut-to fill operation where the excavated material will be used to build the downstream berm as a second barrier
- The topsoil removed from the footprint of the diversion berm will be used for the rehabilitation of the berm embankments.
- The diversion berms will be grassed using the indigenous grasses of the area
- Manning value of 0.15 assumed (For a grassed canal during operational life of the Mine)
- Diversion berm slope of maximum 1:200 (0.5%)

A typical clean water diversion berm is shown below in **Figure 7**.

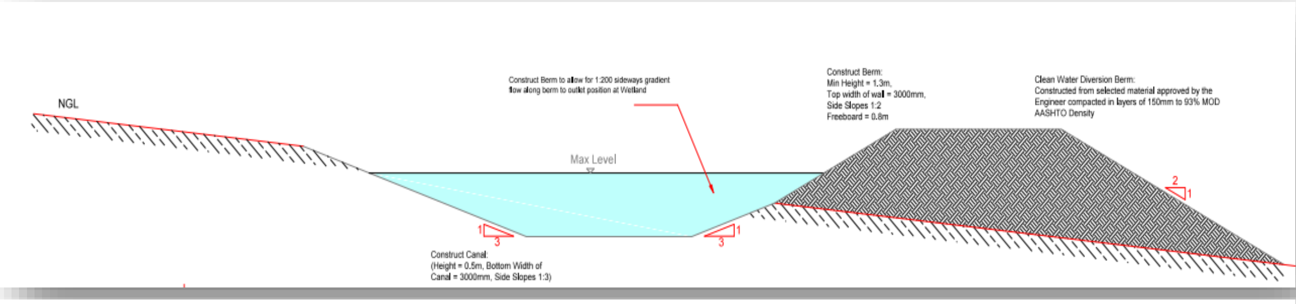


**Figure 7: Typical Clean Water Diversion Berm/ Canal**

To ensure that no erosion will be experienced during the initial construction stages of the berm, it is recommended that erosion stilling basins are installed where high velocities are encountered. For lower velocities, reno-mattresses are installed at maximum 50m spacing's all along the canal long-section. This will limit the initial velocities in the gravel canal to below 0.8m/s until the vegetation lining of the canal has established.

The clean water diverted along these diversion berms are released to the natural environment where a special outlet structure will be built to prevent erosion. The detail for this Erosion Outlet Structure is shown in in **Figure 8** below.

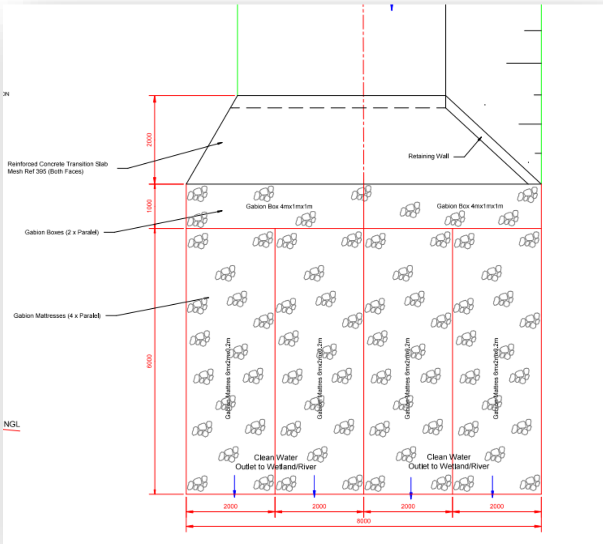


**Figure 8: Typical Erosion Protection at Clean Water Diversion Berm Outlets**

## 7.9 Wastewater & Grey Water

The wastewater and greywater originating from the change houses and laundry will drain into a modular Calcamite septic tank system that will need to be emptied twice a week. The wastewater flows were calculated as follows:

- 150 Persons
- The design flows were taken as 70ℓ/person/day as per SABS 1993 for workers per shift
- The Septic Tank will be cleaned twice a week giving a maximum retention time of 4 days

The septic tank will therefore need a capacity of 42 000 ℓ (150 people*70 ℓ*4 days).

It is recommended to install a 44 500 ℓ modular Calcamite tank to allow for some additional storage capacity.

## 7.10 Water Balance

A detailed average daily water balance was done for Rietkol Mine. The main items to highlight from the water balance are the following:

- RWD Inflows: The RWD will receive inflows from dewatering operations in the opencast pit as well as borehole water.
- PCD Inflows: The PCD will only receive inflow from dirty stormwater runoff
- Dust Suppression: Dust suppression will be done at a rate of 6 ℓ/m²/d for a 12-hour working day. Dust suppression will be done from by using water from the PC Dam & RWD.
- Plant Demand: The Plant demand of 3.4ℓ/s will be supplied by water from the RWD & PC Dam.

The Water Balance is attached in **Appendix G.**

# 8. WASTE LICENCE APPLICATION & CHECKLIST

## 8.1 Conclusion from Waste Classification

Recommendations and comments on an appropriate barrier designs have been made by the groundwater specialist based on the waste classification and AMD tests conducted for the project, and involves the following:

- PC Dam: Standard Class C
- ROM & Product Stockpiles: Standard Class D
- Topsoil Stockpiles: Standard Class D
- Return Water Dam: Standard Class D

The recommendations are mostly focused on the ROM & Product stockpiles as well as the PC Dam.

### 8.1.1 ROM & Product Stockpiles

The waste classification recommends a standard Class D barrier design for the ROM & Product Stockpiles. Tailings will be backfilled into the open pits and no surface tailings facilities are planned.

## 8.2 Barrier Design - PC Dam

The PC Dam must comply with the waste classifications and requirements of SANS 10234. The PC Dam was designed to a Class C Landfill barrier system, details of which are shown below in **Figure 9**.

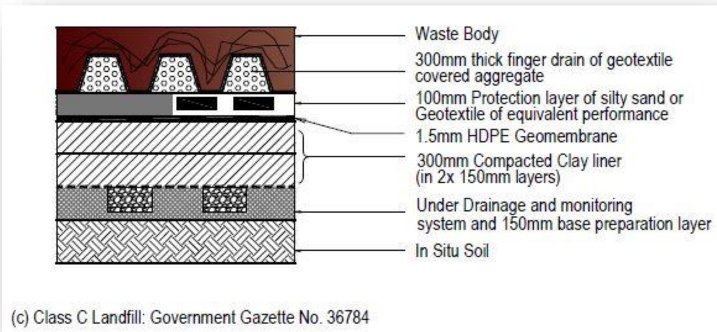


**Figure 9: Class C Landfill (Barrier Design - GN36784)**

An alternative design that can be considered if there is no readily available clay from the area is to adopt a Geo-Synthetic Equivalent design where the clay layers are substituted with a Geo-Synthetic Clay Liner (GCL) as shown below in **Figure 10**.

