DUNBAR COAL MINE

Stormwater Management Plan

Revision 1

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Table of Contents

Figures

Tables

Appendices

1. Client and Project Details

The Company Details are listed blow, i.e.:

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The Project Details are listed blow, i.e.:

- PROJECT NAME:
  - Dunbar Coal Mine.

1.1 LOCATION AND BACKGROUND

The project is situated in the Mpumalanga Province, South Africa, approximately 18 km west of Hendrina. The project area is shown in **Figure 1-1**.

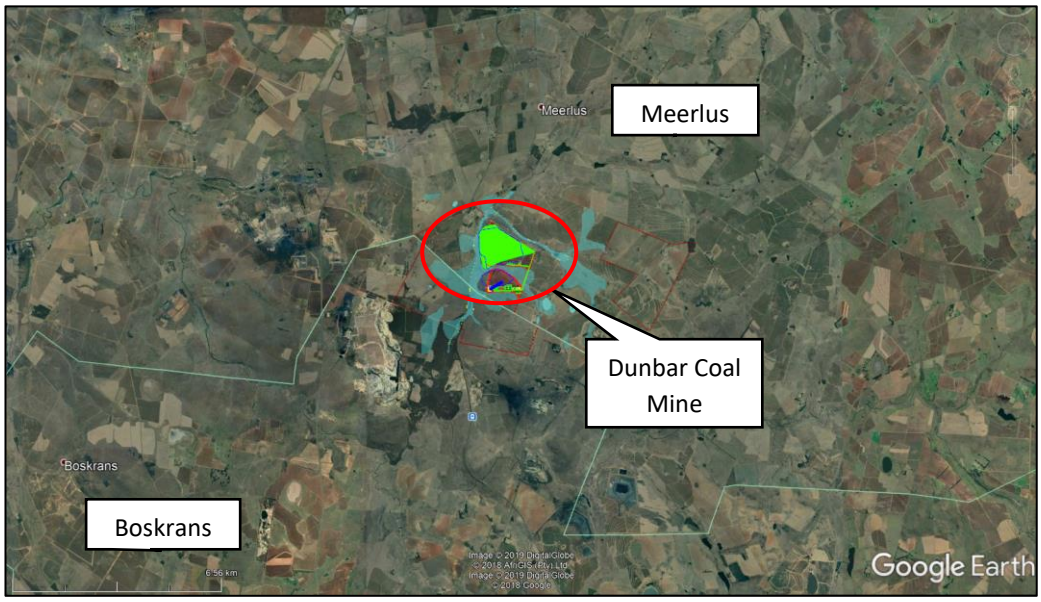

Figure 1-1: Project locality plan

The mining will be opencast, with the prospecting right area shown in **Figure 1-2**.

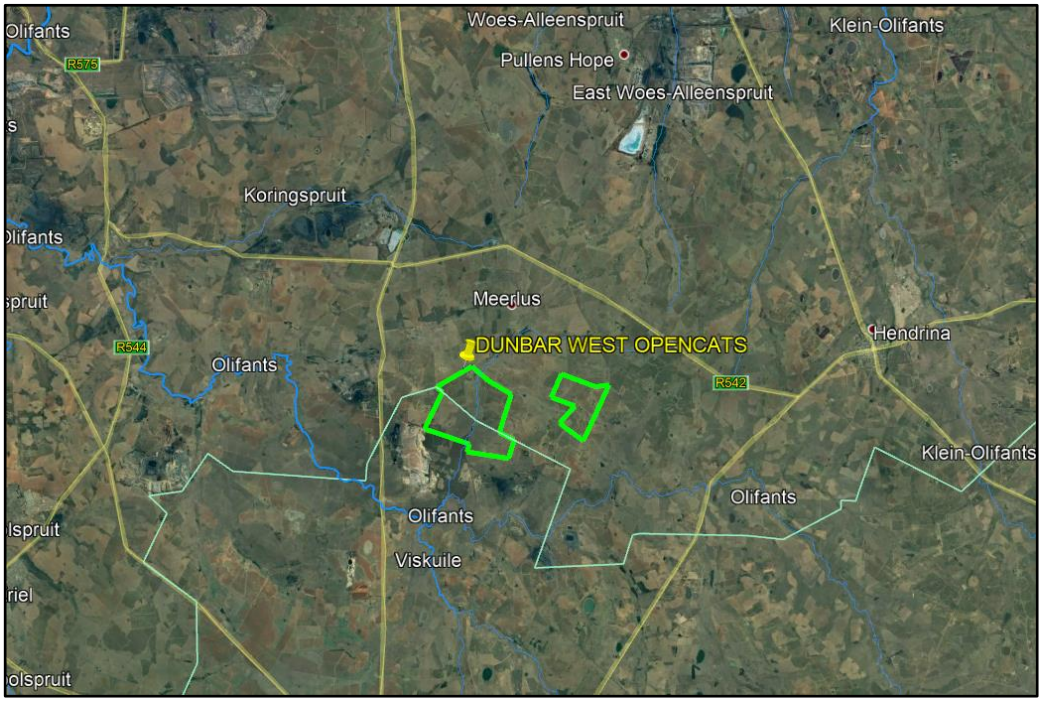

Figure 1-2: Dunbar Mine – Prospecting Right Areas.

1.2 DESIGN DRAWINGS

The design drawings are included in **Appendix A**.

2. STORMWATER MANAGEMENT

2.1 SITE DESCRIPTION

2.1.1 Topography

The proposed opencast mine consists of two areas named Dunbar West and East sloping towards the Olifants River valley with the ground elevations varying between approximately 1700 m to 1600 m.

The infrastructure is placed in two areas, as shown in **Figure 2-1**, i.e.

- Stormwater Area 1 – to the north, consisting of:
  - Office Area, ROM Stockpiles, Workshops, Process Plant area, overburden and waste stockpiles and product stockpiles.
  - This area is classified as **Dirty Water**.
- Stormwater Area 2 – to the south, consisting of:
  - Office Area.
  - This area is classified as **Clean Water**.

A PCD is designed for Area 1.

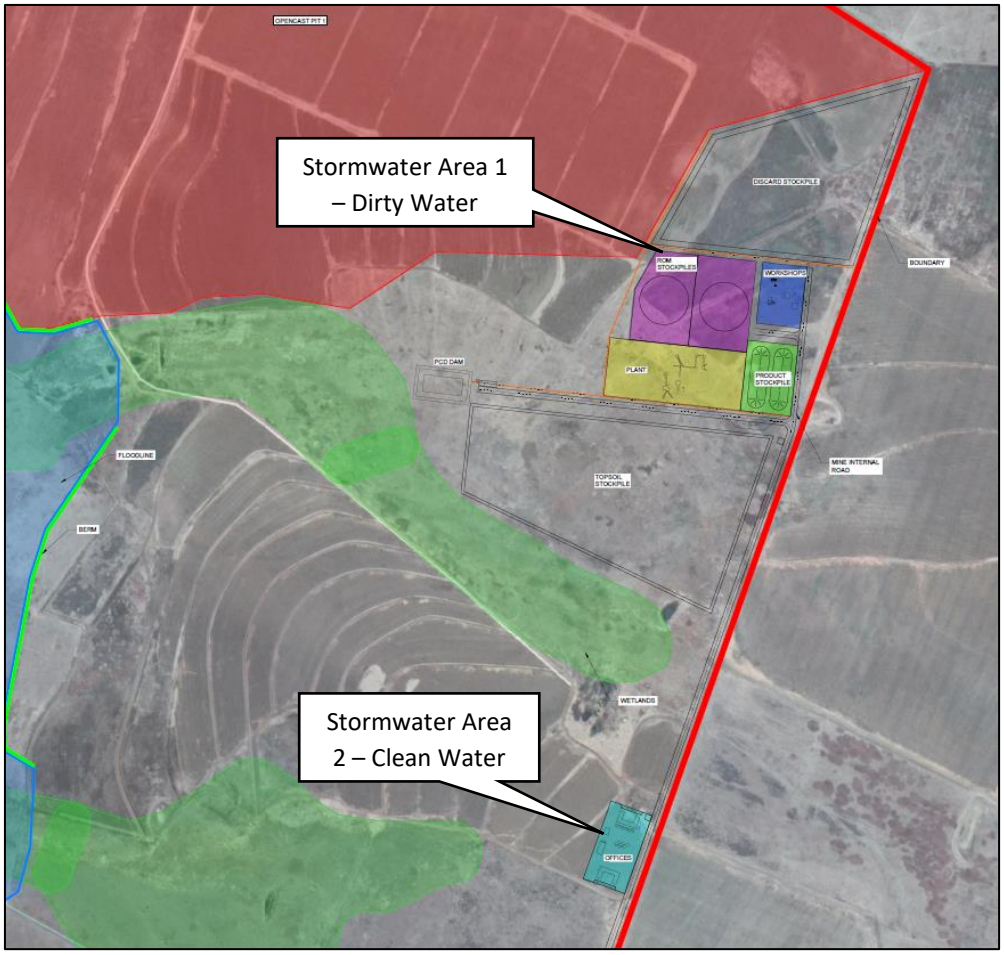

Figure 2-1: Stormwater Areas

2.1.2 Geology

The site area is underlain by sandstone, shale and coal seams of the Vryheid Formation of the Ecca Group, which forms part of the geological Karoo Supergroup. The Vryheid Formation comprises mainly of sandstone, shale and coal seams.

