EXXARO

Belfast Mine Feasibility Study

REP/22474800/S002

Final 2 | 21 January 2014

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 22474800

Arup (Pty) Ltd
Reg. No. 1994/004081/07 Registered Firm
Consulting Engineers South Africa

Arup (Pty) Ltd
10 High Street
Postnet Suite No.93 Private Bag X1 Melrose Arch
Johannesburg 2076
South Africa
www.arup.com

ARUP

Document Verification

ARUP

Job title		Belfast Mine Feasibility Study			**Job number** 22474800
Document title					**File reference**
Document ref		REP/22474800/S002			
Revision	**Date**	**Filename**	Belfast Mine Infrastructure.docx		
Draft 1	13 Dec 2013	**Description**	First draft		
			Prepared by	Checked by	Approved by
		Name	Gerhard Duvenage	Willem Van Rijn	Willem van Rijn
		Signature			
Final 1	10 Jan 2014	**Filename**			
		Description	Final		
			Prepared by	Checked by	Approved by
		Name	Gerhard Duvenage	Willem Van Rijn	Willem van Rijn
		Signature			
Final 2	21 Jan 2014	**Filename**			
		Description			
			Prepared by	Checked by	Approved by
		Name	Gerhard Duvenage	Willem Van Rijn	Willem van Rijn
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
				Issue Document Verification with Document	✓

Contents

Appendix A

Stormwater Management

Appendix B

Roads And Stormwater

Appendix C

Water Management

Appendix D

Sewer Network

Appendix E

Architectural – Finishing Schedule

Appendix F

Pollution Control Dams

Appendix G

Structures

1 Scope of Work

1.1 General

1.1.1 Background

In 2012 Arup (Pty) Ltd were appointed to undertake a feasibility study on civil infrastructure requirements for the proposed Belfast Mine.

Arup are responsible for the civil infrastructure namely:

- Bulk Earthworks Terraces for all infrastructure
- Stormwater Drainage systems
- Roads, Parking, Weighbridge, Major culvert over Klein Komatie and Stormwater
- Area Lighting Design
- Geotechnical Investigation for off-site infrastructure
- Potable Water Reticulation, storage and Pump Stations
- Fire Water Reticulation, Storage and Pump Stations
- Process Water Distribution and Pump stations
- Sewer Network
- Waste Water Treatment Works
- Security Fencing
- Communication Sleeves
- Architectural and Structural Design
- Dams

1.1.2 Geology

1.1.2.1 General

The regional geology of the area indicates that it forms part of the Vryheid Formation of the Ecca Group, Karoo Super Group. The Vryheid Formation generally consists of sandstone and shale. Coal also occurs commonly in the area. In addition to the bedrock mentioned, this region is also known for its pedogenic deposits, in particular, ferricrete. The ferricrete forms in the soil profile due to the abundance of moisture in the region.

1.1.2.2 Influence of Geology on Construction

Based on information obtained from visual observations and from test pits, it appears there is adverse subsoil conditions present such as collapsing sands and active clays.

1.1.3 Site Location

Belfast Mine is a greenfields project located approximately 18km south west of Belfast in the Mpumalanga Province. Access to the site will be via the Eerstelingsfontein Road off the N4. This can be seen in **Figure 1** below.

Figure 1: Site Location Plan

1.1.4 Site Operation

Information provided by Exxaro indicates that at its peak production the mine is anticipated to produce 2.75 million tonnes per annum (mtpa) of raw material. Of this, 2.25 mtpa is destined for domestic markets and 0.5 mtpa is destined for export.

1.2 Geographical Information.

1.2.1 Topography

Belfast is situated in the Highveld of South Africa at 2025m above sea level and one of the coldest and highest towns in South Africa.

The area forms part of the Steenkampsberg which is a South African mountain plateau in the Dullstroom - Belfast district of Mpumalanga Province. The plateau consists largely of high-altitude grassland, ranging between 1700 and 2274 metres above sea level, broken by rocky outcrops. Coal and black granite is predominantly mined and sourced in the area due to the geology of the area.

1.2.2 Climate

Belfast is located in the Highveld climatic region and experiences warm summers and cold winters. Information pertaining to rainfall has been obtained using software developed by JC Smithers and RE Schulze. The information pertaining to this section has been obtained from the Weather Station No 0517072_W situated at Belfast, and is summarised in Appendix B.

1.2.3 Temperatures

The monthly distribution of average daily maximum temperatures shows that the average midday temperatures for Belfast ranges from 14.7°C in June to 22.5°C in January. The region is the coldest during June when the temperature drops to 1.3°C on average during the night.

1.2.4 Rainfall

The average annual rainfall for the area is 780 mm. The rainy season starts in October and lasts until April with the average maximum reached in January. Winters are dry and cold with an average rainfall for the months May to September contributing approximately 10 percent of the average annual rainfall. The driest months are June and July.

1.2.5 Climatic classification of region

The Weinert N-value for Belfast falls between 2 and 5. This area is classified as moderate/wet in terms of the influence of climate on weathering and durability of natural materials.

1.2.6 Geotechnical Investigation

Geotechnical investigation for the mining and plant area has been excluded from Arup's scope. However a centreline soil survey was carried out by Arup on the new link and, gravel roads D1770 and D1110, and is reported in the Belfast Roads report, report number Rep/01 draft 2.1 of 18 September 2012.

An intrusive geological investigation has been done by Exxaro during October and November 2013. The geotechnical report will only be available early 2014 and designs assumptions for terraces, dams and building foundation has been based on borehole logs received and the geotechnical model can be summarised as follows:

Plant Area

- Thin Layer of topsoil of about 0.3 m average
- A very loose pin hole voided, silty fine sandy colluviums about 1.3 m average thickness.
- Hardpan ferricrete variable in thickness – 1.3 to 1.5 m average
- Soft intact, clayey silt with scattered weakly developed Fe/Mn nodules and slickensides. Residual siltstone below the hardpan ferricrete up to 2.8m below NGL

- Very hard Rock Sandstone from approximately 2.8m below the surface.
- Groundwater seepage from about 1.6 m below surface

Mining Area

- Thin Layer of topsoil of about 0.3 m average
- A very loose pin holed sandy colluviums which varies from 0.3 m up to 1.2 m thick below natural ground level.
- Hardpan ferricrete variable in thickness – 1.2 to 1,4 m average
- Groundwater level has been noted generally at 1.6 m below surface

2 Bulk Earthworks – Engineered Terraces

2.1 Design Criteria and Assumptions

Earthworks design should normally be carried out in accordance with the requirements of the Geotechnical Report. In the absence of the final geotechnical results the following assumptions have been made for the design for terraces:

- In terms of the soil testing done by Jeffares and Green, the colluviums soil seems likely to be classified as a G7 type material.
- Due to the shallow depth of Colluviums, sourcing this material for bulk earthworks will be problematic for excavators and have to be stockpiled with dozers first. This operation will tend to mix the soils and may result in a lower quality of material.
- For the purpose of this report it has been assumed that the colluviums will comply with a G7 type material.
- Soft excavation occurs generally in the first 1.3 meter below natural ground surface.

2.2 Design Methodology

Based on the above information and assumptions the terraces have been designed as follow:

Table 2.2 : Design Methodology

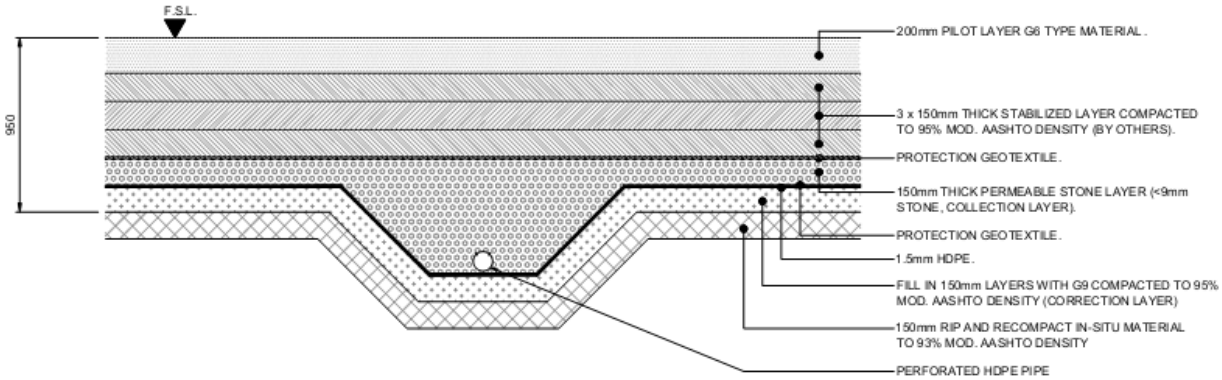
Terrace description	Design Methodology	Source
Plant and mining terraces designed with a seepage collection and subsoil drainage system: • Middling's Stockpile area and export stockpile area combined • Thickener Area • 18000t live stockpile • 50 t discard bin • Primary crusher stockpile area	Remove 200 mm topsoil	Local
	Excavate 950mm below finish surface level and use material in dam wall	Local
	In-situ treatment of excavation	Local
	150 mm protection layer consist of aggregate < 3mm	Commercial source
	1.5 mm HDPE	Commercial Source
	Protection Geotextile Bidum A10	Commercial Source
	150 mm protection layer consist of aggregate < 9mm	Commercial source
	Protection Geotextile Bidum A10	Commercial Source
	3 x 150 mm Layers (G9 -10 type material – cement stabilised)	From dam excavations
	200 mm Pilot Layer (G6 Type Material	Selected G6 material from dam Excavations
Terrace's for buildings	Remove 200 mm topsoil	Local
	Back fill (G7 type material)	Cut to fill operation