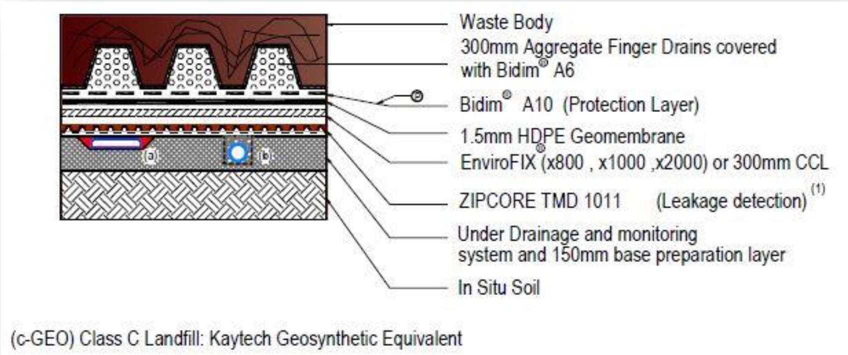


**Figure 10: Class C Landfill Barrier (Geo-Synthetic Equivalent)**

### 8.2.1 HDPE Liner for PC Dam

The Life of Mine (LOM) expectancy for Rietkol Mine is 20 years. The recommendation for the HDPE liner design is as follows:

- Side Walls exposed to sunlight:
  - Use textured HDPE lining material (1.5mm) which has a better friction when using Hyson cells.
  - The liner company will issue a warranty for the side-slope liner to match the life expectancy of the Mine (It is recommended that the warranty is issued for at least ±8 years).
  - Cleaning operations of the PC Dam will be limited to small rubber wheel machinery such as bob-cats. No track machinery is allowed.
- Bottom of PC Dam:
  - A special soilcrete layer (500mm thick layer of graded sand with ±6% cement) is proposed as a working platform during regular cleaning operations.
  - A bidim geomembrane (A8) will be used on top of the HDPE Liner as protection layer to the soilcrete working platform layer.

### 8.2.2 Geometric Design of the PC Dam/ Return Water Dam

The dam wall height is restricted to maximum 2m above the natural surface level. This was done to ensure that the wall embankment does not go above the 5m safety risk impoundment limitation. The natural topography of the area has a gentle slope in a North-Easterly direction.

This sloping terrain was used optimally to create both dams along the contours where the volume of the dam could be obtained by building the dam wall in a cut-to-fill operation. The side slopes for the PC Dam were limited to maximum 1:3 side slopes to ensure built in stability of the wall.

It is anticipated that, if a mixture of the material layers that underlie the site is compacted in layers 150mm in thickness at -1% + 2% of optimum moisture content, to a density greater than 95% Mod AASHTO, then a CBR value of at least 7 should be attainable, and it is anticipated that the material could be used in the proposed dam embankments.

The PC Dam/ Return Water Dam has been designed with a freeboard height of minimum 0.8m. A special overflow structure has been provided where this structure has been designed to accommodate at least a 1:100-year flood event.

### 8.2.3 Leakage Detection System

A special under drainage and monitoring system is proposed underneath either the clay layers or the Bentonite/ GCL liner system of the PC Dam where special detection drains will be built. The drains will be built along the sloped bottom floor of the PC Dam where 19mm crushed stone will be wrapped in A4 Bidim. Special drainage pipes M110 (Drainex or equivalent approved) will be placed in the 19mm crushed stone.

The leakage detection system is shown in **Dwg: RS-D-03** where each of the leakage drains are connected to one outfall pipe leading to a monitoring manhole outside the PC Dam footprint. Any leakage water will then collect in this manhole. The manhole will be equipped with a submersible pump which operates with floating switch valves. Dirty seepage water collected will be pumped back to the PC Dam. A red alarm light will signal to the operators that the liner has probably been damaged.

## 8.3 Barrier Design - ROM & Product Stockpiles

The waste classification for the ROM & Product stockpiles has been classified as a Type 4 waste with an associated Class D barrier design. The proposed barrier design for the ROM -and Product Stockpiles is shown below in **Figure 11**.

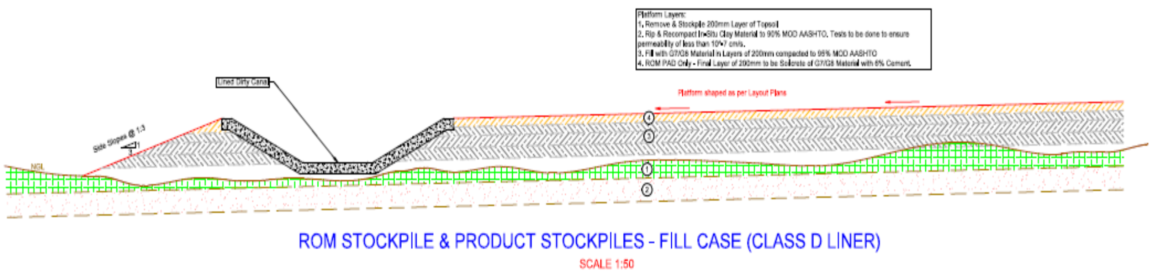


**Figure 11: Barrier Design - ROM & Product Stockpiles (Standard Class D)**

The Class D barrier design is shown in **Drw: RS-D-04** attached. This is a standard Class D barrier design.

The ROM and Product stockpiles have been identified as dirty water areas where the surface runoff from these stockpiles must be managed as part of the dirty water system of the Mine.

- The topsoil will be removed and stockpiled for later re-use as part of the overall rehabilitation.
- The in-situ material will be ripped and re-compacted to 90% MOD AASHTO Density.
- Final Fill with layers of selected G7/G8 material compacted to 93% MOD AASHTO density.
- For the ROM Pad, the final Layer will be constructed from a 200mm soilcrete layer (G7/G8) compacted to 95% MOD AASHTO density.
- The platforms will be sloped where we recommend a minimum of 1:200 cross fall across the platform.
- This sloped platform will divert impacted surface water to lined dirty water canals placed around the platform from where this is channeled to the PC Dam.


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## 8.4 Barrier Design - Topsoil Stockpiles & Return Water Dam

From the waste classification, the topsoil stockpiles are classified as a Type 4 waste with a Class D platform.

A typical Class D barrier design is shown below in **Figure 12**.