2.1.3 Climate

The general climate conditions of the project area are representative of the Highveld region of South Africa, characterised by a high intensity summer rainfall and a dry winter season as shown in **Figure 2-2**. Mean Annual Precipitation (MAP) is 704mm. The following rain stations' data were used:

Average temperatures range between 12 and 27°C, falling to a minimum of 2°C during the winter months.

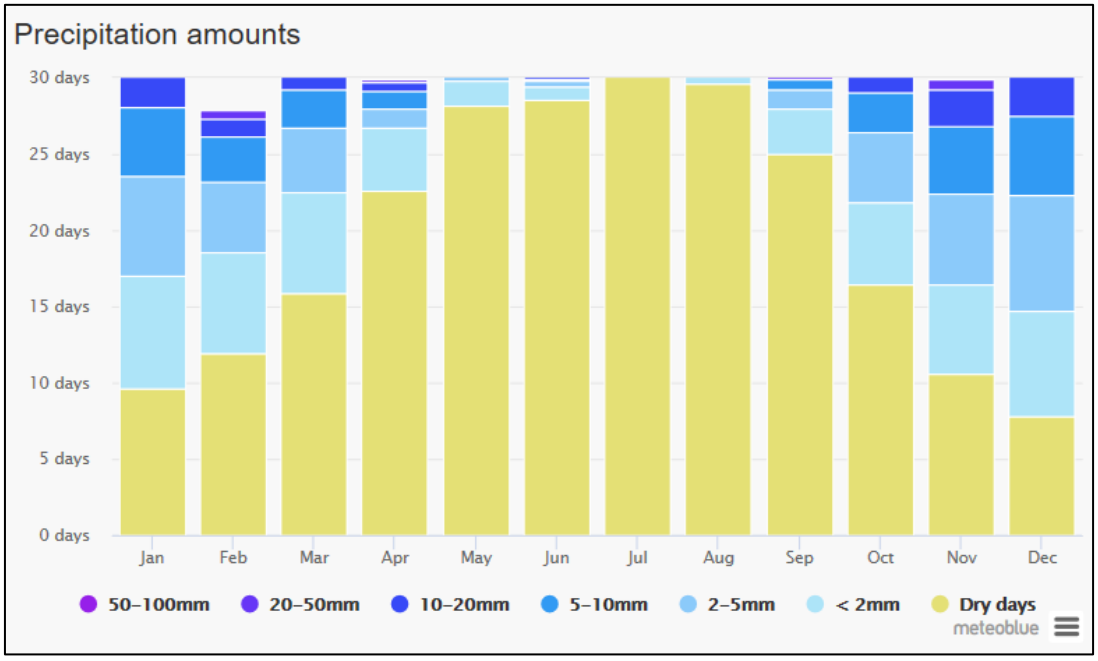

Figure 2-2: Precipitation

2.1.4 Surface Hydrology

The site falls within B11A Quaternary Catchment within the upper reaches of the Olifants River, forming part of Olifants Water Management Area. Dunbar West mining area is crossed Leeufonteinspruit and its smaller tributary. The area covered by the proposed Dunbar East mine is located on the elevated local high point, with no major water courses crossing this area.

2.2 STORMWATER MANAGEMENT PLAN METHODOLOGY

2.2.1 Regulations and Definitions

Regulation No. GN 77 (more commonly referred to as GN 704) of the National Water Act stipulates that to reduce the impact of mining activities on the environment, the watercourses that fall within a mine's footprint shall be separated into a 'clean' and 'dirty' water systems, the latter forming part of a closed system.

- **Dirty** water is defined as stormwater runoff from an area (or areas) where the water could have encountered a potential source of contamination, e.g. hydrocarbons. Water from such sources should be intercepted and stored in a pollution control dam (PCD) to form part of a closed system, whereby the water is recycled for use in mine operational processes.
- **Clean** is defined as stormwater runoff from areas which fall outside operational areas and are not contaminated by plant process. A mine's clean water management system should wherever possible, be separated from the closed dirty system if it is to be discharged into a natural watercourse.

The approach used to formulate the stormwater management plan strategy is based on the Best Practice Guideline G1 Stormwater Management as published by the South African Department of Water Affairs (DWA).

In term of Regulation 704 of the National Water Act (Act No. 36 of 1998), any person or company intending to operate a mine must comply with the requirements of this regulation to ensure conservation of South Africa's water resources. The design of the stormwater management system is based on the requirements of Regulation 704.

The relevant clauses, in terms of this stormwater management system, are listed below as well as the steps to be taken to ensure compliance (**Table 2-1**).

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Table 2-1 - Regulation 704 Requirements and Compliance

Clause	Requirement	Compliance
4. Restrictions on locality		
4(a)	No residue deposit, dam, reservoir and associated infrastructure must be located within the 1:100-year flood line or within 100m from any water course, estuary, borehole or well.	All water related infrastructure are positioned outside of these flood lines (as well as outside of the 100m requirement).
4(d)	No sanitary convenience, fuel depots, reservoir or depots that can cause pollution of a water resource must be located within the 1:50 year flood line of any watercourse.	The infrastructure is positioned to ensure compliance with this clause. The stormwater run-off from dirty water areas will be collected in the PCD from where it will be re-used.
5. Restrictions on use of material		
5	Material that is likely to cause pollution may not be used in the construction of any dam or other impoundment.	Selected engineering material will be specified for the construction of the PCD. The dam will furthermore be lined with an impervious HDPE lining (1.5mm), complete with 2 x 150mm clay layers, 100mm silty sand layer and 300mm dump rock – refer to the detail included in **Appendix A**.
6. Capacity requirements of clean and dirty water systems		
6(a)	Unpolluted water must be confined to a clean water system, away from a dirty water area.	The mine infrastructure area is classified as dirty and the stormwater will be conveyed to a PCD. Any unpolluted stormwater will be conveyed away from the infrastructure area by means of a combination of stormwater channels and cut-off berms.
6(b)	The clean water system must be designed, constructed, maintained and operated to ensure that the clean water does not spill into the	The mine infrastructure area is classified as dirty and the stormwater will be conveyed to a PCD. Any unpolluted stormwater will be conveyed away from

Clause	Requirement	Compliance
	dirty water areas for a flood recurrence of 1:50 years.	the infrastructure area by means of a combination of stormwater channels and cut-off berms.
6(c)	Water arising from a dirty area must be collected in a dirty water system.	The dirty stormwater water will be confined and conveyed to a PCD.
6(d)	The dirty water system must be designed, constructed, maintained and operated to ensure that the clean water does not spill into the dirty water areas for a flood recurrence of 1:50 years.	The stormwater infrastructure was designed to cater for a 1:50 year flood occurrence.
6(e)	The dirty water dam must have a freeboard of 800mm.	The PCD were designed with a freeboard of 800mm for a 1:50 year flood occurrence.
6(f)	The water systems must be designed, constructed and maintained to guarantee the serviceability of such conveyances for a 1:50 year flood occurrence.	The dirty water areas will be designed for a 1:50 year flood occurrence. Allowance will be made for maintenance and serviceability requirements.
7. Protection of water resources		
7(a)	Any water that is likely to cause pollution of a water resources must be prevented from entering a water resource.	The water collected in the dirty water areas will be conveyed to a PCD by means suitably lined channels. The PCD will be HDPE lined.
7(b)	All water systems and residue deposits must be designed, modified, located, constructed and maintained so as to prevent the pollution of any water resource through the operation or use thereof.	All dirty water reticulation systems will be adequately lined to ensure containment.