	In-situ treatment of excavation	Local

2.3 Seepage Collection and Subsoil Drainage System

The purpose of a seepage collection system is to prevent contaminated surface water to contaminate the clean groundwater. Subsoil drainage system is provided to intercept and drain contaminated surface rainfall infiltration to the pollution control dams via the stormwater drainage system. The figure below indicates the lining system adopted for terraces stockpiling contaminated material

Figure 2.1: Typical Seepage Collection and subsoil drainage system



TYPICAL SECTION THROUGH SEEPAGE COLLECTION AND DRAINAGE SYSYTEM

3 Stormwater

Stormwater management for the mine is regulate by the National Water Act, 1998 (act no. 36 of 1998). This Act distinguishes between clean water systems and dirty water systems. Dirty water systems convey and store water from areas classified as dirty which by definition, means any area of a mine which is likely to cause pollution of a water source.

3.1 Stormwater Design Criteria

Table 3.2: Stormwater Design Guidelines

Design Codes/Guidelines	Reference
Drainage Manual(DM)	(ed Kruger) SANRAL
Chapters 6 of "Guidelines for Human Settlement Planning and Design"	CSIR Building and Construction Technology
Regulations on use of water for mining and related activities aimed at the protection of water sources	NATIONAL WATER ACT, 1998 (ACT NO.36 of 1998)

Design criteria for clean water systems:

- Confine any unpolluted water to a clean water system
- Design a clean water system that it is not likely to overspill into any dirty water system more than once in 50 years

Design criteria for dirty water systems

- Design all water systems, including residue deposits, in any area so as to prevent the pollution of any clean water resource.
- Prevent polluted water from entering any clean water source, either by natural flow or by seepage.
- Design a dirty water system that it is not likely to overspill into any clean water system more than once in 50 years

Design criteria for hydraulic analysis of drainage systems.

- Stormwater systems inside the plant and mining area are designed for 1: 10 year peak flow.
- Stormwater systems forming a boundary between the dirty water area and clean water area have been designed not to overflow more than once in 50 years.
- Open stormwater drains are designed as trapezoidal 1.5 m minimum width with side slope of 1:3.
- The hydraulic design accounted for roughness of concrete, transition losses, bend losses etc.

- All the channels in the dirty water area are concrete lined. Channels conveying clean water are either unlined unless the velocity criteria and minimum slope necessitates the channel to be lined.
- Permissible velocity in reinforced concrete lined channels is 8 m/s and joints should be design to withstand pulsating pressure changes for velocities higher than 2.5m/s The linings of channels that carry high-velocity flow should be poured as nearly monolithic as possible, without expansion joints or weep holes, and using as few construction joints as possible. Construction joints should be made watertight. Longitudinal and transverse reinforcing steel should be used throughout to control cracking with the longitudinal steel carried through the construction joints. The lining should be anchored to the slope as necessary by reinforced cut-off walls to prevent sliding.
- Standard box culverts have been used at channel road crossings. Box culverts have been designed to function as open channels where linked to concrete lined channels.

3.2 Catchment Delineation and Properties

The flood hydrology analysis is carried out using the Rational Formula, alternative method and SDF method.

The catchment areas were delineated in accordance with the topographical information and the Block Plan layout.

Each sub-catchment was reviewed with respect to present day land use and proposed future land use and run-off parameters applied. These were defined from values recommended by the drainage manual, visual inspection of the soil type and vegetation.

Catchment Slopes were represented as a percentage and obtained from topographical information of the site. Slopes in plant and mining area vary from 0.01% to 3.0 %.

The first 1.3m consist of silty fine sandy colluviums of about 1.3 m average thickness. The permeability of the material should fall between semi-permeable and an impermeable material.

3.3 Rainfall Estimate

Rainfall data was extracted from software that implements the procedures developed by Smithers and Schulze (2003) to facilitate rainfall depths for any location in South Africa. The software estimates design rainfall in South Africa. (See Appendix A for summary of results)

Smithers and Schulze utilised data from 1806 rainfall stations in South Africa which have at least 40 years of recorded history. Quality controlled daily records were utilised to identify 78 relatively homogeneous clusters of extreme daily rainfall in South Africa. For each cluster and for all durations (5 minutes to 7 days) and return periods (2 to 200 years) considered, a growth curve relating the scaled design rainfall depth to return period was developed.

A 2 minute grid was established across the Belfast area catchment in order to apply the rainfall profile to the model as shown in Table 3.3

Table 3.3 - Rainfall data generated by software implements the procedures developed by JC Smithers and RE Schulze

Latitude		Longitude		MAP	Altitude	Duration	Return Period					
(°)	(')	(°)	(')	(mm)	(m)	(m/h/d)	2U	5U	10U	20U	50U	100U
25	42	30	3	822	1899	24 h	75.5	100.1	118.1	136.3	161.9	183.2
25	40	30	1	783	1844	24 h	74	98.1	115.7	133.6	158.6	179.5
25	41	30	2	782	1862	24 h	73.7	97.8	115.3	133.2	158.1	178.9
25	42	30	1	783	1859	24 h	74.3	98.5	116.2	134.2	159.3	180.3
25	42	30	2	779	1871	24 h	73.6	97.7	115.2	133	157.9	178.7
25	41	30	3	782	1887	24 h	72.9	96.7	114.1	131.7	156.4	177
25	42	30	0	754	1860	24 h	72.6	96.3	113.6	131.2	155.7	176.2
25	43	30	4	774	1920	24 h	72.3	95.9	113.1	130.6	155.1	175.5
25	40	30	2	751	1875	24 h	71.2	94.4	111.4	128.6	152.7	172.8
25	41	30	1	753	1862	24 h	72.3	95.9	113	130.5	155	175.4
25	43	30	2	749	1884	24 h	71.9	95.3	112.4	129.8	154.1	174.4
25	39	30	1	738	1875	24 h	70.8	93.9	110.8	127.9	151.9	171.9
25	43	30	0	726	1860	24 h	71	94.1	111	128.2	152.2	172.2
25	43	30	3	755	1934	24 h	71.3	94.6	111.6	128.9	153	173.2
25	39	30	3	728	1871	24 h	69.4	92.1	108.6	125.4	148.8	168.4
25	40	30	3	743	1902	24 h	69.8	92.6	109.2	126.1	149.7	169.4
25	40	30	4	748	1923	24 h	69.8	92.6	109.2	126.1	149.8	169.5
25	40	30	0	702	1860	24 h	69.1	91.7	108.1	124.9	148.2	167.8
25	41	30	4	729	1920	24 h	68.7	91.2	107.5	124.1	147.4	166.8
25	42	30	4	732	1923	24 h	69.3	91.9	108.3	125.1	148.5	168.1
25	43	30	1	707	1890	24 h	69.3	92	108.5	125.2	148.7	168.3
25	39	30	0	699	1880	24 h	68.7	91.1	107.5	124.1	147.3	166.8
25	41	30	0	690	1878	24 h	68.4	90.7	107	123.5	146.6	166
25	39	30	2	694	1896	24 h	67.5	89.6	105.7	122	144.9	164
25	39	30	4	668	1935	24 h	64.9	86.1	101.5	117.2	139.2	157.5

Daily rainfall depths for Belfast mine were taken at an average for each period calculated as shown in Table 3.4 is as follows

Table 3.4 - Rainfall Average 90th Percentile

Return Period (years)	2	5	10	20	50	100
Daily Rainfall Depth (mm)	70.9	94	110.9	128.1	152	172

3.3.1 Roughness Coefficient

The design of drainage waterways, culverts and structures shall be based on sound hydraulic principals in order to effect an optimum combination of efficiency and

economy. Roads, drainage channels and culverts shall be designed using the Manning formulae with coefficients of roughness shown in the table 3.5 below.