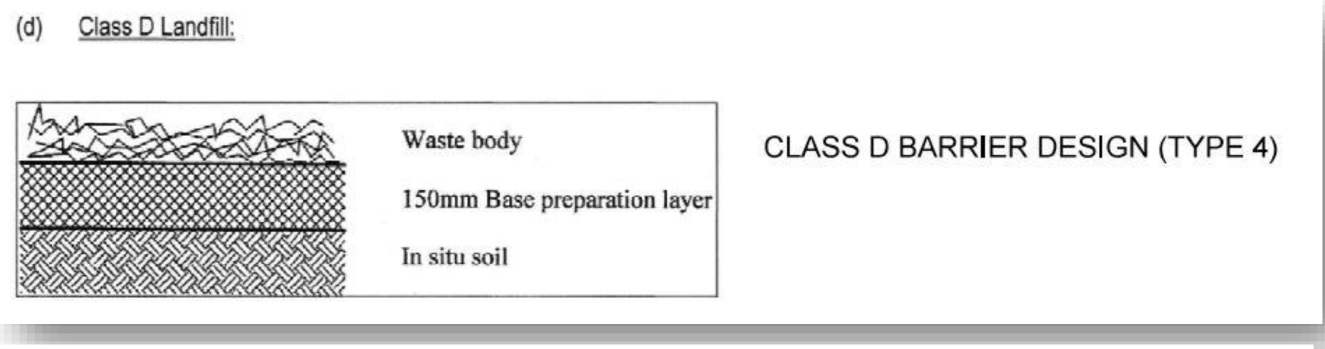


**Figure 12: Topsoil Stockpiles & Return Water Dam - Class D Platform**

The construction of the topsoil stockpiles will comprise of the following:

- The topsoil will be removed and stockpiled for later re-use as part of the overall rehabilitation.
- The in-situ material will be compacted to 90% MOD AASHTO Density.
- Placing of one-layer of 150mm thickness (G7/G8) material as Base Preparation Layer to construct the platform.
- It is recommended that this platform is shaped to ensure that the clean water from this platform is routed and managed as part of the Mine's clean water system.
- The surface –and seepage water can drain into the natural clean water drainage system of the Mine.

## 8.5 NEMWA Regulations 2013 – R636 Regulation 3

This section of the report deals specifically with the waste management licence application in terms of Regulation 2013 -R636.

The Department of Water Affairs & Sanitation (DWS) has issued an advisory document during July 2020; "Checklist for the Lead Authority (National or Provincial) in advance of document submission to commenting Authority". This document is used as a checklist when considering a waste management license application in terms of the specific requirements for a pollution control barrier technical report.

The following containment barrier requirements must be included in an application for a waste management licence:

a) Design reports and drawings that must be certified by a registered, professional civil engineer.
b) Service life considerations that must be quantified considering temperature effects on containment barriers.
c) Total solute seepage (inorganic and organic) that must be calculated in determining acceptable leakage rates and action leakage rates.

d) Alternative elements of proven equivalent performance which has been considered, such as the replacement of filters or drains with geosynthetic filters or drains, protective soil layers with geotextiles, or clay components with geomembranes or geosynthetic clay liners.
e) All drainage layers must contain drainage pipes of adequate size, spacing and strength to ensure atmospheric pressure within the drainage application for the service life of the landfill.
f) Alternative design layouts for slopes exceeding 1:4 (vertical: horizontal) may be considered provided equivalent performance is demonstrated.
g) Construction Quality Assurance during construction.
h) Geosynthetic materials must comply with relevant South African National Standard specifications, or any prescribed management practice or standards which ensure equivalent performance.
i) Consideration of the compatibility of liner material with the waste stream, in particular noting the compatibility of natural and modified clay soils exposed to waste containing salts.

These items will be addressed individually as part of this Construction Quality Assurance (CQA) in support of this waste management licence application.

## 8.6 DESIGN REPORT & DRAWINGS

The overall designs in support of this project are stipulated in the following documents:

- Design Report: "SWMP – Design Development Report in support of the Integrated WUL Application", dated June 2021.
- Complete set of signed-off design development drawings that are attached as Appendix B to the above report.

### 8.6.1 Professional Indemnity Cover

It is important to note that the design developments have been done to a detailed level based on the specialist studies that were conducted in support of this project. However, as a registered professional engineer with Professional Indemnity (PI) insurance, it is a requirement that additional tests and studies will be required prior to the project being implemented. This will be critical to ensure that the design developments provided herewith does in fact comply with the approved WUL that has been issued for the project.

We, therefore, take full liability for our designs so proposed and will ensure that the designs so developed for this project are implemented under our direct supervision and control to ensure compliance to the WUL & Waste licences issued by the Authorities. If OFC is not involved with the implementation phase, our PI insurance is automatically cancelled and DWS will be informed accordingly.

As-Built drawings will be issued confirming the final designs so implemented for the project.

## 8.7 Service Life Considerations

Regulation 3(2) specifically requires that the service life considerations must be quantified considering temperature effects on containment barriers.

### 8.7.1 Mining Schedule

The North Block will be mined for the first 3 years of LOM in a northernly direction.

The mined-out void created from the first box-cuts will be used to dump the tailings from the washing plant from about YR2 onwards. Tailings will be dumped in the North Block for the first 16 years of mining.

Once the North block has been mined out, mining in the Main Mining Block will commence in YR4, in a southernly direction up to YR20. The barrier between North Block and the Main Mining Block is 30m.

Various machinery and vehicles will be used in the pit and to transport the ROM to the crushing plant. The equipment includes excavators, front-end loaders, and ADT's.

Slimes will be pumped into the North Block and will form part of the rehabilitation process. As most of the material mined is processed and removed from site as product, backfilling of the Main Block to a free-draining state will not be possible. Therefore, the final rehabilitation plan allows for the backfilling of all the remaining material and building rubble into the pit area, sloping of the high-wall areas, and establishment of a recreational area within the Main Block final void area, as per the agreement with the stakeholders and authorities.

### 8.7.2 Pollution Plume & LOM Decant

Most of the potential pollution sources pose no real threat to the underlying aquifer in terms of impacts on groundwater quality. Both the target mineral and host rock that will be processed in the plant and then stockpiled/dumped are chemically inert and will therefore not react with oxygen and water to create poor quality leachate (such as acid mine/rock drainage). (Groundwater Complete, 2021).

The dolomitic aquifer scored a groundwater vulnerability rating of 9 and is therefore regarded as being highly vulnerable. The sensitive dolomitic aquifer will not be intersected by the proposed opencast pits. There will be a ± 90 to 300 meters buffer, or low transmissivity quartzite between the pits and surrounding dolomite. The quartzite deposit in its entirety is expected to act as a buffer between the proposed mining activities and the surrounding and underlying dolomite. (Groundwater Complete, 2021).

### 8.7.3 Service Life Period of Materials used in Barrier Design

It can therefore be concluded that the PC Dam, ROM and Product stockpiles and workshop buildings will have a service life period of maximum twenty (20) years after which, these will be demolished and rehabilitated.

The following is therefore confirmed:

- LOM projected at 20-years.
- Operating period of the waste disposal (maximum 20-years).
- The anticipated leachate temperatures for the PC Dam are estimated at 10°C - 25°C, depending on the seasonal temperatures.
- Total tensile strain in the geomembrane (percentage): This is estimated at ±1.8% of the allowable tensile yield elongation (12% for 1.5mm HDPE) which is made up of installation strain, a settlement component and some point load effects. Technical data for the HDPE liner is attached in the Construction Quality Assurance (CQA) Report attached as **Appendix C** to this report.