Clause	Requirement	Compliance
7(c)	The flow of any surface water or floodwater must be minimised into the opencast pit.	Cut-off berms will be constructed upstream to divert stormwater away from it.
7(d)	The mine's tailings storage facility must be designed, modified, constructed and maintained to ensure that water or waste therein will not cause the failure thereof.	N/A - No tailings facility.
7(e)	The erosion and leaching of the residue deposit must be prevented from entering and polluting any water course.	Dirty water from the waste stockpile will be conveyed to a PCD.
7(f)	Water used in any process or activity is recycled as far as possible.	The water balance system for the mine will be designed as a closed water system. The water from the dirty areas will be collected for re-use in a PCD.
7(g)	The water systems must be kept free from any matter or obstruction which may affect the efficiency.	The infrastructure will be designed to allow for easy access and maintenance.
7a.	All domestic waste (including wash water) must be disposed of in terms of an authorisation under the Act.	The sewage / effluent will be treated in i) a wastewater treatment work (to General Limits as per the NWA) and conveyed to the PCD for re-use or ii) septic tanks.
8. Security and additional measures		
8(a)	Any dam containing harmful substances must be effectively fenced-off.	Although the water collected in the PCD is not expected to be harmful, it is recommended that all dams be fenced-off to restrict access in terms of the MHSA.
8(b)	Access control is required for the stockpiling area.	The access routes to the stockpiling area will be classified as dangerous and

Clause	Requirement	Compliance
		specific inductions will be required to enter this area.
8(c)	The areas mentioned in 8(a) and 8(b) may only be used for its intended purpose.	The mine will operate and maintain these areas as per their intended purposes.

2.2.2 Stormwater Management Principles

The following basic principles form an integral part of the development of the stormwater management strategy for the proposed mine:

- Dirty and clean stormwater catchments shall be delineated and separated whereby clean stormwater runoff is diverted around plant operations/contaminated areas and into/towards natural water courses;
- Impacts on the existing groundwater resources, in terms of quality and quantity shall be minimised through the use of impermeable membranes in the design of dirty stormwater infrastructure, i.e., High-density polyethylene (HDPE) liners for the pollution control and concrete linings for the dirty water drainage channels;
- Prevention of erosion of the existing water courses, particularly at clean stormwater system discharge points;
- Mitigation of flooding to neighbouring properties in the areas due to the proposed mine footprint and mining activities;
- The required capacity of the individual elements comprising the dirty water system considered the following:
    - Projected water balance, with the aim of retaining the contaminated (dirty) water within a closed system;
    - Maximum estimated stormwater peak flow generated by a storm event with a 1 in 50-year recurrence interval; and
    - Maximum estimated 24-hour runoff volume with 1 in 50-year recurrence interval.

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2.2.3 Stormwater Management Details

The stormwater management was designed for a return period of 1:50 years as prescribed by Regulation 704 (4 June 1999) of the National Water Act, 1998 (Act No. 36 of 1998 - Regulations on use of water for mining and related activities aimed at the protection of water resources).

The design calculations are presented in Appendix B for the dirty stormwater area.

The mean annual precipitation / rainfall (MAP) was calculated at 704mm, using information from the following rainfall stations (refer to **Table 2-2**):

Table 2-2 – Rain Stations

Station Name	SAWS Number	Distance from Site (km)	MAP (mm)
Middelkraal	0478853_W	5.7	694
Weltevreden	0479104_W	6.5	698
Bankpan	0479167_W	12.1	716
Vlaklaagte	0479225_W	12.1	680
Hendrina (Mun)	0479369_W	20.1	681
Vlaklaagte	0478862_W	20.5	701

The proposed mine's infrastructure area (dirty water) has a surface area of approximately

- Dirty Stormwater Area = 0.2013km^2.

The design methodology used for the stormwater management is summarised below:

- The infrastructure areas are classified as dirty stormwater, as indicated;
- The entire area will be "enclosed" by means of a combination of stormwater channels and cut-off berms. Stormwater from the surrounding areas will therefore be diverted away from the infrastructure areas;
- The stormwater run-off for the infrastructure areas were calculated using the rational method. Based on the information, PCD volume as indicated below is required
  - Dirty Stormwater Area = 15 183m^3 (excluding 800mm freeboard);
- Reinforced concrete stormwater channels will be constructed. The purpose of these channels is to collect all the stormwater from the infrastructure area and convey it to the Pollution Control Dam (PCD); and
- The water from the PCD will be re-used (wash water, fire water, dust suppression, etc.).

2.2.4 PCD Sizing and Lining

As indicated, the following PCD is required (refer to **Figure 2-3**):

- Dirty Stormwater Area:
  - PCD volume of 15,183m^3 (excluding 800mm freeboard) is required;
  - The actual size of the PCD (including freeboard) is 19,278m^3; and
  - The maximum depth is 4.7m (including freeboard).

The PCD's design drawings are included in **Appendix A**.

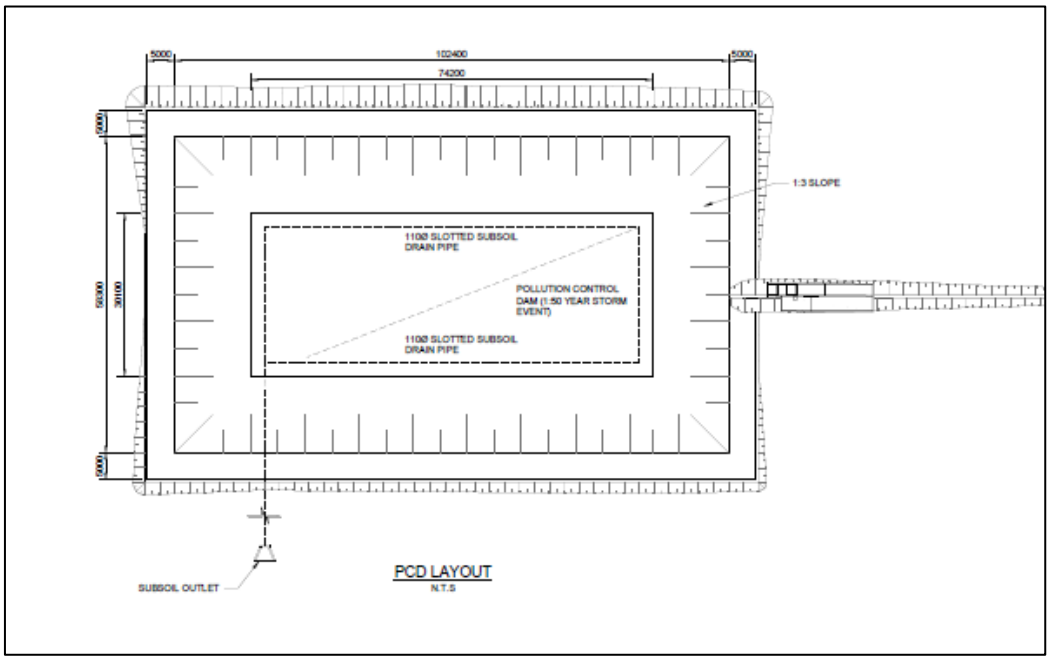

Figure 2-3: PCD Layout

The PCD barrier design was carried out in accordance with regulation 36784. The proposed barrier is a class C barrier that is required for the Type 3 material in terms of Regulation 634 and 635 (refer to **Figure 2-4**).

The geomembrane will be an 1.5mm HDPE liner. This HDPE liner will have a maintenance free life of 5 years. After this period routine inspections and maintenance will need to be undertaken on in order to ensure the performance of the liners.

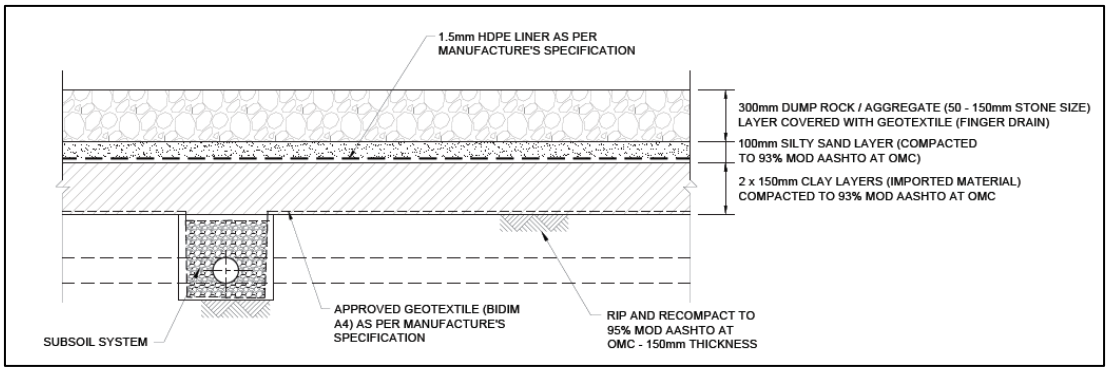

Figure 2-4: PCD Liner Details

2.2.5 Catchment Delineation

The separation of clean and dirty water is the underlying principle in developing and maintaining an effective stormwater management strategy.

The clean water drainage proposed for the project consists of earth channels, v-shaped drains, diversion berms and culverts which are designed to reroute surface water runoff from upstream catchment away from the areas affected by mining activities and usually towards an existing water course.