Table 3.5: Open Channel – Manning roughness Coefficients

Open channel Manning roughness coefficients	
Lined channels	
Concrete	0.014
Grouted stone	0.025
Rock Rip-Rap	0.035
Paving Blocks	0.025
Gabion	0.028
Unlined channels	
Earth uniform section	0.030
Rock cuts	0.040

3.4 Clean and Dirty Water division

A dirty water area is any area at the mine or activity which causes, or is likely to cause pollution of the water course.

3.4.1 Plant Area

For drainage layout see drawing 224748-SW-CA-0101-02. Network A forms part of the boundary between the dirty water and clean water area. This drain is designed to carry the 1:50 year event from the stockpile area.

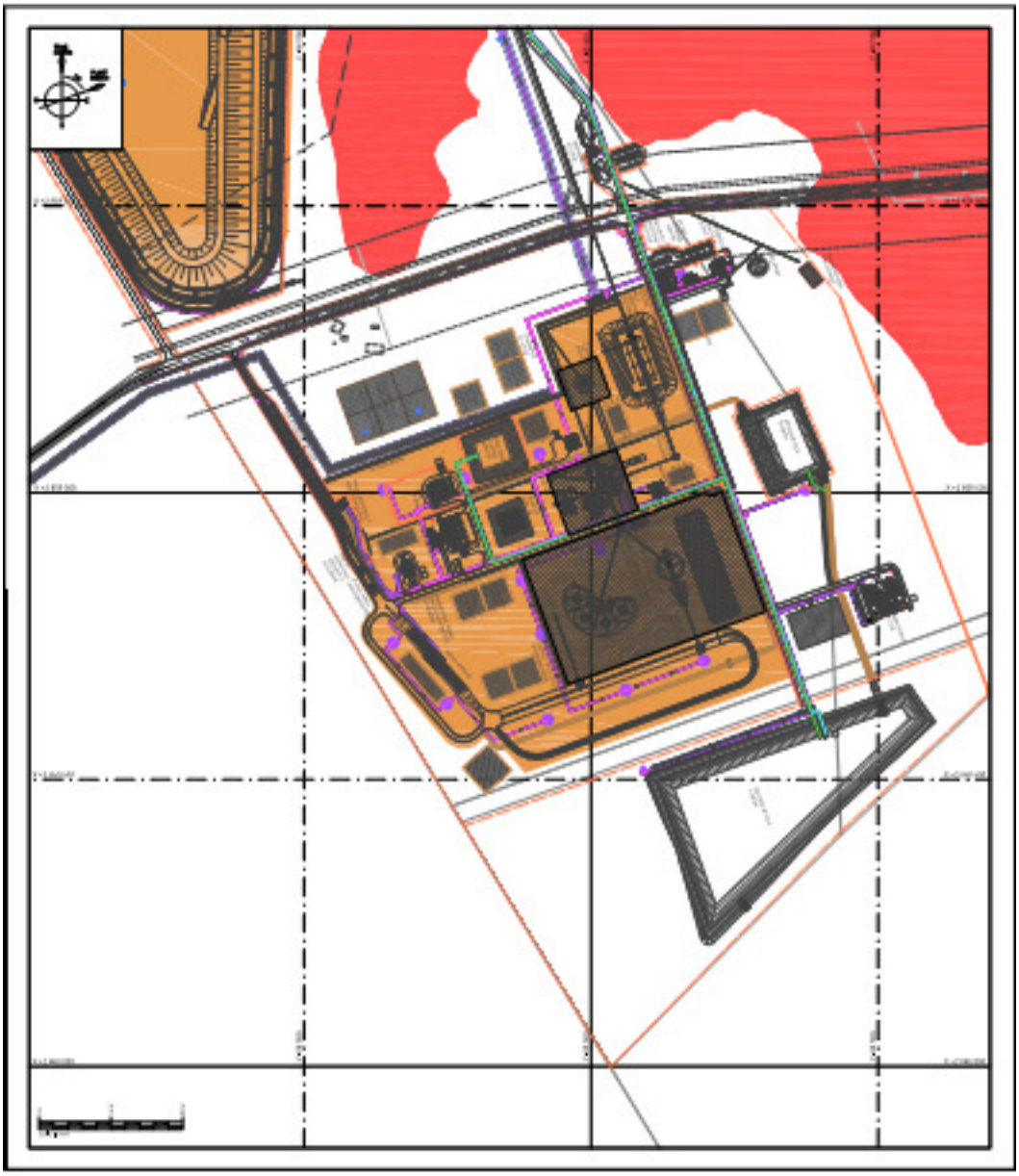
All the dirty water channels feeding into Network A have been design to convey the 1:10 year return. Humps will be placed at the end of Plant Link Road across the road to drain water to network A and to prevent the spillage of dirty water into the clean water area.

A berm is placed between the clean water area and dirty water channel running from dam D4 to dam D5 to prevent spillage of clean water into the dirty water area. Network E (channel connection D4 and D5) is design to convey the 1:100 year return. Where clean water collecting at low points adjacent dam D4 and the dirty water channels a concrete structure will be placed over the dirty water channels (Network A and E adjacent to dam D4) to discharge clean water back into the environment.

The roads to the west of the plant will serve as a clean water diversion barrier. The contours in this area fall away from the plant assisting in the drainages of clean water.

Clean water from the areas between the Process water dam and Road D1770, the interlink truck parking and the Plant Office Road discharge through the existing drainage system provide along Road D1770 and will eventually discharge into the Klein Komatie River. To prevent the spillage of dirty water into the clean water area a berm has been provided on southern side of the clean water area.

The drawing below is a view of the proposed demarcated dirty water areas for which pollution control dams has been provided.



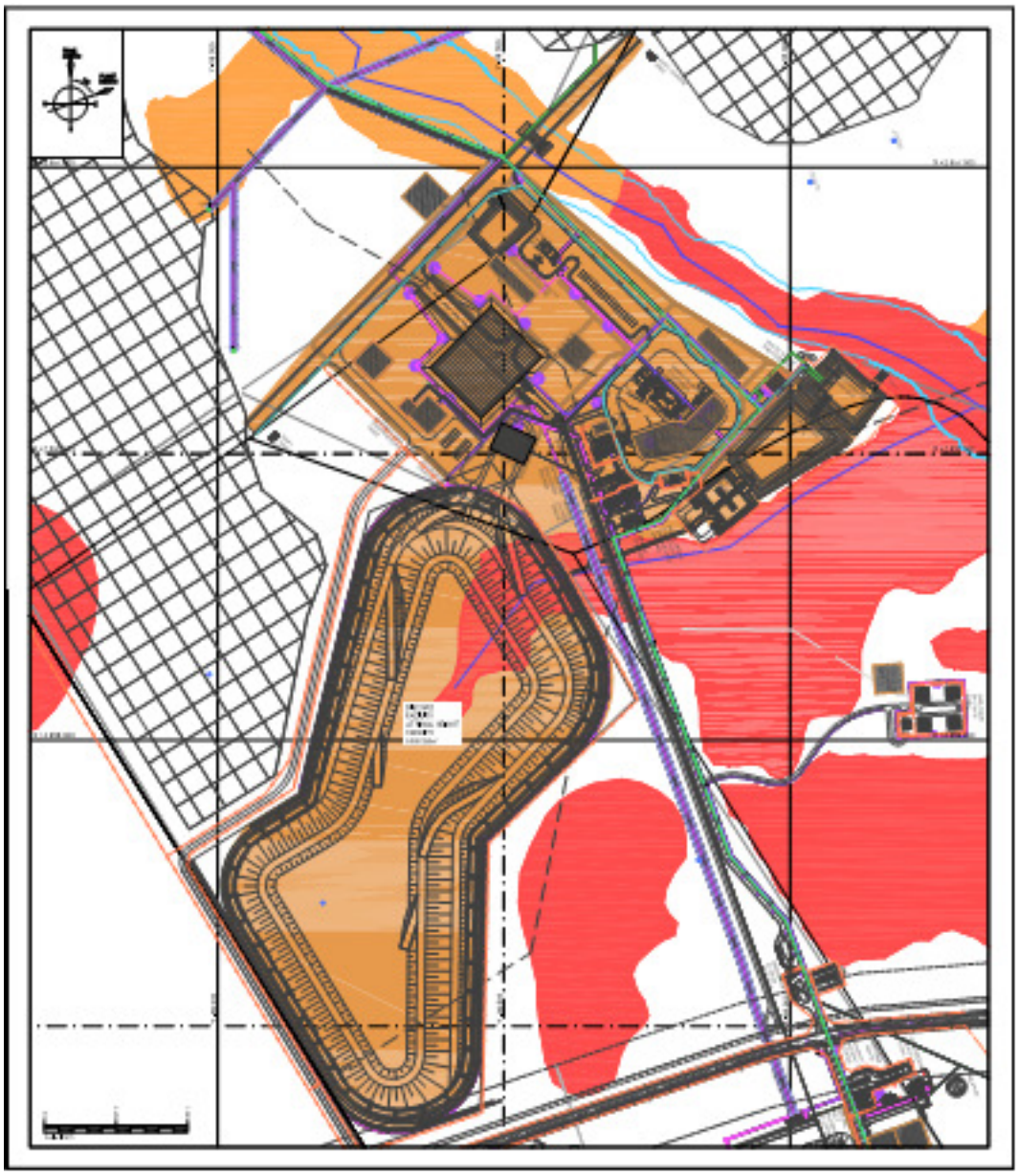
Plant Dirty Water Area

3.4.2 Mining Area

A dirty water channel running parallel to the Klein Komati river. This channel carried the dirty water from the Tip and Primary crusher stockpile, Mobile

Equipment Yard, Discards roads and Discards Stockpile area. The dirty water channel running North East carried storm water from the Discard dump through a silt trap to dam D2-3 Pollution Control Dam. Both channels are designed to convey the 1:50 year storm event.