- Service life of the drainage system is estimated at maximum 20-years.
- Service life of other materials: The standard Class C barrier design is the recommended option for the PC Dam. Should clay not be readily available, it is recommended that the alternative Class C (GCL or double HDPE) barrier design is proposed. The service life of the HDPE and GCL complies with maximum 20-years LOM expectancy.

## 8.8 Leakage Rates Anticipated

The total solute transport/ seepage through the barrier system is calculated, using the Rowe formula (adapted from 1998), as shown below in the Schematic Diagram in **Figure 13**.

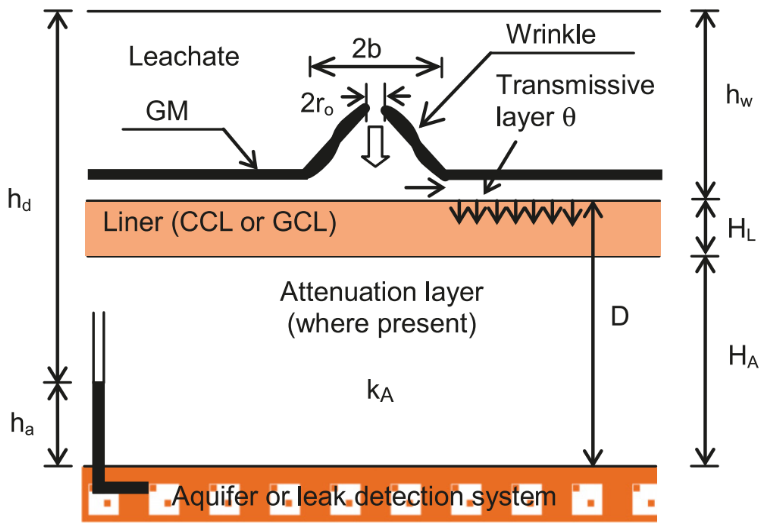


**Figure 13: Rowe 2012 Leakage Formula - Through a wrinkle of Length (L) and Width (2b) with a Hole of radius ($r_0$)**

The formula is as follows:

$$Q = 2L[kb + (kD\theta)^{0.5}]h_d/D$$

### 8.8.1 PC Dam

The leakage calculated through the Class C PC Dam is as follows:

- Standard Class C Barrier (300mm CCL + 1.5mm HDPE Geomembrane): 172.46 L/day
- Standard Class C Barrier (10mm GCL + 1.5mm HDPE Geomembrane): 143.57 L/day

The leakage calculation for the pc Dam barrier design is attached as **Appendix D**.

## 8.9 ALTERNATIVE ELEMENTS OF PROVEN EQUIVALENT PERFORMANCE

Regulation 3(2) requires alternative elements to be proven where this has been considered as part of the design, such as the replacement of:

### 8.9.1 Granular Filters or Drains replaced with Geosynthetic Filters or Drains.

Our designs do not incorporate geosynthetic filters. Our designs allow for granular filter material used in the seepage drains where 19mm crushed stone is wrapped within an A4 bidim geotextile. An M110 drainex perforated drainage pipe is installed to allow for the drainage to the following:

PC Dam: Seepage drains used as leakage detection underneath the HDPE barrier design reports to the monitoring manhole.

ROM & Product Stockpiles: Sloped Class D platform provides barrier to the dirty water canals. No seepage drains are installed.

### 8.9.2 Protective Soil Layers with Geotextile

For the PC Dam HDPE liner, the following protection layers are provided in the designs:

PC Dam Floor Basin: A 100mm protection layer of graded sand is proposed to protect the HDPE liner when installing the soilcrete ballast as a workable platform in the PC Dam.

PC Dam Side Walls: As an alternative to the sand layer, it is recommended to use A8 Bidim against the side slopes for the protection of the HDPE liner with Hyson cells for temperature impacts.

Both these designs are part of the standard Class C barrier design.

### 8.9.3 Clay Components with Geomembranes or Geosynthetic Clay Liners

The following barrier designs are proposed for the various waste management activities:

PC Dam: The standard Class C barrier design is proposed where 2 x clay layers (150mm thickness each) is covered by an HDPE geomembrane. If suitable quality clay material is not available, the alternative Class C barrier design using a Geosynthetic Clay Liner (GCL) is being proposed. This GCL will then replace the 2 x clay layers. A further alternative that has been investigated is to use a double HDPE liner material to replace the GCL. The motivations for these alternatives have all been investigated as a suitable Class C barrier design.

The appropriate Class C barrier design will be confirmed when the project is put out on tender.

## 8.10 Atmospheric Pressures within Drainage System

The draining seepage pipes are linked to daylight exits where the seepage water discharges into the monitoring manhole adjacent to the PC Dam. The leakage detection comprising of a herringbone draining system below the HDPE liner is shown on drawing **RS-L-01**.

Special bidim material is used to prevent the clogging of the drainage system that comprise of the graded stone wrapped in the A4 bidim geotextile with the perforated draining pipe inside. No build-up of internal water is anticipated where the seepage drains will immediately drain away seepage water collected.

## 8.11 Alternative barrier design on slopes steeper than 1:4

The only sloped barrier design relates to the PC Dam. The standard Class C barrier design is proposed where this is based on the 2 x clay layers with the associated HDPE liner. Two alternatives have been investigated where clay material is not readily available from the box cut operations. The option to either use an approved GCL or the double HDPE liner system is then recommended.

## 8.12 Construction Quality Assurance (CQA) Report

The Construction Quality Assurance (CQA) Report covers the following aspects of this Rietkol project:

- Site Actions during Construction
- Quality Records during Construction
- Construction Quality Assurance i.t.o:
    - Earthworks
    - Drainage Aggregate
    - Geotextile (Bidim)
    - Geomembrane (HDPE Liners)
    - Geosynthetic Clay Liners (GCL)
    - Cuspated Leakage Detection
- Construction Quality Control (CQC) Plan

The detailed Construction Quality Assurance (CQA) Report is attached as **Appendix C**.

## 8.13 Checklist for Waste Management Licence

DWS has issued a checklist during July 2020 to confirm the readiness when a waste management licence application is being made in terms of the pollution control barrier design. This completed checklist is attached as **Appendix E**.

## 8.14 Activity Method Statements

Various Activity Method Statements have been prepared for the Rietkol Mine. This relates to site specific Construction Quality Assurance (CQA) requirements that have been compiled where a step-by-step method statements is given how best the environmental impacts will be managed or prevented during the construction stage.

These method statements form part of a declaration where the responsible Design Engineer, the Employers Environmental Manager as well as the contracting party undertake to comply with the conditions of the Environmental Method Statements.