2.2.5.1 Dirty Water Catchment

It is envisaged that the following areas will form part of the dirty water catchment within the proposed project area:

- Crusher/beneficiation plant;
- ROM stockpiles;
- Product stockpiles;
- Waste stockpiles;
- Coal loading platform;
- Internal haul roads;
- Contractor Yard area; and
- Weighbridge.
- Overburden Stockpiles.

The stormwater collected in the Opencast pits will be managed inside these pits. Diversion berms will be provided to direct overland stormwater flow away from these facilities.

The total areas contributing to the dirty stormwater runoff are:

- Dirty Stormwater Area = 0.2013km^2.

Stormwater runoff upstream of the affected areas will be diverted away by means of earth berms and drainage channels.

The dirty water runoff from the above catchment will be directed towards HDPE lined pollution control dam (PCD).

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2.2.5.2 Clean Water Catchment

Stormwater run-off within identified 'clean' catchments will be intercepted by diversion channels and/or earth berms which divert the water towards culverts, before being discharged to the existing watercourses.

In an effort to limit the impact of the proposed mining activities on the existing water resources in the area, clean stormwater runoff from the majority of the area would be diverted to established stormwater courses.

2.3 HYDROLOGY

2.3.1 Groundwater

Groundwater will form part of the overall stormwater management strategy to be address in more detail subject to available information. Any excess groundwater from the opencast pits will be managed inside these pits, with the option to pump to the PCD (as required for emergency situations), to be reused.

2.3.2 Stormwater Runoff Analysis

The required capacity of the pollution control dam, as stipulated in terms of the 'Best Practice Guideline A4: Pollution Control Dam' (DWA - Aug 2007), is governed by the condition which will allow spillage out of the dam to occur only once every 50 years, based on the runoff generated by a 24-hour rainfall event. This is a function of rainfall intensity, catchment size and its surface characteristics, such as slope, type of surface cover, etc.

The main purpose of the runoff calculations is to determine the infrastructure requirements in terms of stormwater drainage and containment capacities of the infrastructure elements. This exercise was undertaken for both the dirty water and clean water systems. The latter covered a large percentage of the project site. The approach adopted for the purpose of the stormwater runoff analysis was based on the Rational Method to determine the stormwater runoff figures. This method is based on the principle of mass conservation with the calculated flow rate being directly proportional to the size of the catchment and the rainfall intensity. The rainfall intensity is a function of the return period and the time of concentration and it is assumed to be constant throughout the duration of a storm event.

The Rational Method was used to determine runoff figures for the purpose of this report, in which the contributing flow rate is directly proportional to the size of the contributing area and the rainfall intensity for the design storm event. The rainfall intensity is a function of the return period and the time of concentration, as expressed by:

$$Q = 0.278*C*I*A \quad \ldots (5)$$

Where:

Q = peak flow (m^3/s)

CT = run-off coefficient

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

A = effective area of catchment (km^2)

0.278 = conversion factor

2.3.2.1 Rainfall Intensity

The required capacity of the pollution control dam as stipulated in terms of the 'Best Practice Guideline A4: Pollution Control Dam' (DWA - Aug 2007), is governed by the condition which will allow spillage out of the dam to occur once every 50 years.

In order to establish the design parameters governing the flow capacities of dirty water drainage system the following criteria for rainfall intensities were adopted to calculate the critical values based on 1 in 50-year storm event:

- **5 minutes storm**: to determine peak flow runoff for sizing stormwater drainage channels for the upstream "dirty" water sub-catchment area
- **10 minutes storm**: in order to size the main concrete lined collector drains, which intercept the runoff from the upstream drainage channels before discharging to PCD in order to model, a longer time of concentration would be applicable for the peak to reach the end of the "dirty" water drainage system.
- **30 minute storm** for the design of infrastructure for the clean water catchment (1:50 year)

Computer software Design Rainfall in SA (WRC Project K5/1060) has been used to determine the applicable value for the rainfall intensities.

2.3.2.2 Catchment Characteristics

The Runoff Coefficient (CT) is directly related to the physical characteristics of the catchment areas and is linked to:

- Land use category (urban/rural/industrial)
- Topography
- Type of soil (permeable/semi or non-permeable)
- Size of catchment area

The value of the run-off coefficient ranges between 0.85 for impervious areas (such as roofs, paved streets and parking) and 0.15 (at the lower range) for catchments covered by impervious soils and dense vegetation. The value of Rational Method runoff coefficient can be determined according to the following:

$$CT = Ft * (Cs + Cp + Cv) \quad \ldots (6)$$

In this case, the coefficient for the dirty water catchment was determined as 0.47 based on the following:

Cs (Surface Slope Coefficient) = 0.08 (moderate to flat slopes across the site)

Cp (Permeability Coefficient) = 0.20 (semi-permeable to impermeable soil conditions)

Cv (Vegetation Coefficient) = 0.25 (none or sparse vegetation)

Ft (C value adjustment factor) = 0.9

CT =Ft (Cs + Cp +Cv) = 0.47

In terms of the adopted strategy for the dirty water areas, the stormwater runoff would be intercepted by way of concrete-lined channels and discharged into the PCD.

2.3.3 Analysis Results

2.3.3.1 Dirty Water Catchment

The minimum required capacity of the pollution control dam will be:

- Dirty Stormwater Area:
  - PCD volume of 15,183m^3 (excluding 800mm freeboard);
  - The actual size of the PCD (including freeboard) is 19,278m^3.

2.4 STORMWATER INFRASTRUCTURE SYSTEM

Typically, a stormwater management infrastructure system for a mine site will include the following elements (Refer to **Figure 2-5**):

- Clean water drainage:
  - Earth berms (alongside platforms in cut);
  - Earth (unlined) channels; and
  - Clean water culverts for road and railway crossings.
- Dirty water drainage:
  - Concrete-lined drainage channels;
  - Dirty water culverts;
  - Pollution control dam for dirty water drainage (with silt trap);

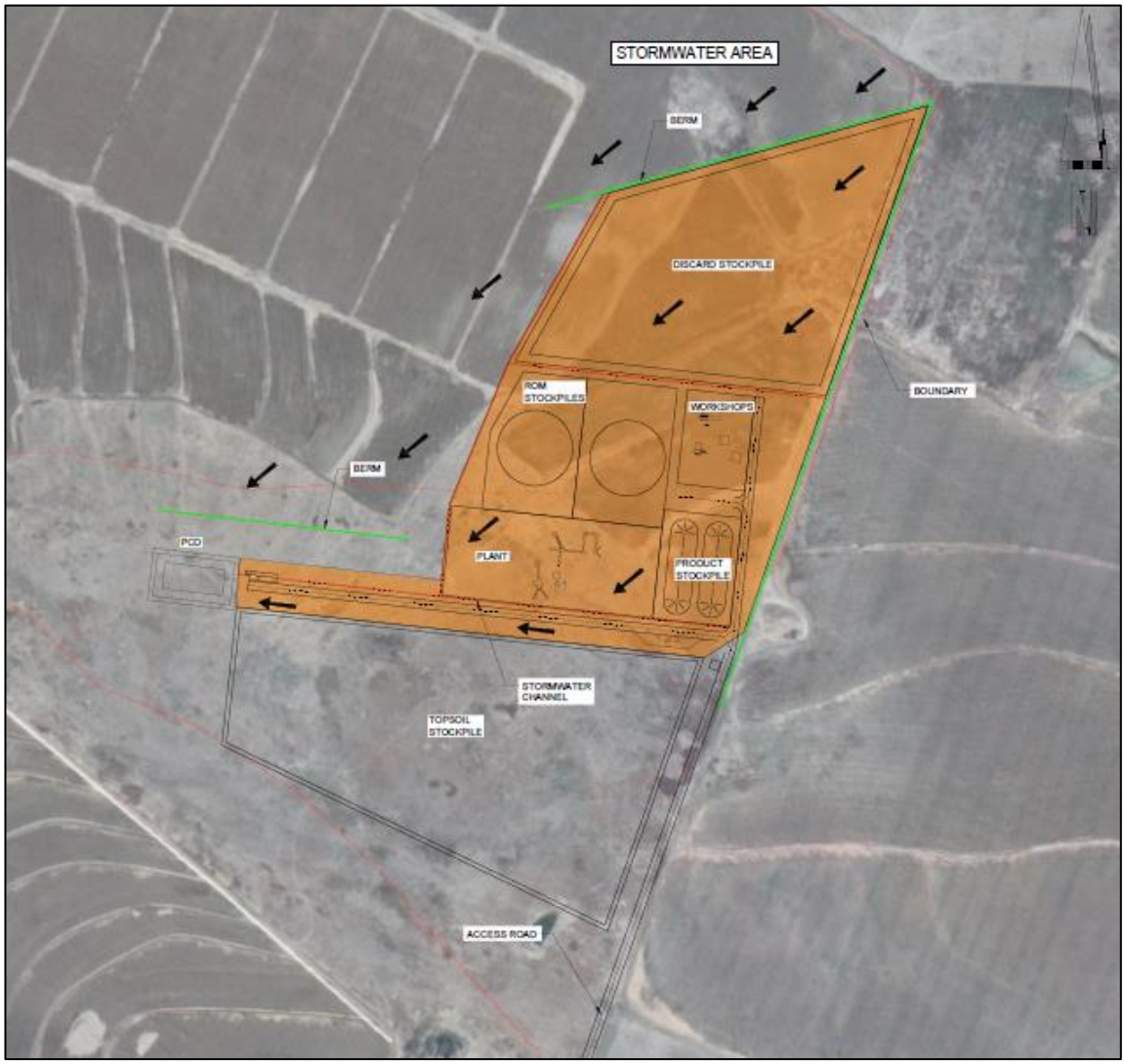

Figure 2-5: Stormwater Management

2.5 STORMWATER CONVEYANCE INFRASTRUCTURE SIZING

The sizing of the stormwater channels was done using Manning's equation, with a roughness coefficient (n) of 0.015 (for concrete lined channels).