The drawing below is a view of the proposed demarcated dirty water areas for which pollution control dams has been provided



Mining Dirty Water Area

3.4.3 Design Data

The basic design information for the channels is appended to Appendix A.

3.5 Sediment Control Structures

3.5.1 Objective

Sedimentation traps are required to manage coarse sedimentation from the disturbed mining areas before it enters into the major silt basin. Stormwater runoff is collected from dirty water areas in stormwater channels and is routed through the silt traps.

All mining operations involving earthmoving, stockpile areas, Discards, tips and primary crushing, including haul roads are sources of sedimentation.

Sediment control measures aim to capture soil particles by slowing down the velocity of stormwater flow so that particles can settle out by gravity. In a coal mine environment the fine coal silts and sands swept along due to rainfall runoff and are eventually transported in streams due to high velocities.

Silt traps are placed as close as possible to the major sediment source as possible. The coal washing plant and stockpile areas are identify as major sediment source. The silt traps are placed directly downstream of the major sediment to remove the coarse fraction of the sediment.

Sediment basins are runoff detention systems that promote settling of sediments through the reduction of flow velocities and temporary detention. It is important to note that 100% sedimentation of incoming particles is not feasible due to practical limits of storage space, cost and settling time available and should be used in conjunction with other erosion control measures.

3.5.2 Silt Trap

3.5.2.1 Design Criteria and Assumptions

The trap has been divided into two compartments which together can handle the 1:10 year return event with penstocks fully opened to match the channel design capacity. During low flow the entrance to one of the traps can be closed off for drying and removal of the silt in one bay. Table 3.10 below indicates the volume of dirty runoff for the channel catchment for the 1:2 (utilising one bay) and 1:10 year rainfall event (utilising two bays).

3.5.2.2 Maintenance

The silt trap is recommended to be cleaned out regularly, preferably before the rainy season. Cleaning out can be done with a TLB or Bobcat. It is recommended to clean out the bays when 50% full since it can become difficult to remove when the silt level is too deep. When cleaning is to be carried out one bay can be closed off.

Drainage pipes and a sump have been provided to drain trapped stormwater runoff. A portable pump can be used to draw down the water elevation in the silt trap prior to cleaning.

3.5.3 Sedimentation Basin

3.5.3.1 Design Criteria and Assumptions

The table below indicates the storage volume, runoff and settling velocity for the basin catchment for the 1:2 and 1:10 year rainfall event. The Stokes Law equation is used to calculate the settling velocity of a particle:

$V_p = (g/18\mu)(s-1)\ D^2$ Where

- Vp is settling velocity
- g is gravitational constant
- μ is viscosity of fluid
- S is specific gravity and
- D is diameter of the particle

For calculations see addendum A5

Table 3.10: Basin Catchment, Runoff and storage volume.

	Catchment (Ha)	Velocity 1:2y (m/s)	Velocity 1:10 y (m/s)	Flow Q_2 (m^3/s)	Flow Q_{10} (m^3/s)	Storage Volume (m^3)	Minimum particle settling out (micron)
Plant Area	38.57	0.38	0.44	1.79	3.00	1668	77
Mining Area	79.91	0.37	0.46	1.8	3.03	914	61

Basin design criteria.

- The inlet section of the basin has been designed to reduce the incoming velocity and to distribute the overflow evenly to prevent scour of the settled sediment.
- The velocity in the settling zone must be such as to allow settling of the particles and to prevent excessive turbulence and mixing.
- The discharge section of the basin has been placed at the opposite end of the inlet section and designed to maintain a minimum freeboard of 800mm
- A long rectangular sedimentation basin can be divided into four different functional zones:
- Inlet zone: Flow is uniformly distributed over the channel cross section not to disturb the settled material
- Settling zone: Settling of coal, sand and silt occurs in this zone

- Sediment Storage zone: The storage zone is size for regular cleaning to reduce storage capacity. Storage volume is given in table 3.10.
- Outlet zone: Clarified effluent is collected and discharged through outlet risers into the pollution control dam.

Embankment Requirements

- Maximum upstream slope – 1:3
- Maximum Downstream Slope – 1:4
- Freeboard – 800mm
- Crest 5.0m

Dewatering Provisions – Outlet Riser and pipe

- 3 by Outlet Risers have been provided to drain the basin to enable cleaning operations.
- Minimum outlet pipe diameter of 250 mm
- 2 – year and 10 - year 24-hour storm flow rates
- Anti-vortex device provided
- Minimum 300mm elevation difference from the top of the riser to the crest of the emergency spillway.
- The outlet riser has been designed to dewater the basin down to the cleanout elevation.

Emergency Spillway Location

- The outlet must pass peak runoff from the 1:100 year storm.
- The spillway has been placed at the opposite side of the inlet to allow a particle to follow the longest path through the basin.
- The design height water level through the spillway is 300mm below the top of the embankment.

3.5.3.2 Access for Maintenance

Accessibility for maintenance is an important design consideration. If an excavator (potential damage by bucket teeth to surface and to be managed with assistance) is able to reach all parts of the sedimentation basin from the top of the batter, an access ramp may not be required. Access ramps will be provided to freeboard level at storm water dam D2-2 for bobcat access. A 5m wide access track around the perimeter of the sedimentation basin has been provided for the movement of cleaning equipment. A culvert crossing over the channels has also been provided to get access to the silt basin in the mining area.

Downstream batters have been sloped to a1:4 fall to make it possible for earthmoving equipment to access the sediment basin for cleaning purposes. If sediment collection requires trucks to enter the sedimentation basin, a stable ramp must be provided into the base of the sedimentation basin (minimum slope 1:10).

3.5.3.3 Maintenance

General guidelines for sedimentation basin operation are:

- Basin must be inspected and maintained at regular intervals and also after each period of heavy rains.
- The depth of sediment in the sedimentation basin must be monitored at sufficient intervals to plan sediment removal. Normally a basin is allowed to fill with sediment up to 50% of is effective depth, with 1.5m depth of pond liquid above sediment.
- The sediment removed from the basin may be disposed of at the discard dump.

The maintenance plan should address the following:

- Inspection frequency;
- Maintenance frequency;
- Data collection/storage requirements (i.e. during inspections);
- Detailed clean out procedures (main element of the plan) including:
  - Equipment needs
  - Maintenance techniques
  - Occupational health and safety
  - Environmental management considerations
  - Disposal requirements (of material removed)
  - Access issues

3.6 Floodline assessment

The development falls under sub clause 4a of 704 on Regulations on Use of Water for Mining and Related Activities Aimed at the Protection of Water Resources, which stipulates that the development should be outside the 1 in 100 year floodline or at a distance of at least 100m from the watercourse, whichever is the greater. It was therefore necessary to determine the 1 in 100 year floodline for the Klein Komati River along the development.

3.6.1 Previous Floodline Assessment

There is an existing 1 in 100 year floodline for the Klein Komati River, from a previous floodline assessment done by Golder. The 1 in 100 year floodline determined by Arup for this study was overlay on top of the Golder floodline. The floodlines compare favourable and the result can be seen in fig 2 below.

3.6.2 Proposed Haul Road Culvert

The proposed haul road culvert should be designed to pass the 1 in 50 year flood peak without overtopping. The impact of the proposed haul road culvert on the 1 in 50 year floodline was investigated as part of the floodline assessment.

3.6.3 Flood Determination

3.6.3.1 Catchment Area and Topography

The catchment area for the Klein Komati River at the development is approximately 21 km2. The average watercourse slope is approximately 1%. The catchment characteristics are summarised in Table 1.