The following Environmental Method Statements are included:

- PC Dam, Return Water Dam & Overflow Structures
- In-Line Silt Traps
- ROM & Product Stockpiles

These method statements are attached as **Appendix F**.

## 8.15 SA National Standards

The project will be implemented using the South African National Standards (SANS 1200) series for typical civil projects. These specifications apply to typical civil construction activities and will be implemented using specific project specifications.

The HDPE liner is a critical component of the project and the following specifications are included to manage the quality -and installation of the liner:

- SANS 1526-2015 – Thermoplastic sheeting for use as geomembranes. This standard covers the requirements for thermoplastics sheeting for use as Geomembranes. This relates to the Manufacturing Quality Control (MQC) and Manufacturing Quality Assurance (MQA) to ensure that the materials were constructed as specified. This includes amendments to the GRI – GM13 document.
- SANS 10409-2005 – Design, selection and installation of geomembranes. This standard addresses the minimum measures that shall be incorporated by the installation contractor in his Construction Quality Control (CQC) plan to ensure the quality of workmanship and the integrity of the geomembrane liners during the installation phase. It also provides measures for the Engineer to assess if the installation and civils contractors follow the drawings and specifications in terms of the Construction Quality Assurance (CQA). This relates to inspections, verifications, audits and evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility.
- Geosynthetic Research Institute (GRI) – Test Method GM13 for Test methods, test properties and testing frequencies for HDPE smooth and textured geomembranes.
- Geosynthetic Research Institute (GRI) – GM19b Standard Specifications for the "Seam Strength and related properties of Thermal Bonded Reinforced Polyolefin Geomembranes/ Barriers".
- Geosynthetic Research Institute (GRI) – GCL3 Specification for Geosynthetic Clay Liners (GCL's). This specification gives standards for Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs).
- Geosynthetic Research Institute (GRI) – Test Methods GT12(b) ISO Version. This specification gives standards for Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials.
- Geosynthetic Research Institute (GRI) – GN2 standard for the Joining and Attaching Geonets and Drainage Composites.

# 9. DECLARATION OF INDEPENDENCE

Onno Fortuin Consulting (Pty) Ltd (OFC) was appointed to develop a Surface Water Management Plan (SWMP) in support of an Integrated Water Use Licence Application (IWULA). OFC performed the work relating to this application in an objective manner, even if this resulted in views and findings that are not favourable to the Applicant.

The design developments in support of this SWMP for the Mine are covered by our Professional Indemnity (PI) Insurance, being a direct requirement from DWS. OFC must therefore be involved with the implementation of the SWMP measures so recommended in support of this WUL application to ensure that our PI Insurance covers the parties impacted. The parties directly covered by this PI Insurance are the Mine, the Environmental Assessment Practitioner (EAP), OFC and the Authorities (DWS) who act in a legal capacity.

However, should OFC not be involved with the implementation phase of the SWMP design developments undertaken in this report, the OFC PI Insurance is automatically cancelled. The design developments, and drawings in support of this WUL application are therefore automatically cancelled. As a registered Professional Engineering company, OFC must then advise the DWS in writing of this impact where OFC can be held liable if it, knowingly, did not warn the DWS that the PI Insurance for the WUL application has been suspended.

We hereby declare that OFC has the expertise to conduct this specialist investigation relevant to this application and did not engage in conflicting interests in the undertaking of this study.

## Report Compiled By:

If any additional information is required, please feel free to contact the undersigned.

**H O Fortuin (Pr Eng)**
**Reg. No: #900166**
**DIRECTOR**

**Robert Fortuin (B Eng – Civil)**

# APPENDIX A – GEOTECHNICAL INVESTIGATION

**REPORT ON A GEOTECHNICAL INVESTIGATION AS PART OF THE DESIGN DEVELOPMENT TO PROVIDE INFORMATION REGARDING SUB-SURFACE CONDITIONS UNDERLYING THE PROPOSED SITE OF THE RIETKOL POLLUTION CONTROL DAM, NEAR DELMAS, MPUMALANGA PROVINCE**

**D G Purnell**
**Engineering Geologist**

**Project No.: 7058-JD**
**Report No. : DGP7058-01**

JD GEOTECHNICAL SERVICES CC

**JUNE 2021**

**Title** : **Report on a geotechnical investigation as part of the design development to provide information regarding sub-surface conditions underlying the proposed site of the Rietkol pollution control dam, near Delmas, Mpumalanga Province**

**Prepared by** : *J D Geotechnical Services CC*
*P O Box 2862*
*FAERIE GLEN 0043*

*Tel: 083 234 9023* *Email: dave.geotech@gmail.com*

**Client** : *Onno Fortuin Consulting (Pty) Ltd*
*28 Carrington Way*
*Belgravia*
*KIMBERLEY 8300*

*Tel: +27(0)53 831 1675* *Email: onno@consultme2.co.za*

**Keywords** : *Rietkol, geotechnical, pollution control dam, silty sandstone, ferricrete hardpan*

**Project No.** : *7058-JD*

**Report No.** : *DGP7058-01*

**Project Team** : *DG Purnell Pr.Sci.Nat.*

**Date** : *June 2021*

**Compiled by** : *DG Purnell Pr.Sci.Nat.*

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**Approved**

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*DG Purnell* *Pr.Sci.Nat.*

**REPORT ON A GEOTECHNICAL INVESTIGATION AS PART OF THE DESIGN DEVELOPMENT TO PROVIDE INFORMATION REGARDING SUB-SURFACE CONDITIONS UNDERLYING THE PROPOSED SITE OF THE RIETKOL POLLUTION CONTROL DAM, NEAR DELMAS, MPUMALANGA PROVINCE**

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## DISCLAIMER

- This document has been prepared as part of the Design Development to provide information regarding sub-surface conditions prevailing on the site at the time of the field work and in the context of the limitations and extent of the field work and samples taken of the materials at the time. The investigation does not include any infrastructure or developments on the site, unless expressly stated in the report.

- The investigation is done with a specific purpose in mind as described in the scope of work. Should the purpose or context be changed, no responsibility is accepted for interpretations beyond the original intentions.

- No responsibility is accepted for the coverage and representativeness of soil samples of all the possible conditions prevailing on the site under investigation nor for the accuracy of laboratory tests conducted on soil samples taken during the investigation, or of in situ tests conducted by other parties or that were previously conducted on the site.

- Any opinion expressed or implied is of a preliminary nature. No responsibility is accepted for the use of this document, in whole or in part, in other contexts or for any other purpose.

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- It is also recognised that information, laws, regulations and/or conditions may change over time as this may influence the context and validity of this document.

- Variations in conditions may occur, and there may be conditions which have not been exposed by the investigation and which have therefore not been taken into account. Additional investigations and actions may consequently be required.