The required size of the channels (maximum size) are:

- Stormwater Area 1:
  - Shape = Trapezoidal;
  - Bottom width = 1.5m;
  - Side slopes: 1:2; and
  - Depth = 0.6m (including freeboard)
- Stormwater Area 1:
  - Shape = Trapezoidal;
  - Bottom width = 1.5m;
  - Side slopes: 1:2; and
  - Depth = 0.4m (including freeboard)

The size of the stormwater berms (Stormwater Areas 1 and 2) to divert clean stormwater away from the dirty water area are:

- Shape = Trapezoidal;
- Top width = 3m;
- Side slopes: 1:2; and
- Height = 1.5m minimum.

2.6 WATER BALANCE

2.6.1 Principle

The site water management will be operated as a closed system, i.e.:

- Stormwater runoff within the dirty water area will be collected and conveyed to the PCD.
- The water from the PCD will be re-used and no water from the PCD will be released into the environment.

2.6.2 Sewage Management

The sewage / effluent will be treated in either:

- Wastewater treatment works (to General Limits as per the NWA) and conveyed to the Mining Area PCD for re-use; or
- Septic tanks, to be emptied periodically.

3. CONCLUSION

This report (P0366/RPRT/03) presents the stormwater management plan for the Dunbar Coal mine.

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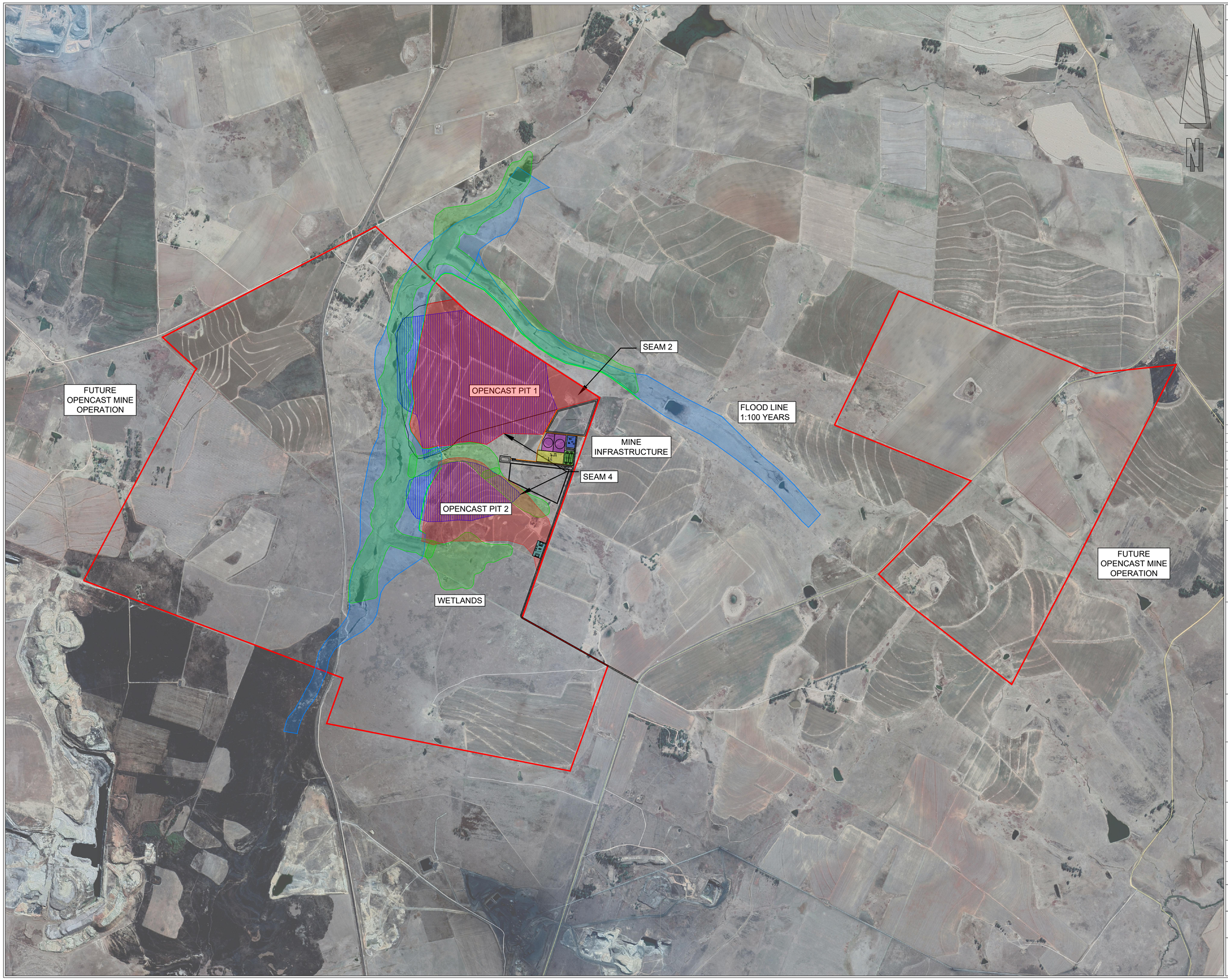
APPENDIX A

Design Drawings



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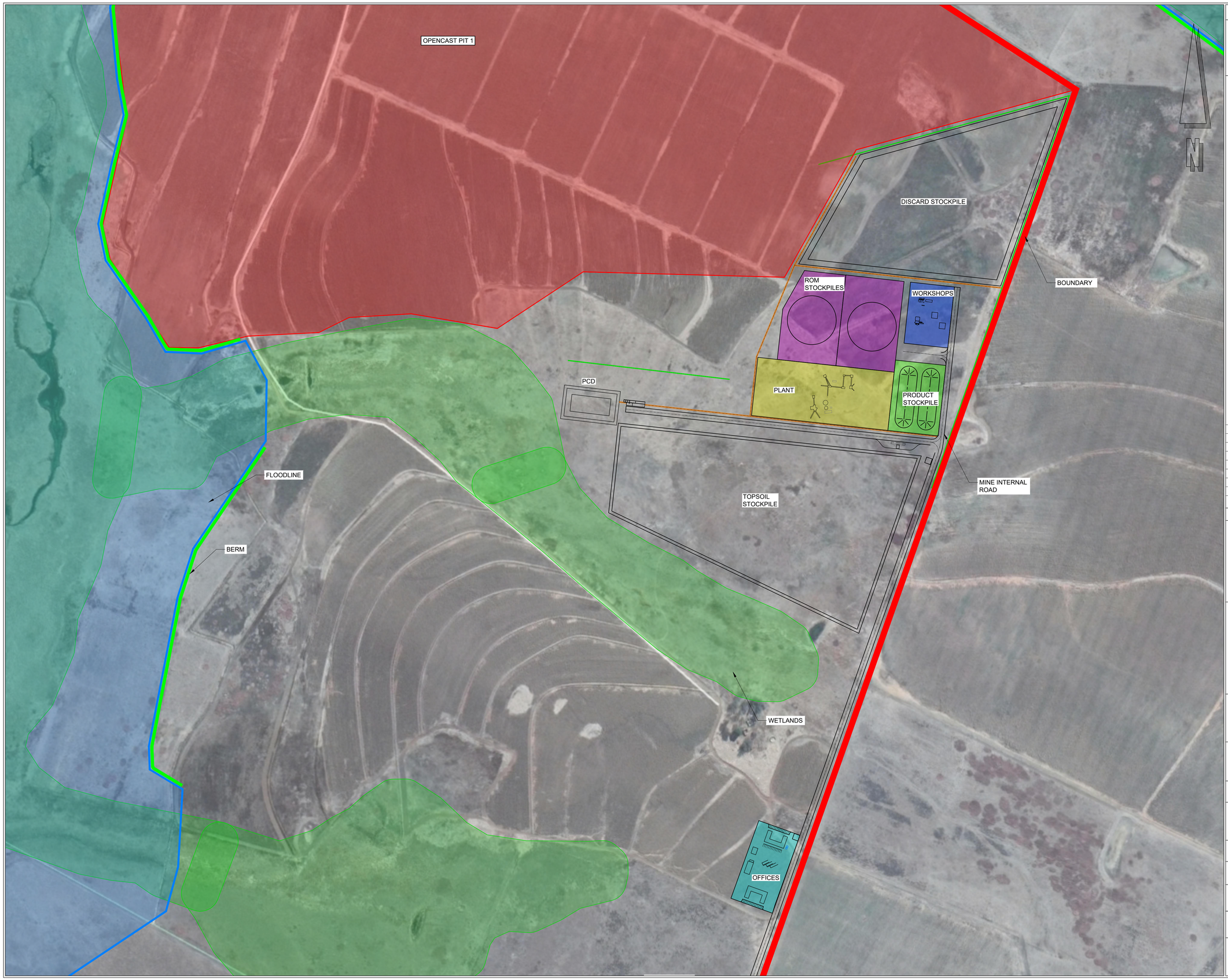