3.6.3.2 Design Rainfall

The design rainfall was obtained from the software, Design Rainfall Estimation in South Africa (Smithers and Schulze, 2002). This is described in more detail in Section 3 above. The mean annual precipitation obtained for the catchment is 782mm.

3.6.3.3 Land Cover and Soils

Catchment soils are assumed to be similar to soils at the development site, described in Section 3 above. 50% of the catchment area was assumed to be semi permeable and 50% impermeable. Information on land cover was obtained from observations made on site. From the observations, the land cover was classified as light bush and farmlands.

3.6.3.4 Flood Peak Calculation

The Rational Method was used to determine the flood peaks for the floodline assessment. The rational method results are summarised in Table 1.

Table 1: Catchment characteristics and Flood Determination Results

Catchment Area	21 km²
Length of longest watercourse	7.3 km
Average Slope, of watercourse	1%
Mean Annual Precipitation (MAP)	782 mm
1 in 50 year flood peak (m^3/s)	64
1 in 100 year flood peak (m^3/s)	87

3.6.4 Flood Profile Computation

The flood profile computation was carried out using the HEC RAS river analysis system. This is a generally accepted river flood modelling computer programme, developed by the U.S. Army Corps of Engineers.

Civil 3D software was used to extract cross sections of the river channel and flood plain from the LIDAR survey of the site, for input into HEC RAS.

The haul road culvert was included in the HEC RAS model of the river reach.

The selection of the Manning's roughness coefficient for the river cross sections was based on observations made on site. A roughness coefficient of 0.04 was used, depicting a grassed channel and floodplain.

The 1 in 50 year and 1 in 100 year flood peaks calculated with the rational Method, Alternative Rational and SDF method, were used to calculate a flood level at each cross section.

3.6.5 Floodline Results

The Arup 1 in 50 and 1 in 100 year floodlines are shown on Drawing 224748-CS-CA-0103-01 in Appendix A3, together with the Golder 1 in 100 year floodline. Also shown on Drawing 224748-CS-CA-0103-01 are the cross sections used to produce the Arup floodlines. The full HEC RAS results for the floodline are included in Appendix A3.

Drawing 224748-CS-CA-0103-01 shows that the Arup 1 in 100 year floodline is similar to the Golder 1 in 100 year floodline downstream of the proposed culvert. This instils confidence in the floodline assessment.

The Regulations on Use of Water for Mining and Related Activities Aimed at the Protection of Water Resources, require that no part of the development be placed within the 1 in 100 year floodline; however a portion of the fence around stormwater dam D2-3, fall within the floodline. In order to comply with the regulations, the position of these services must be adjusted during detailed design.

3.6.6 Haul Road Culvert Results

The haul road culvert parameters modelled and the results obtained for the 1 in 50 year flood peak are summarised in Table 2. The results show that, for the 1 in 50 year flood, the culvert design allows flow through the culvert, without overtopping of the haul road, and with allowance for 300mm freeboard. The full HEC RAS results for the culvert are included in Appendix A3.

Table 2: Haul Road Culvert details

No of barrels	4
Shape	Box
Width (m)	3.6
height (m)	1.5
Upstream Water surface level	1762.58
Maximum allowable water surface level (Road shoulder break point with 0.3m freeboard allowance)	1762.66

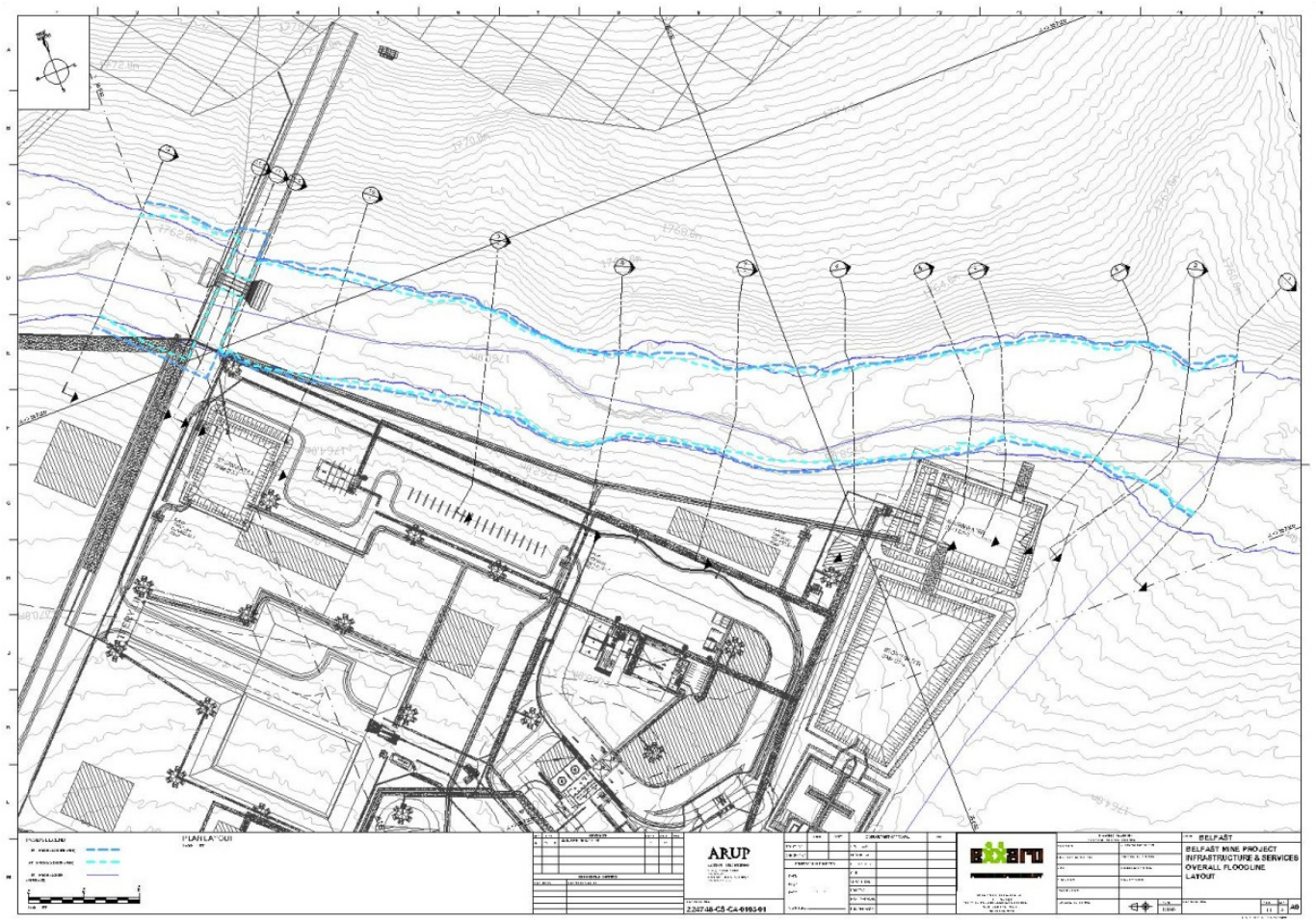


Figure 2: 1 in 50 and 1 in 100 year floodlines

4 Roads and Stormwater

4.1 Roads

4.1.1 Design Codes/Guidelines

Table 4.7: Design Guidelines for Pavements and Road Geometry

Design Requirements for Road Geometry	MCG-O78-0000-0000-C-SPC-008
Design Requirements for Flexible Pavements	MCG-O78-0000-0000-C-SPC-001
Design Requirements for Rigid Pavements	MCG-O78-0000-0000-C-SPC-007
Design Requirements for Segmental Concrete Block Pavements	MCG-O78-0000-0000-C-SPC-009
Chapters 7 of "Guidelines for Human Settlement Planning and Design"	CSIR Building and Construction Technology
Catterpillar® Haul Road Design and Management	CAT Global Mining

4.1.2 Geometric Design

Table 4.9: Road classification for Belfast Mine

Roads have been classified into 4 different classes as follows:	
Minor Gravel Roads	Roads used primarily along perimeter fencing, conveyers and service roads where occasional accesses are required.
Gravel Road	Provide access for vehicles in and around the plant sites or other industry centres within the area.
Surface Treated Roads	Used primarily for access to plant for the import and export of product and around the plant, Offices and for the delivery of goods to the supply chain store and mobile equipment yard
Mine haul Roads	Restricted uses by mine haul heavy vehicles.