- No warranty is provided, either express or implied, that the actual conditions will conform exactly to the information contained within this document.

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***REPORT ON A GEOTECHNICAL INVESTIGATION AS PART OF THE DESIGN DEVELOPMENT TO PROVIDE INFORMATION REGARDING SUB-SURFACE CONDITIONS UNDERLYING THE PROPOSED SITE OF THE RIETKOL POLLUTION CONTROL DAM, NEAR DELMAS, MPUMALANGA PROVINCE***

## *EXECUTIVE SUMMARY*


- *Onno Fortuin Consulting appointed JD Geotechnical Services CC to conduct a geotechnical investigation as part of the design development to provide information regarding the sub-surface conditions underlying the proposed site of the Rietkol pollution control dam near Delmas, Mpumalanga Province.*

- *This report presents the findings of the investigation.*

- *According to the published 1:250 000 scale East Rand geological map, the site is in close proximity to the contact between rocks of sedimentary origin (shale, mudstone or sandstone) of the Vryheid Formation, Ecca Group, Karoo Supergroup, and dolomite of the Malmani Subgroup, Chuniespoort Group, Transvaal Supergroup. This indicates that, should the site be immediately underlain by rocks of the Vryheid Formation, they would, in turn, probably be underlain at depth by dolomite.*

  *The indications from the present geotechnical investigation are that the site is immediately underlain by silty sandstone of the Vryheid Formation.*

- *The indications from the investigation are that, from a geotechnical viewpoint, the site is suitable for the proposed development, providing the recommendations that are given in this report are followed.*

- *The primary purpose of the investigation was to assess the geotechnical conditions that directly underlie the proposed Pollution Control Dam site. These have been discussed in detail in **Section 8**; it is recommended that reference should be made to that discussion*

  *In brief:*

- *The test-pitting investigation indicated that the site could be subdivided into two areas on the basis of the geotechnical conditions that were encountered, the areas being referred to as **Areas A** and **B**. The locations of the areas are indicated on a plan in **Appendix D**, and the generalied soil profiles that underlie each area have been described in **Section 7.***

- *The Pollution Control Dam site is covered by transported, very loose to medium dense silty sands in the order of 0,5m in thickness which generally have an estimated bearing capacity in the order of 30kPa. These materials are underlain by residual silty sandstone in the form of a medium dense to dense clayey sand, which generally has an estimated bearing capacity in the order of 80kPa to 100kPa. With depth the residual silty sandstone becomes very dense and is sometimes ferruginised, causing backactor refusal at depths ranging from 0,75m to 1,0m in **Area A**, and 1,45m to 2,2m in **Area B.***

- *Regarding **excavatability**, it is anticipated that it should generally be possible to excavate to a depth of at least 3,0m beneath the site providing use is made of large excavating equipment equipped with ripper teeth. However, it is possible that **silty sandstone rock** could be encountered with depth, and it would therefore be advisable to make provision for the possible use of power tools and/or explosives in the deeper parts of the excavation.*

- *The sides of excavations may tend to be unstable, and should either be shored or else battered back.*

- *As regards the probable **permeability** of the materials that underlie the site, the test-pitting investigation did not indicate the presence of clay that could have a low permeability. The materials that were encountered were generally clayey sands, having a Unified Soil (US) classification of SC; such materials characteristically have permeabilities in the order of $10^{-5}$ cm/sec, which indicates that the soils should probably be slightly permeable.*

- *It should be noted that the indications of the laboratory test results on representative samples taken from the soil profile underlying the site indicate that, according to the COLTO classification, the materials are slightly poorer than G9 in quality. As discussed in **Section 8** it is anticipated that, if a mixture of the material layers that underlie the site is compacted in layers 150mm in thickness at -1% + 2% of optimum moisture content, to a density greater than 95% Mod AASHTO, then a CBR value of at least 7 should be attainable, and it is anticipated that the material could be used in the proposed dam embankments. This would need to be confirmed by laboratory testing of representative samples of the mixed material during the construction phase.*

- ***Seepage** of groundwater did not occur in any of the test pits that were dug on the site, which were dug to depths ranging from 0,75m to 2,2m. It should be borne in mind that the investigation took place during the dry season (May 2021), and it is possible that seepage could take place at shallower depths during the rainy season. It is therefore recommended that provision should be made for the removal of groundwater from excavations.*

- *pH and conductivity tests carried out on representative samples of the materials underlying the site indicate that the materials should be neutral and should have a low corrosivity as regards underground services.*

# REPORT ON A GEOTECHNICAL INVESTIGATION AS PART OF THE DESIGN DEVELOPMENT TO PROVIDE INFORMATION REGARDING SUB-SURFACE CONDITIONS UNDERLYING THE PROPOSED SITE OF THE RIETKOL POLLUTION CONTROL DAM, NEAR DELMAS, MPUMALANGA PROVINCE

## 1. TERMS OF REFERENCE

Onno Fortuin Consulting appointed JD Geotechnical Services CC to conduct a geotechnical investigation as part of the design development to provide information regarding the sub-surface conditions underlying the proposed site of the Rietkol pollution control dam near Delmas, Mpumalanga Province.

This report presents the findings of the investigation.

## 2. PURPOSE OF THE INVESTIGATION

**2.1** To determine the geological origin of the material on the site.

**2.2** To determine the engineering properties of the different material layers.

**2.3** To assess the geotechnical conditions and material properties that directly underlie the proposed pollution control dam site.

## 3. THE SITE

The proposed site is in the order of 0,5ha in area, and is situated approximately 7km to the north-west of the Delmas CBD, the locality of the site being indicated on a **Locality Plan** in **Appendix D**.

The vegetation cover of the site is veldt grass, with occasional bluegum trees up to 20m in height. The highest point of the site is at the south-western corner, which has an elevation in the order of 1595m above mean sea level (AMSL), and the lowest pont is at the north-eastern corner that has an elevation in the order of 1592m AMSL.The site drains gently towards the east with a slope in the order of 3 per cent.

There are no structures on the site. An overhead electricity line runs in a north-east to south-west direction beyond, and parallel to, the south-eastern boundary of the site.

## 4. REGIONAL GEOLOGY, SEISMICITY AND GROUNDWATER

### 4.1 <u>Regional geology</u>

According to the published 1:250 000 scale East Rand geological map, the site is in close proximity to the contact between rocks of sedimentary origin (shale, mudstone or sandstone) of the Vryheid Formation, Ecca Group, Karoo Supergroup, and dolomite of the Malmani Subgroup, Chuniespoort Group, Transvaal Supergroup. This indicates that, should the site be immediately underlain by rocks of the Vryheid Formation, they would, in turn, probably be underlain at depth by dolomite.

The indications from the present geotechnical investigation are that the site is immediately underlain by silty sandstone of the Vryheid Formation.