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STORMWATER INFRASTRUCTURE LAYOUT

- DIRTY STORMWATER CHANNELS
- CLEAN STORMWATER BERMS AND CHANNELS
- DIRECTION OF FLOW
- DIRTY STORMWATER AREA

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PROJECT DESCRIPTION

INSA COAL HOLDINGS DUNBAR MWP

TITLE

STORMWATER LAYOUT

DESIGN BY	M. EINKAMERER	DRAWN BY	E. COETZEE
DESIGN CHECKED	PR.ENG 20110130 M. EINKAMERER	DWG CHECKED	PR.ENG 20110130 M. EINKAMERER
SIGNED		SIGNED	
DRAWN DATE	2019/06/04	APPROVED DATE	

FOR INFORMATION

SCALE	PAPER SIZE
N.T.S	(A1)
CO-ORDINATE SYSTEM	REVISION B

DWG NO

P0366-CIV-STW-0100

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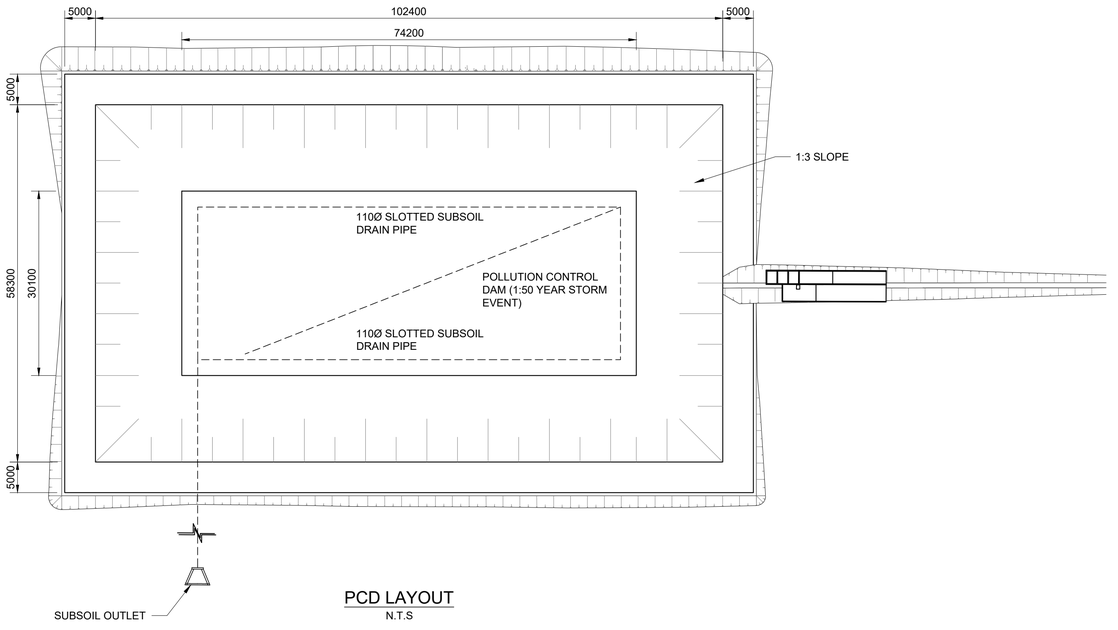

PCD LAYOUT
N.T.S

REV	DATE	DESCRIPTION	BY
B	2019/09/25	SLOPES REVISED	M.E
A	2019/06/04	FOR INFORMATION	M.E

REVISIONS

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DRAWN DATE	2019/09/25	APPROVED DATE	

FOR INFORMATION

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CO-ORDINATE SYSTEM	REVISION B

DWG NO

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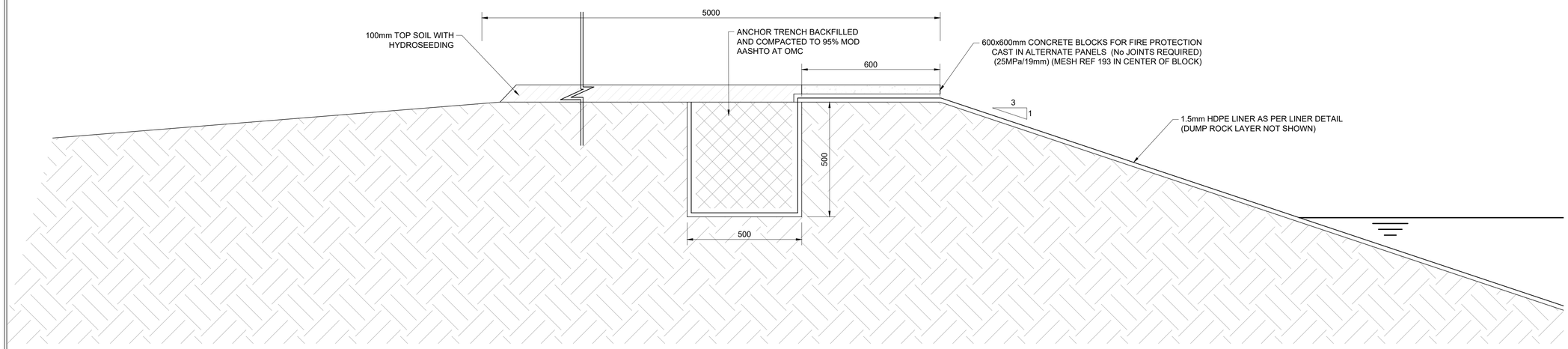
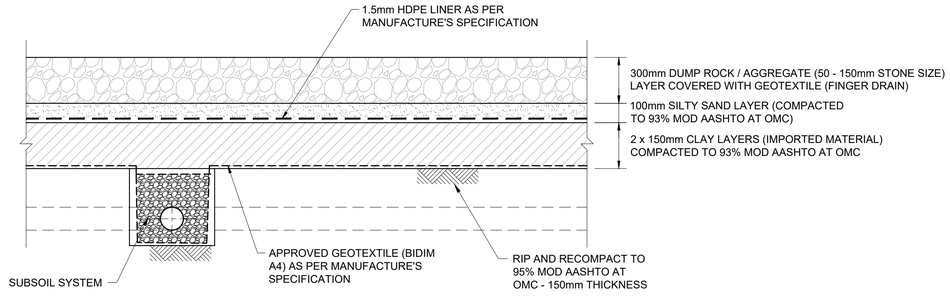


POLLUTION CONTROL DAM
LINING AND ANCHOR DETAIL
SCALE 1:10



LINER DETAIL
SCALE 1:20

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A	2019/06/04	FOR INFORMATION	M.E.