The table below provide the minimum geometric design parameters

Table 4.10: Geometric design Parameters

Description	Minor Gravel Roads	Gravel road	Main Plant and Office Road	Mine Haul Roads
Elements of design				
Design speed (km/h)	15 - 25	25 - 35	40	15 - 25
Cross Section Design				
Carriageway width (m)	4 to 5m	6 to 8m	6 to 7m	15 to 20m
Shoulder	0.5m	1m	1m or kerbed	1m
Cross fall	One-way – 2% typical	Two-way – 2% typical	Two-way – 2% typical	Two-way – 2% typical

Surfacing type	Thin layer Gravel wearing course.	300mm Gravel wearing course	Bituminous surface treatment	Gravel
Stopping Sight Distance				
Stopping Sight Distance	30	30	40	30
Horizontal alignment				
Minimum radius (m).	15	15	15	50
Vertical Alignment				
VC sag (k)	1	4	6	1
VC crest (k)	1	21	8	1
Min vertical curve (m)	10	20-40	80	40
Gradients				
Min. Grad.(%)	0.5	0.5	0.5	0.5
Max. Grad.(%)	10	10	10	10

4.1.3 Minor Gravel roads

Minor gravel roads provide access to areas where occasional access is required for maintenance, repair or regular inspections. The following roads are considered as minor gravel roads:

Table 4.1: Minor Gravel Roads

Road	Description	Length (m)
Plant Area		
Main 22Kv Road	Provide access to the Main 22 Kv Substation	163
Mining Area		
Conveyor Maintenance Road	Access is off the Mine Access road and provide access for maintenance vehicles for repair or maintenance work on the conveyers	1073.79
WWTW Road	This road provides access to the Waste Water Treatment Works, Booster Pump station and D4 Pump station. It also provides access to the silt basin.	270.71
Prills and Explosives road	Provide access to deliver explosives and Prills from the suppliers and loading of materials for blasting operations.	608.00
	Total	2115.5

4.1.4 Gravel Roads

Gravel roads are used primarily by vehicles in and around the plant sites or other activities within the area. The table below is a summary of all the gravel roads:

Table 4.2: Gravel Roads Mining Area

Road	Description	Length (m)
Heavy Plant Access Road	Provide access to the plant off-loading area for heavy vehicles.	1548.69
Matrix Silo Road	Provide access for delivery vehicles for off-loading and also access from the haul road for loading Matrix	308.4
	Total	1857.09

4.1.5 Surface treated Roads

The roads will join all the respective plant and mining areas. It also provides access to the National Road. The table below summarized the Surface Treated roads.

Table 4.3: On Site Surface Treatment Roads

Road	Description	Length (m)
Plant Area		
Plant Access Road	Provide access for trucks to security and the Weigh bridge. 30 parking bays have been allowed for trucks to park.	530.23
Weighbridge Road	This area contains the weighbridge for weighing empty and full trucks	270.972
Weighbridge Return Road	Provide access for overloaded/ half loaded trucks to return to the Export Middling's Area	372.00
Middling's and Export Road	Provide access to the Export and Middling's loading bins. It also provide standing space for trucks to queue in the case of an emergency or breakdown	1051.00
Office Road	Provide access to the Offices and Plant area.	912.20
Conference Road	Provide access to the change house and Conference and clinic facility	118.00
Office Building Road	Provide access to the Office and Water treatment Plant	311.0
Magnetite Road	Provide access for delivery vehicles and for the off-loading of silt to the 3600t weekend discard stockpile	205.20
Plant Link Road	This road links the weighbridge area with the Offices, conference and clinic and change house areas	625.51
Supply Chain Road	Provide access to the LV wash bay, Workshop and Supply Management Store	329.00
Mining Area		
Mine Access Road	Provide access to the Mining Area	1241.64
	Total	5966.68

4.1.6 Tip and Primary Crusher Haul Road (Red Area Roads)

Haulage Roads for the CAT 773 – Between the western and eastern lymph pit Boundaries, Tip and Primary Crusher, and Mobile Equipment Workshop

Table 4.5: Haul Roads

Road	Description	Length (m)
Haul Road 1	Runs in a north south direction and links the two lymph pits on either side of the river	960.51
Haul Road 2	Provide access to the Mobile equipment yard, HV Wash bay, and diesel depot	1057.68
	Total	2018.19

The minimum road width for straight double lane haul road is 3.5 times the operating width of the largest truck using the haul road. The operating width for a CAT773 is 5,673m therefore the minimum road width is 3.5x5,63 = 19,705m

On a curved section a factor of 4 should be applied to allow for the front and rear overhang. Therefor the width is 4x5,673 = 22,5m

4.1.7 Dump Haul Road (Red Area Roads)

Haulage Roads for the CAT 740 has been provided between Discard Dump, Discard Bin and mobile equipment Workshop

Table 4.6: Dump Haul Roads

Road	Description	Length (m)
Discard Link Road	Provide access to the Mobile Equipment yard and diesel Depot. Road Width = 15m (Connecting to Haul road 1)	356.50
Discard Bin Road	Provide access between the Discards and the loading bin. Road width = 7m (One direction traffic)	334.52
	Total	691.02

The operating width for a CAT740 is 3,82m therefore the minimum road width is 3.5x3,82 = 13,37m

On a curved section a factor of 4 should be applied to allow for the front and rear overhang. Therefor the width is 4x3,82 = 15,28m

4.1.8 Parking and Bus Offloading areas

Employees need to park their car at the place of work almost every day. Therefore they need their own parking space assigned. This space should be as close as possible to the place of work.

Visitors parking opposed to staff parking are temporary or require short term parking.

The number of parking bays required is also influenced by the availability of public transport in the area. In general mine workers will be transported by busses

to the mine while the operators and the more senior staff would generally prefer to use their own transport.

The demand for parking bays selected for the Belfast mine has been decided by the owner's team and the table below gives a summary of the number of parking bays for each work place.

Table 4.3: Parking

Road	Description	Covered Parking Bays	Open Parking Bays	Area (m^2)
Plant Area				
Visitors, Drop off, and Staff Parking	Parking has been provided for visitors, staff and deliveries at the main Security building as follow: • Staff • Drop off zone(64 seated bus) • Visitors • Gravel Overflow Parking	 30	 2 25 10	2084.30
Conference and Clinic	Open Parking has been provide at the conference and clinic centre.		10	212.50
Office Staff and visitors Parking	Parking has been provided as follow: • Staff • Visitors	 48	 10	2483.00
Master Control Room Parking	Limited parking has been provided for mine vehicles and parking for the senior staff.		6	143.00
Workshop Parking	Parking has been provided as follow: • Staff • Mine vehicles and deliveries	 10	 14	1102.00
Supply Chain Management Parking	Parking has been provided for delivery and mine vehicles		7	282
Interlink Truck Parking	Parking has been provided for 30 trucks before the Plant Security entrance. The purpose of this is to allow for cases of fog, plant break downs or before the gates open in the morning and to keep the trucks off the provincial road		30	3074
Mining Area				
Mine Security Parking	A drop off zone will be provided for a 64 seater bus outside and inside the mining area. The mine bus transports the mine staff to the change house. Parking for staff has been provided who prefer to use their own transport • Drop off area outside the security gate		 2 by 64 seats or 4 by 32 seats	588

	• Drop-off area inside the mine area • Staff Parking • Gravel area for overflow parking	 24	2 by 64 seats or 4 by 32 seats 24	 1256
Mine Staff Parking at Mining Office	Staff parking has been provided at the mining office		20	454
Change House Bus Parking	Provision for day time parking for staff busses has been made at the change house		4 by 64 seats bus	
Change House pickup parking	Daytime parking has also been provided for the mining bus transporting staff to the mine and back		3 by 32 seats bus	
Mine vehicle Parking	Parking for mine vehicles has been provided inside the red area	10		
Mobile Equipment Workshop	Allowance has been made for a gravel parking area at the workshop		14	
Discards Mobile Equipment parking	Parking has been provided for discards trucks		10	
Dump Truck Parking	Parking adjacent to the mobile equipment workshop has been allowed for weekend parking of the trucks		18	
	Total			13287.38

4.1.9 Walkways

Walkways have been provided for in the plant area and the mining area. A continues handrail has been placed along the east side of the walkway to aid pedestrians. The walkway path consist of segmented paving

4.1.9.1 Plant Area

The walkway links the drop-off zone with the Change House and from the change house runs parallel to the Office road, and forms a connection with the Plant Workshop. A turnstile has been placed where staff enters the Plant area. Staff entering the plant area has to clock in at the turnstiles.

4.1.9.2 Mining Area

The walkway starts from the Change House and passes the diesel depot. After the diesel depot the walkway splits and branches off to the Discards Area. The other branch of the walkway goes to the Mobile Equipment yard. Staffs gets access to the mining area by clocking in at the turnstile placed adjacent to the mining Change House.