## 4.2 Seismicity

Kijko (2003)[10.9] indicates that a 10% probability exists that an earthquake with Peak *Ground* Acceleration (PGA) of 0.14g may take place once in 50 years. The following table indicates the Acceleration Response Spectra (ARS) of a *structure* during an earthquake.The table is based on a 10% probability of exceeding the 1, 3, 5 and 10 Hz *spectra*l accelerations at least once in 50 years.

| Spectral Acceleration (Hz) | Spectral Acceleration (g) |
|---|---|
| 1 | 0.50 |
| 3 | 0.36 |
| 5 | 0.22 |
| 10 | 0.18 |

It must be borne in mind that the seismic information from Kijko is **generalised** information, and should not be used for design purposes. For design purposes a site specific investigation may be required.

## 4.3 Groundwater Conditions

### 4.3.1 Perched groundwater

Groundwater seepage did not occur in any of the 9 test pits that were dug during the investigation, the test pits being dug to depths ranging from 0,75m to 2,2m.

It should be borne in mind that the present investigation took place during the dry season (May 2021), and that the level of the groundwater table could rise during the rainy season, particularly during periods of heavy rainfall.

### 4.3.2 Permanent groundwater

Vegter[10.10] indicates the probability for drilling successfully for water in the area to be greater than 60% and the probability that such a borehole will yield more than 2 l/s to be greater than 50%. Groundwater is expected to occur at depths between 20m and 30m in openings varying in size from fissures to caves extensively developed: also pores in dissolution residuum and collapsed unconsolidated deposits.

## 5. CLIMATE

The site falls within the Moist Highveld Grassland climatic region. The climate for this region is described as having summer rainfall with dry winters.

The rainy season is from October to April. The wettest month is generally January, with rainfall in the order of 120 mm, the yearly rainfall being in the order of 700 mm. The hottest month is January and the coldest month June, with average maximum temperatures of 26°C and 19°C respectively.

The Weinert N-value for the area is in the order of 2,4 which indicates that predominantly chemical weathering of the underlying bedrock has probably taken place.

## 6. METHOD OF INVESTIGATION

### 6.1 Test-pitting investigation

Nine test pits were dug on the site, in a grid pattern with a spacing in the order of 30m to 40m by means of a Cat 428B backactor. The test pits were dug to refusal, the depths ranging from 0,75m to 2,2m, and were fully profiled by a registered Engineering Geologist according to the standard method of Jennings et al[10.2].

The bearing capacity of each layer was estimated, and disturbed samples of representative materials were taken in order to determine their physical properties by means of laboratory testing.

### 6.2 General

The material properties are summarised in **Table 1** and the hand-held GPS coordinates of the test pit positions are recorded in **Table 2**, The tables are at the back of the report after **Section 10**.

The laboratory test results, test pit profiles, photograph album and site plan with test pit positions are included in the **Appendices** to this report.

## 7. GENERALISED SOIL PROFILES

The test-pitting investigation indicated that the site could be subdivided into two areas on the basis of the geotechnical conditions that were encountered. The two areas will henceforth in this report be referred to as **Areas A** and **B**, the locations of the areas being indicated on a plan in **Appendix D.** The soil profiles for each area will be described in turn:

### 7.1 Area A (TLB refusal at 1m or less)

The soil profiles that were encountered in **Area A** were reasonably similar. The generalised soil profile that underlies **Area A** is as follows:

0,0 – 0,5m Slightly moist to very moist, dark brownish-grey, loose to medium dense, fine to medium grained silty SAND
Transported
P = 30kPa Heave class = Low

0,5 – 0,8m Slightly moist to very moist, light grey blotched dark yellow-orange, medium dense to dense, fine to medium grained clayey SAND
Residual silty sandstone
P = 80kPa to 100kPa Heave class = Low or Low/Medium

0,8 – 0,9m Dark yellow-orange blotched light grey, very dense, cemented, ferricrete HARDPAN
Pedogenic
P = 450kPa Heave class = Low

Where P is the estimated bearing capacity of the layer, taking into account the soil structure and the possibility of future inundation.

Refusal of a Cat 428B backactor took place in all of the five test pits that were dug in **Area A**, generally on ferricrete hardpan, at depths ranging from 0,75m to 1,0m.

## 7.2 Area B (TLB refusal deeper than 1m)

The soil profiles that were encountered in **Area B** were reasonably similar. The generalised soil profile that underlies **Area B** is as follows:

0,0 – 0,6m Slightly moist to very moist, brownish-grey, loose to very loose, fine to medium grained silty SAND
Transported
P < 20kPa to 30kPa Heave class = Low

0,6 – 1,6m Very moist, light grey blotched yellow-orange, medium dense to dense, fine to medium grained clayey SAND
Residual silty sandstone
P = 80kPa to 100kPa Heave class = Low or Low/Medium

1,6 - 1,7m Either:

Very moist, light grey mottled yellow-orange, very dense, fine to medium grained clayey SAND
Residual silty sandstone
P = 300kPa Heave class = Low or Low/Medium

Or:

Dark yellow-orange blotched light grey, very dense, cemented, ferricrete HARDPAN
Pedogenic
P = 450kPa Heave class = Low

Where P is the estimated bearing capacity of the layer, taking into account the soil structure and the possibility of future inundation.

Refusal of a Cat 428B backactor took place in all of the four test pits that were dug in **Area B** at depths ranging from 1,45m to 2,2m, either on residual silty sandstone in the form of a very dense clayey sand, or else upon ferricrete hardpan.

## 7.3 General

Groundwater seepage did not take place in any of the nine test pits that were dug on the site, although it should be borne in mind that the investigation took place during the dry season (May 2021).

## 8 DISCUSSION

**8.1** As discussed in **Section 7**, the test-pitting investigation indicated that the site could be subdivided into two areas on the basis of the geotechnical conditions that were encountered, the areas being referred to as **Areas A** and **B**. The locations of the areas are indicated on a plan in **Appendix D**, and the generalied soil profiles that underlie each area have been described in **Section 7.**

The summaries of the generalised soil profiles are as follows:

### 8.2 Area A (TLB refusal at 1m or less)

| **Soil type** | **Depth (m)** | **Origin** | **Estimated bearing capacity (kPa)** | **Heave class** |
|---|---|---|---|---|
| Brownish-grey, loose to medium dense, silty sand | 0,0 – 0,5 | Transported | 30 | Low |
| Light grey, medium dense to dense, clayey sand | 0,5 – 0,8 | Residual silty sandstone | 80 to 100 | Low or Low/Medium |
| Dark yellow-orange, ferricrete hardpan | 0,8 – 0,9 | Pedogenic | 450 | Low |

### 8.3 Area B (TLB refusal deeper than 1m)

| **Soil type** | **Depth (m)** | **Origin** | **Estimated bearing capacity (kPa)** | **Heave class** |
|---|---|---|---|---|
| Brownish-grey, loose to very loose, silty sand | 0,0 – 0,6 | Transported | <20 to 30 | Low |
| Light grey, medium dense to dense, clayey sand | 0,6 – 1,6 | Residual silty sandstone | 80 to 100 | Low or Low/Medium |
| Either ;<br>Light grey, very dense, clayey sand<br>or:<br>Dark yellow-orange, ferricrete hardpan | 1,6 – 1,7<br><br>1,6 – 1,7 | Residual silty sandstone<br><br>Pedogenic | 300<br><br>450 | Low or Low/Medium<br><br>Low |

**8.4** As can be seen from the above summaries, potentially collapsible materials were not encountered during the test-pitting investigation. However, according to the Van der Merwe method[10.4] the heave classification of the residual silty sandstone was sometimes slightly active. Therefore, although collapse settlement of the materials under load is not anticipated for the site, slight heaving or shrinkage of the residual materials may possibly occur.