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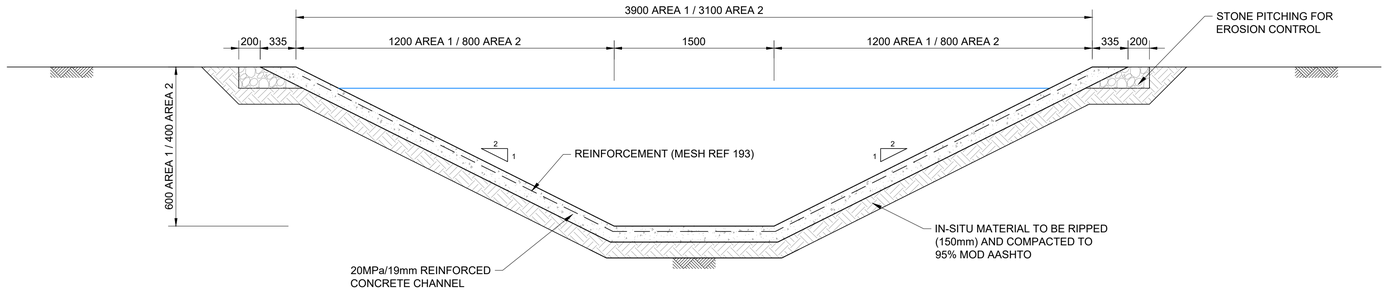
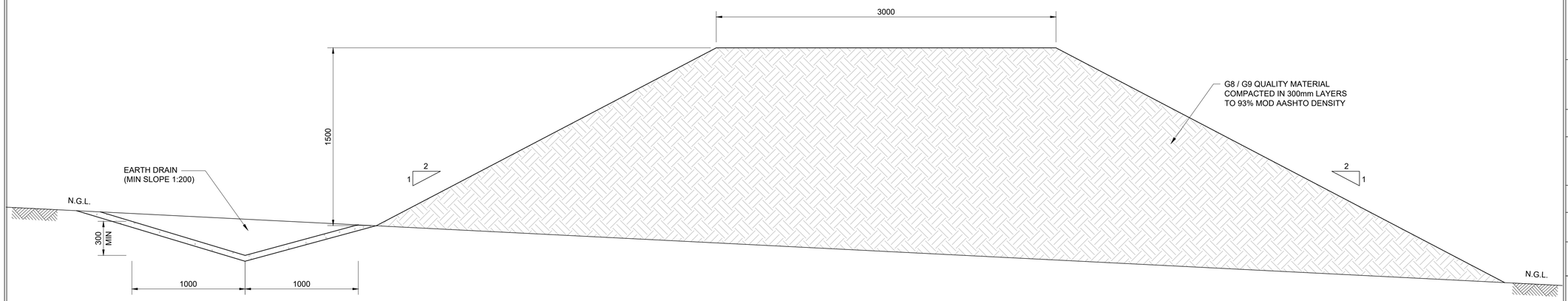


DIRTY WATER CHANNEL DETAIL
STORMWATER AREA 1
N.T.S



TYPICAL STORMWATER BERM DETAIL
SCALE 1:20

NOTES:

1. ALL CHANNELS TO BE SAW CUT EVERY 2.25m AND SEALED WITH SIKAFLEX PRO-3WF MOISTURE CURING POLYURETHANE JOINT SEALANT OR SIMILAR APPROVED POLYURETHANE SEALANT (10mm WIDE x 15mm DEEP).
2. WELDED FABRIC REINFORCEMENT (MESH) TO STOP 50mm FROM JOINTS.
3. 50mm COVER REQUIRED FOR THE WELDED FABRIC REINFORCEMENT.

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CHANNEL AND BERM DETAILS

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SIGNED		SIGNED	
DRAWN DATE	2019/06/04	APPROVED DATE	

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SCALE: AS SHOWN	PAPER SIZE: (A1)
CO-ORDINATE SYSTEM	REVISION: A

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APPENDIX B

Design Calculations – Dirty Stormwater Area

Stormwater Management Plan

Dunbar Coal Mine

Project No: P0336

Issued & Approved By:
Michael Einkamerer (Pr. Eng), B.Eng (Hons)
ECSA Registration Number: 20110130

Revision: Rev 1
Date of Original Submission: 2019/06/03
Date of Revision: 2019/09/25

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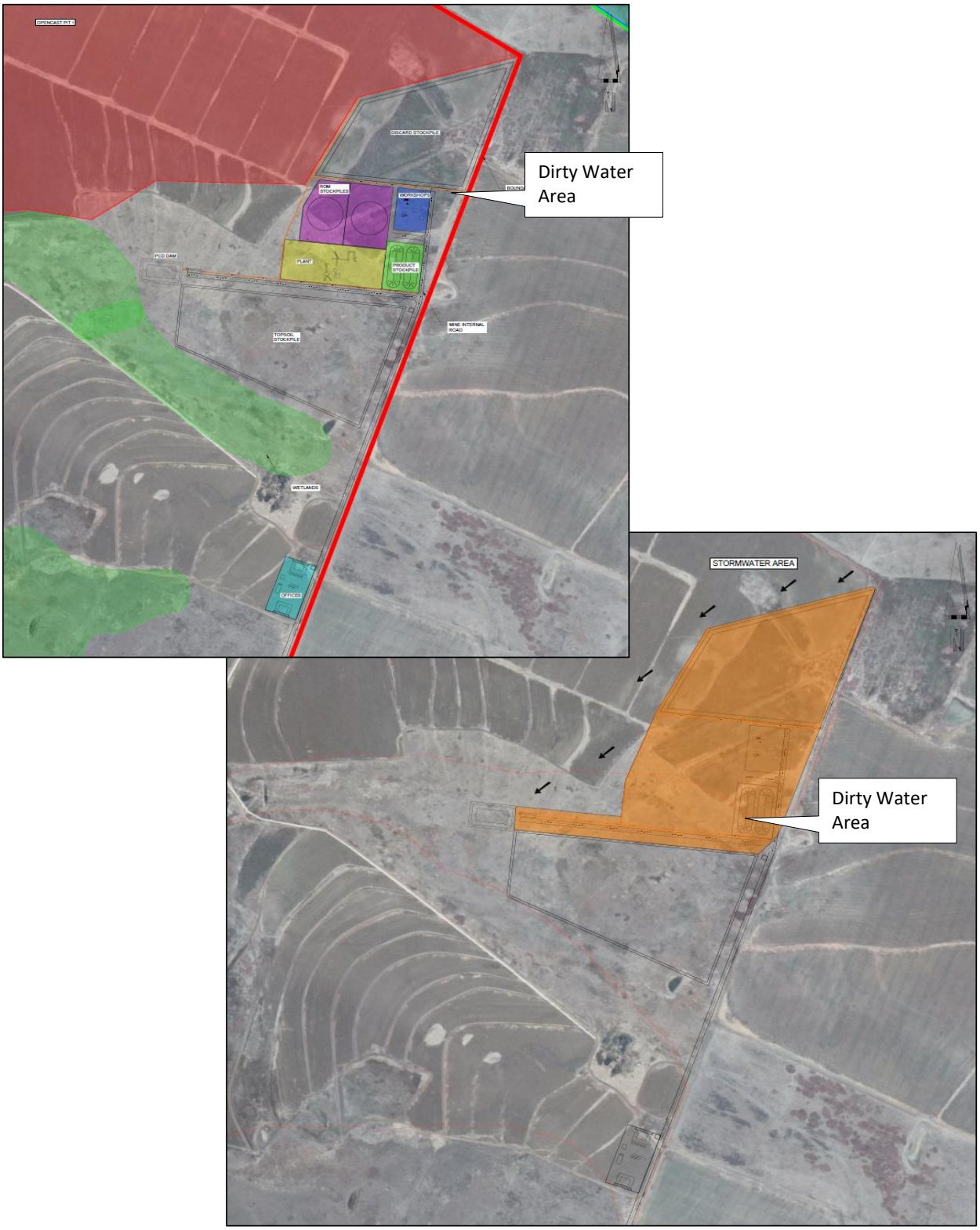
Drawing / Sketch



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Project Title	**Dunbar Coal Mine**	Sheet No	**1**	of	**3**
Project No.	**P0336**	Prepared by	**ME**	Date	**2019/05/31**
Element	**Stormwater Design**	Checked by		Date	

PCD - Design Criteria and Assumptions Revision: Rev 1

1.0 General

1.1 Site Information

1.1.1 Dunbar Coal Mine

1.1.2 Life of Mine (LOM) = years

1.1.3 Type of Mine = Coal

1.1.4 Mine scenario = Mtpa

1.2 Rainfall

1.2.1 MAP = 704 mm

1.2.2 Altitude = 1653 m

1.2.3 Design rainfall depths (mm)

Duration	Return Period (years)							
	2	5	10	20	25	50	100	200
5 m	9	12	14.1	16.2		19.1	21.4	23.8
10 m	13	17.3	20.3	23.3		27.5	30.8	34.3
15 m	16.1	21.4	25.1	28.9		34	38.1	42.4
30 m	20.7	27.4	32.2	37		43.6	48.9	54.3
45 m	23.9	31.7	37.2	42.8		50.4	56.5	62.8
1 h	26.5	35.1	41.2	47.4		55.9	62.6	69.7
1.5 h	30.6	40.6	47.7	54.8		64.6	72.4	80.5
2 h	34	45	52.9	60.8		71.7	80.3	89.3
4 h	40.7	53.9	63.3	72.8		85.9	96.2	107
6 h	45.2	60	70.4	81		95.5	106.9	119
8 h	48.8	64.6	75.9	87.3		102.9	115.3	128.2
10 h	51.7	68.5	80.5	92.5		109.1	122.2	135.9
12 h	54.2	71.9	84.4	97		114.4	128.2	142.5
16 h	58.4	77.5	91	104.6		123.3	138.1	153.7
20 h	61.9	82.1	96.4	110.9		130.7	146.4	162.9
24 h	64.9	86.1	101.1	116.3		137.1	153.6	170.8
1 d	56.3	74.6	87.6	100.7		118.8	133.1	148
2 d	69.5	92.1	108.1	124.3		146.6	164.2	182.7
3 d	78.6	104.1	122.3	140.6		165.8	185.7	206.6
4 d	85.4	113.2	133	152.9		180.3	202	224.6
5 d	91.1	120.8	141.9	163.2		192.4	215.5	239.7
6 d	96.1	127.4	149.6	172.1		202.9	227.3	252.8
7 d	100.5	133.3	156.5	180		212.2	237.7	264.4

2.0 PCD design assumptions

2.1 Storm duration = 1:50 years

2.2 Water Balance

2.2.1 Stormwater management - semi-closed system. All dirty water collected in a PCD for re-use and evaporation. All clean water runoff to be diverted away from the mine.