4.1.10 Pavement Design

4.1.10.1 On site Surfaced roads

The pavement design is based on THR4:1996. The pavement for surfaced roads has been designed to meet the following requirements:

- Sufficient thickness to distribute the wheel load stresses to a safe value on the sub-grade soil
- Structurally strong to withstand various types of stresses imposed upon it
- Adequate coefficient of friction to prevent skidding of vehicles
- All weather surface so that traffic safety is not impaired by reducing visibility.
- Impervious surface, so that sub-grade soil is well protected
- Long design life with low maintenance cost

During the designing of the pavement the following has been taken into account:

- The design lifetime of the facility.
- The estimated E80 axle loading over the design lifetime.
- Available construction materials
- The macro-climatic region in which the facility is to be constructed.
- The maintenance related to the type of pavement design.
- Based on traffic counts done on the national roads from and to the mine including the mine coal trucks, the Annual Daily Traffic (ADT) has been estimated for the link road and the Main Plant Road, which will be used to design the pavement structure. (Reference Belfast Roads report, number Rep/01 draft 2.3 of 4 January 2013.)
- Traffic counts for the Office Road are based on traffic counts previously done for Glisa Mine by ARUP and adjusted to match the expected traffic for Belfast mine. (Reference Belfast Roads report, number Rep/01 draft 2.3 of 4 January 2013.)

The table below summarises the design of the pavements

Table 4.11: Pavement design

Road type	Minor Gravel Roads	Gravel Roads	Main Plant Roads	Office Road and ancillary Roads	Mine Access Road
Analysis Period	17 years				
Climate Region	Wet Moderate				
Design Traffic Indicative volume (v.p.d.)	1 - 25	25 - 100	639 (100% heavy vehicles)	350 (2 % Heavy vehicles)	60(16 % Heavy vehicles)

Growth Rates adopted		N/A	N/A	0	0	
Growth rates in heavy vehicles		N/A	N/A	0	0	
Total E80's per lane				30×10^6	0.17×10^6	0.35×10^6
Road Category		N/A	N/A	UA	UC	UC
Pavement Structure	Pavement Class	N/A	N/A	ES30	ES0.3	ES1
	Surface	150 mm Gravel	200 mm Gravel	40 mm Asphalt	Single Seal	Double Seal
	Base Course	N/A	150 mm G5	150 mm G1	125 mm G4	125 mm G4
	Upper Sub-base	N/A	N/A	150 mm C3	125 mm C4	150 mm C4
	Lower Sub-base	N/A	N/A	150 mm C3	N/A	N/A
	*USSG	150 mm G7	150 mm G7	150 mm G7	150 mm G9	150 mm G9
	*LSSG	150 mm G9	150 mm G9	150 mm G9	150 mm G10	150 mm G10

*The in-situ material appears to be of a G7 type material but show signs of collapsibility and will be impact rolled.

4.1.10.2 Haul Roads (Red Area Roads)

The pavement for the haul roads has been design to meet the following requirements:

- Sufficient thickness to distribute the wheel load stresses to a safe value on the sub-grade soil
- Structurally strong to withstand various types of stresses imposed upon it, thereby reducing rolling of layers
- Provide necessary traction where required and reduce roughness to prevent wear to vehicles
- Allowed for a dust palliative (Dust Treat or Similar) to be placed so that traffic safety is not impaired through reduced visibility.

During the designing of the pavement the following has been taken into account:

- The design lifetime of the facility.
- The estimated amount of heavy vehicles over the design lifetime.
- Available construction materials
- The macro-climatic region in which the facility is to be constructed.
- The maintenance related to haul roads to reduce possible delays.

The table below summarises the design of the pavements

Table 4.11: Pavement design (Red Area Roads)

Road type		Dump Haul Road	Pit Haul Roads
Analysis Period		17 years	
Climate Region		Wet Moderate	
Design Traffic Indicative volume (v.p.d.)			
Growth Rates adopted		N/A	N/A
Growth rates in heavy vehicles		N/A	N/A
Total E80's per lane		N/A	N/A
Road Category		N/A	N/A
Pavement Structure	Pavement Class	N/A	N/A
	Surface Course	2 x 150 mm layers G4 2 x 150 mm layers G8 stabilised	2 x 150 mm layers G4 2 x 150 mm layers G8 stabilised
	Base Course	4 x 150 mm layers G8 stabilised	4 x 150 mm layers G8 stabilised
	USSG/In-situ Material	impact rolled	impact rolled

*The in-situ material appears to be of a G7 type material but show signs of collapsibility and will be impact rolled.

4.1.10.3 Trade-off Study of pavements proposals.

The following pavement structure has been proposed as listed in the table below:

Table 4.11 (a): Pavement Structure

Pavement Type	Tensar - TriAx	PC Grid
Surface Course	450 mm layers G4 Tensar TX 160	900 mm layers G6 2 x PC Grid Layers
Base Course	250 mm layers G5 Tensar TX 160	

The cost comparison is given in table 4.11 (b) below. It can be seen that the Modified pavement is the most economical solution and therefor adopted in the design of haul road pavements

Table 4.11 (b): Cost Comparison

Standard	R11 702 524,77	

Modified	R5 887 472,29	
Tensar - Triax	R9 939 829,13	
PC Grid	R10 396 420,00	

4.1.10.4 Off-site roads D1110 and Road D1770

The pavement design for off-site surface roads has been reported in the Belfast Roads Report, report number Rep/01 draft 2.3 of 4 February 2013

4.1.11 Weekend Parking area for the Cat 773/Cat740

CAT 773 will park at the shift change area inside the pit area and during weekends will park in an area provided adjacent the Mobile Equipment yard.

4.1.12 Brake Test Ramp

Break Test ramp will be constructed by the mine adjacent Haul rd 2 opposite the Shovel Laydown area.

4.1.13 Discard Contractor's Yard

A Discard contractor's yard and parking area has been provided for the Cat 740 vehicles for office facilities, workshop and parking north of the discard facility.

4.2 Storm Water Design for Road Drainage Structures

4.2.1 Hydraulic Design Criteria

The hydraulic design of the road drainage elements has been carried out in accordance with the following standards:

- The Mean Annual Precipitation (MAP) for this area is 783mm. The peak discharge used in the hydraulic design of the culverts and bridges were determined using the Rational formula and verified with Alternative Rational and SDF formula.
- The peak discharge was determined for each drainage culvert. The table 4.13 below lists the relevant peak discharge flows and design return periods.
- Culverts directly linked with lined stormwater channels have been designed as a channel with allowance for freeboard.
- The 1:50 year peak discharge was use to size the major drainage culvert at haul road 1.
- Back flow calculations indicate that the haul road 1 will not overflow in a 1:50 year rainfall event. (Refer item 3.6)

4.2.2 Surface Drainage

Provision for culverts has been made to allow clean stormwater run-off to flow from higher areas to lower areas across the road. The minimum diameter of the

pipe culverts is 600mm, while the height of the portal culverts ranges from 900 mm to 1500 mm.

4.2.2.1 Minor Drainage Culverts

The pipe and portal culverts are indicated on the road drawings. Culverts placed inside dirty water channels at road crossings are shown on the drainage long sections.

Provision for culverts has been made to allow clean stormwater run-off to flow from higher areas to lower areas across the road. The minimum diameter of the pipe culverts is 600mm, while the hight of the portal culverts ranges from 900 mm to 1500 mm.

4.2.2.2 Major Drainage Structures

The 1:50 year Design Return period is applicable to the hydraulic design in terms of the SANRAL Road Drainage Manual - 2006. The hydraulic design parameters of the Major Culvert are summarised in Table 4.13 below.

Table 4.13: Hydraulic Design for the Major Culvert at Haul Road 1

Method used to Determine Hydrology	1:50 Year Design Peak Discharge	Catchment and Design Rainfall details	
Rational Formula, Alternative Rational SDF Method	64 m3/s 74m3/s 86m3/s	Catchment Area: Rainfall Intensity: MAP: Design Duration:	20,74 km2 38.43 mm/hr 783 mm 2.24 hr

4.3 Structural Design of the Major Culvert over Klein-Komatie River

4.3.1.1 Design Criteria

The major culvert has been designed in accordance with TMH7: parts 1 to 3, "*Code of Practice for the Design of Highway Bridges and Culverts in South Africa*", as amended.

4.3.1.2 Traffic Loading.

The type of traffic using the haul road falls outside the scope for standard traffic loading for highway bridges. The expected traffic loading provided by Exxaro is for the PC 1250 excavators, CAT740 articulated trucks and CAT733 rigid type Trucks.

4.3.1.3 Application of Traffic Loading

The structure has separately been examined for the effects of forces which can coexist in every possible combination for the proposed traffic loadings.