**8.5** It is understood that the pollution control dam will be lined, that the dam volume will be approximately 6 000m$^3$ , that the maximum embankment height will be in the order of 3m at the downstream end of the dam, that the maximum water depth in the dam will be 2m, and that the freeboard will be 0,8m. The cut depth at the downslope part of the dam floor will be in the order of 2m, which will increase progressively upslope to be in the order of 3m at the upslope part of the dam.floor.

**8.6** Refusal of a Cat 428B backactor took place in all of the nine test pits that were dug on the site, either on ferricrete hardpan or else upon residual silty sandstone in the form of a very dense clayey sand, at depths ranging from 0,75m to 1,0m in **Area A**, which occurs in the downslope part of the site, and 1,45m to 2,2m in **Area B**, which occurs in the upslope part of the site. The maximum design depth of excavation for the PC dam is in the order of 3,0m, and it is anticipated that large earth-moving machinery equipped with ripper teeth should generally be capable of excavating to such a depth. However, it must be borne in mind that the possibility exists that silty sandstone rock could be encountered while excavating to the required level for the dam floor, and it would therefore be advisable to make provision for the possible use of power tools and/or explosives, particularly for the deeper parts of the floor excavation.

**8.7** Laboratory testing of representative samples indicates that the materials that occur in the upper 2m of the soil profile should have PIs ranging from non-plastic to 13, Grading Moduli ranging from 0,63 to 0,78, CBR values in the order of 6 at 93% Mod AASHTO compaction, and a COLTO classification poorer than G9 in quality. The materials underlying the site are predominantly clayey sands and silty sands. The gradings of the materials are rather fine; when wet the materials will become less trafficable.

**8.8** Regarding whether the materials that are to be excavated from the dam basin could be used in the dam embankments, the CBR values of the individual soil layers are rather low, but it is anticipated that mixing of the various layers that underlie the site should produce a higher consistency, particularly when mixed with the underlying ferricrete hardpan once that has been excavated. If such a mixture is compacted in layers 150mm in thickness at -1% to + 2% of optimum moisture content, to a density greater than 95% Mod AASHTO then it is anticipated that a CBR value of at least 7 should be attainable, and that the mixed material could be used in the proposed dam embankments.This would need to be confirmed by laboratory testing of representative samples of the mixed material during the construction phase.

**8.9** Safe side slopes would be determined by the liner design and by the geometry and drainage in soils in the embankment. Side slopes of 3 horizontal and 1 vertical should be stable, but this presupposes that subsoil drains woulld be installed to prevent seepage of water through the wall, and that any liner does not create a weak surface in the slope. The liner should not extend beneath the wall, since that could result in the formation of a weak interface forming between the subgrade and the dam wall.

## 9 CONCLUSIONS AND RECOMMENDATIONS

**9.1** The indications from the investigation are that, from a geotechnical viewpoint, the site is suitable for the proposed development, providing the recommendations that are given in this report are followed.

**9.2** The primary purpose of the investigation was to assess the geotechnical conditions that directly underlie the proposed Pollution Control Dam site. These have been discussed in detail in **Section 8**; it is recommended that reference should be made to that discussion

In brief:

- The test-pitting investigation indicated that the site could be subdivided into two areas on the basis of the geotechnical conditions that were encountered, the areas being referred to as **Areas A** and **B**. The locations of the areas are indicated on a plan in **Appendix D**, and the generalied soil profiles that underlie each area have been described in **Section 7.**

- The Pollution Control Dam site is covered by transported, very loose to medium dense silty sands in the order of 0,5m in thickness which generally have an estimated bearing capacity in the order of 30kPa. These materials are underlain by residual silty sandstone in the form of a medium dense to dense clayey sand, which generally has an estimated bearing capacity in the order of 80kPa to 100kPa. With depth the residual silty sandstone becomes very dense and is sometimes ferruginised, causing backactor refusal at depths ranging from 0,75m to 1,0m in **Area A**, and 1,45m to 2,2m in **Area B.**

- Regarding **excavatability**, it is anticipated that it should generally be possible to excavate to a depth of at least 3,0m beneath the site providing use is made of large excavating equipment equipped with ripper teeth. However, it is possible that **silty sandstone rock** could be encountered with depth, and it would therefore be advisable to make provision for the possible use of power tools and/or explosives in the deeper parts of the excavation.

- The sides of excavations may tend to be unstable, and should either be shored or else battered back.

- As regards the probable **permeability** of the materials that underlie the site, the test-pitting investigation did not indicate the presence of clay that could have a low permeability. The materials that were encountered were generally clayey sands, having a Unified Soil (US) classification of SC; such materials characteristically have permeabilities in the order of $10^{-5}$ cm/sec, which indicates that the soils should probably be slightly permeable.

- It should be noted that the indications of the laboratory test results on representative samples taken from the soil profile underlying the site indicate that, according to the COLTO classification, the materials are slightly poorer than G9 in quality. As discussed in **Section 8** it is anticipated that if a mixture of the material layers that underlie the site is compacted in layers 150mm in thickness at -1% + 2% of optimum moisture content, to a density greater than 95% Mod AASHTO, then a CBR value of at least 7 should be attainable, and it is anticipated that the material could be used in the proposed dam embankments. This would need to be confirmed by laboratory testing of representative samples of the mixed material during the construction phase.

- **Seepage** of groundwater did not occur in any of the test pits that were dug on the site, which were dug to depths ranging from 0,75m to 2,2m. It should be borne in mind that the investigation took place during the dry season (May 2021), and it is possible that seepage could take place at shallower depths during the rainy season. It is therefore recommended that provision should be made for the removal of groundwater from excavations.

- pH and conductivity tests carried out on representative samples of the materials underlying the site indicate that the materials should be neutral and should have a low corrosivity as regards underground services.

## 10. REFERENCES

10.1 Geological maps:

Number and title : East Rand
Scale : 1:250 000
Date of publication: 1986
Source : Government Printer

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