2.2.2 No stormwater outside development will enter - will be diverted away by means of berms and channels

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Project Title	**Dunbar Coal Mine**	Sheet No	**2**	of	**3**
Project No.	**P0336**	Prepared by	**ME**	Date	**2019/05/31**
Element	**Stormwater Design**	Checked by		Date	

2.3 Stormwater upstream of any dirty water areas will be directed away from these areas by means of berms and channels. Only rainwater falling on the dirty areas will contribute to the dirty stormwater runoff.

2.4 Stormwater conveyance

2.4.1 Earth Channels

3.0 PCD design - Opencast - Area 1 (Plant, Infrastructre, etc. to the South)

Dirty Area 1	201 330	m^2	0.20133008	km^2
Dirty Area 2		m^2	0	km^2
TOTAL	**201 330**	**m^2**	**0.20133008**	**km^2**

PCD Sizing (100% of the dirty areas contributing)

5.1	Rainfall that occurs during a 24 hour, 1:50 year storm event =	137.1	mm
5.2	Total dirty water area =	201 330	m^2
5.3	C factor =	0.5	
5.4	**Storage Area required =**	**13 802**	**m^3**

Additional Allowance	10%	*Water from Underground, safety factor, etc.*	
		1380.2	m^3
TOTAL Volume		**15 183**	**m^3**

Assume a depth of 3.9 m 0.8 m freeboard excluded

Area required = **3 894 m^2**

Therefore, size of dam = **88.3 m x** Length **44.2 m x** Width **3.9 m** Depth

Without Freeboard:	Area =	3 903 m^2	Volume =	15 221 m^3
With Freeboard:	Area =	3 903 m^2	Volume =	18 343 m^3

Side Slopes 1: 3

Top of dam - Length	**102.4 m**	***(Note 800mm freeboard included)***
Top of dam - Width	**58.3 m**	
Bottom of dam - Length	**74.2 m**	
Bottom of dam - Width	**30.1 m**	

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Project Title	**Dunbar Coal Mine**	Sheet No	**3**	of	**3**
Project No.	**P0336**	Prepared by	**ME**	Date	**2019/05/31**
Element	**Stormwater Design**	Checked by		Date	

4.0 **Attenuation Pond design criteria**

3.1 The Pond will be HDPE lined

3.2 Silt trap upstream of PCD

3.3 Subsoil provided

3.4 Freeboard = 800mm

5.0 **Channel Size - Area 1**

Q = 1.97620741 m^3/s

1976.20741 l/s

n = 0.015 Concrete Lined

b = 1.5 m

y = 0.2 m (excl. freeboard) https://www.roof-gutter-design.com.au/ochan/open-channel.php

x = 2

Bed Slope = 1: 97 Use 1:200 (Conservative)

freeboard = 0.2 m

Therefore, size of channels = 1.5 m x 0.2 m x 1: 2

bottom width Depth Side Slopes

Freeboard = **0.2 m**

Therefore, size of channels (with freeboard) =

1.5 m x 0.4 m x 1: 2

bottom width Depth Side Slopes

3.1 m

Top Width

6.0 Outlet Pipe Sizing

Designed for 1:5 year flood

Q = 0.734 m^3/s

Minimum Slope = 0.02 m/m (1:50)

ks = 0.3 mm (concrete outlet pipe)

ν = 1.13E-06 m2/s

$$V = -2\sqrt{2gDS_f}\,log\left[\frac{k_s}{3.7D} + \frac{2.51\nu}{D\sqrt{2gDS_f}}\right]$$

Diameter	v (m/s)	Q (m3/s)	# of Pipes
450	**3.118**	**0.496**	**2**
750	4.274	1.888	1
825	4.531	2.422	1
900	4.779	3.040	1

Project Number:	Dunbar Coal Mine
Element Description:	Catchment Run-off
	Appendix A
Calculated by:	Michael Einkamerer
Date:	2019/05/31

Rational Method

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PHYSICAL PROPERTIES OF CATCHMENT:

Area of catchment:	A=	0.2013	km²
Water path (overland)	L_1=	1.07	km
Average slope:	H_{L1}=		m
Overland	H_{L2}=		m
	L_1=		km
	S_{avg1}=	0.0103	m/m
Area dolomite	D=	0%	

Longest water path	L=	1.07	km
Water path (water course)	L_2=		km
Average slope:	$H_{0.85L}$=		m
Watercourse	$H_{0.10L}$=		m
	0.75L=		km
	S_{avg2}=	0.01028	m/m

Area distribution factors (α + ß + γ = 1)					
Rural		Urban		Lakes	
α=	1	ß=	0	γ=	0

RURAL									URBAN		
SLOPE SLOPE C_S (%)			PERMEABILITY C_p(%)			VEGETATION C_v (%)			USE		
Lakes and pans	30%	0.05	Very permeable	40%	0.05	Thick bush & plantations	0%	0.05	Lawns & Parks	0%	0.15
Flat areas	70%	0.11	Permeable	10%	0.1	Light bush & cultivated areas	10%	0.15	Industrial areas	0%	0.7
Hilly areas	0%	0.2	Semi-permeable	40%	0.2	Grasveld	30%	0.25	City / residential	0%	0.5
Mountainous	0%	0.3	Impermeable	10%	0.3	No vegetation	60%	0.3	Streets	0%	0.95
Total (100)	**100%**	0.092	**Total (100)**	**100%**	0.14	**Total (100)**	**100%**	0.27	Total (100)	0%	0.0

Rural coefficient C_1=	0.50	Urban coefficient C_2=	0.00

Return period	2	5	10	20	25	50	100	200
F_t	0.5	0.55	0.6	0.67	0.75	0.83	1	2
Adjust for dolomite	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Adjusted C_1	0.25	0.28	0.30	0.34	0.38	0.42	0.50	1.00
Total C	0.25	0.28	0.30	0.34	0.38	0.42	0.50	1.00

RAINFALL:

T_c (overland flow)

$$T_C = 0.604 \times \left(\frac{rL_1}{S_{avg1}^{0.5}} \right)^{0.467}$$

r =	0.1	V =	0 m/s
T_c =	0.6194	(0.2 - 0.5m/s)	
	37.163 min		

Values for r	
Paved areas	0.02
Clean soil	0.1
Sparse Grass	0.3
Moderate Grass	0.4
Thick Bush	0.8

T_c (channel flow)

$$T_C = \left(\frac{0.87 \times L_2^{\,2}}{1000\, S_{avg\,2}} \right)^{0.385}$$

T_c =	0.0000	V =	#DIV/0! m/s
	0 min	(0.8 - 1.3m/s)	
T_c =	0.6194		
	37.163 min		

Dolomite reduction (D_r)	
Steep (>30%)	0.5
Hilly (10 -30%)	0.35
Flat (3 - 10%)	0.2
Vlei's & Pans (<3%)	0.1

Average annual rainfall:	704 mm / annum
Rainfall region:	

Return period	2	5	10	20	25	50	100	200
Point rainfall (mm)	22.2	29.5	34.6	39.8	42.3	52.5	58.4	66.3
Point intensity I (mm/h)	36	48	56	64	68	85	94	107
Area reduction factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Average intensity I (mm/hr)	35.9	47.6	55.8	64.2	68.3	84.8	94.2	107.0

PEAK FLOW:

Return period	2	5	10	20	25	50	100	200
Peak flow (m^3/s)	**0.504**	**0.734**	**0.941**	**1.208**	**1.438**	**1.976**	**2.645**	**6.009**
Peak flow (l/s)	**503.76**	**734.26**	**940.64**	**1207.8**	**1438.2**	**1976.2**	**2645.2**	**6009.29**