4.3.1.4 Foundations

The geotechnical report for Belfast mine will be available in 2014. Hole no CL01 provides the following data:

- 150mm Dark brown, very loos fine silt sand. Topsoil
- 450mm Orange brown, very loose, pinhole voided, silt fine sand. Colluvium
- 200mm Red Brown, soft pinhole voided, fine sandy gravelly silt. Slightly ferruginized colluvium.
- 200mm Very dense hard pan ferricrete
- Refusal below 1,0m from natural ground. No seepage

The culvert has preliminary been design for a ground pressure of 75 KPa.

4.3.1.5 Culvert Type

As a result of the design load and hydraulic analysis cast in place multi cell box culvert (4 cells of 3.6 m wide and 1.5 m high) are feasible to pass the 50-year flood. For hydraulic results see item 4.2.2.2

4.3.2 Off Site Roads (New) and Existing

Refer to draft report “Belfast Roads rev 2.3”

5 Water Management

5.1 Scope

In summary, the Water Management of Belfast Mine is discussed in the following sub-sections as shown in table 5.1:

Table 5.1: Summary of Water Management networks

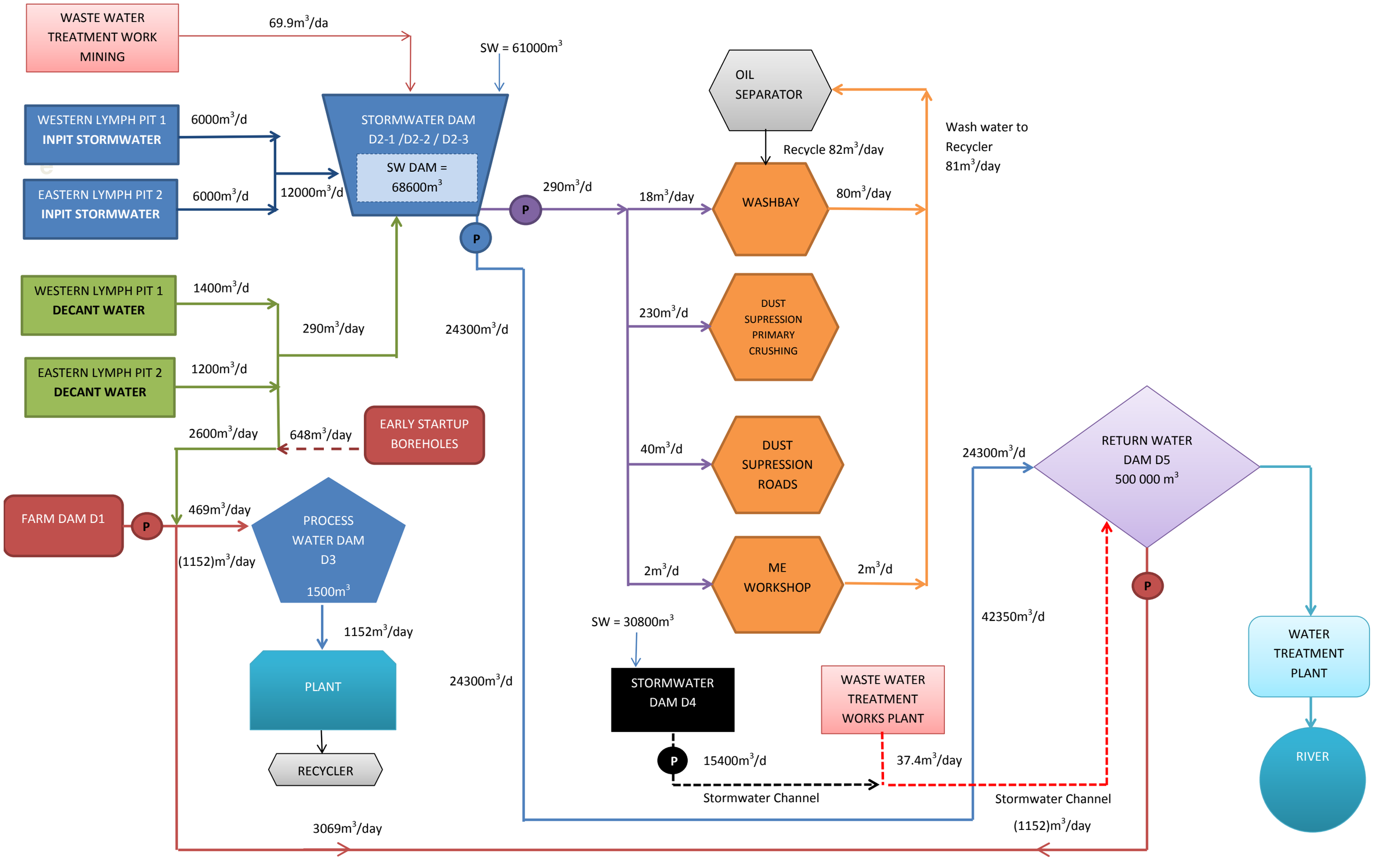
Sub-section	Water supply network	Pipeline reference on drawings	Usage
5.2	Potable Water	PW	Potable water supply to Mine and Plant areas
5.3	Fire Water	FW	Fire water supply to Mine and Plant areas
5.4	Start-up water requirements	FDW	Supply from Farm Dam and Boreholes to Process water dam
5.5	In pit Stormwater	SW	In pit water to Stormwater Dam D2
5.6	Raw Water	RW	Wash-bay, dust suppression, mobile equipment workshop
5.7	Dust Suppression Irrigation Water	DiW	Dust suppression

The water distribution networks for sub-sections 5.3, 5.4 and 5.5 are shown schematically on the next page. Table 5.2 lists the guidelines used for the design of the water supply networks, with a summary of the Design Requirements listed in Appendix C1. The software used to analyse the water networks is EPANET Version 2.0, with uPVC pipe sizes modelled. During detail design various pipe types should be evaluated economical.

Table 5.2: Guidelines used

Design Requirements for Water and Sewer	MCG-O78-0000-0000-C-SPC-004
Guidelines for Human Settlement Planning and Design, Part 9:Water Supply	CSIR Building and Construction Technology
Fire Fighting Equipment	Doc No ESP-XX-00025
Community protection against fire	SANS 10090:2003
The use and control of fire-fighting equipment	SANS 10105-2:2010
Part 1:Water Supply Installations for buildings	SANS 10252-1
Part T- Fire Protection	SABS 0400 (SANS 10400)
Population Estimates as at 28 Aug 2013 Rev 02	Provided by Exxaro
Marley Pipe Systems catalogue	uPVC Class 12, Page 34

Fig 2: Schematic Water Distribution Network (Peak Flow)



5.2 Potable Water

5.2.1 Objective

Potable water is distributed from the Potable Water pump station supplied from the reservoir, through a pipe network to all the buildings and facilities in the Plant and Mining areas. The total length of pipelines is approximately 4.8 km.

5.2.2 Estimated Water Demands

The demand used in this project is taken from guidelines as listed in Figure 2.

5.2.3 Design assumptions

- The maximum probable flow would normally occur during shift changes, when all showers are occupied especially at the showers of the Change houses. The average shower time per person is approximately five minutes. At a design flow rate of 15l/min/per standard shower head gives 75l per person
- Since most plumbing fixtures are used intermittently, with the time of operation being relatively short, it is not necessary to design for the maximum fixtures in use at such facilities.

5.2.4 Daily Water Demands

The daily water demand has been obtained from SANS 10252-1:2012 table 1.

An average daily flow of 150l/capita/day was used for labourers which include for showering. When adding up the average daily demand. From SANS 10252 table 2 it appears office workers will use on average 70 liters/per day/per employer

Peak factors were estimated using the probable flow demands of simultaneous use of fittings, and intermittent usage of fittings as per SANS 10252.

5.2.5 Probable Flow Demand

The peak factor given in Human Settlement Planning and Design, Volume 2, Chapter 9 (Water supply) is developed for residential areas and does not cover mining. The red book recommended a minimum peak factor of 4 and a maximum of 22 based on equivalent erven taken from figure 9.15.

It is expected that the maximum probable flow would normally occur during shift changes. This is when all the showers are fully occupied. It is during this time when the water demand should be at the maximum.

Since most plumbing fixtures are used intermittently and the time in operation is relative small, it is not necessary to design for the maximum possible load.

5.2.6 Estimated daily probable water demand

Table 5.3 summarises the estimated daily probable water demand for the Plant area and Table 5.4 summarises the estimated daily probable water demand for the Mining area.

Table 5.3: Plant area estimated daily probable Flow

Facility	SANS 10252-1:2012 - 4.2.2 Probable (or design) flow demand					From Terminal Fittings (L/min)	Probable Flow Q_p L/s
	Wash-hand basin	Shower	Water closet	Urinal	Sink		
	Design flow rate per fitting (L/min)						
	10	30	5	10	12		
	Number of fittings						
Ablution block - Interlink Trucks	6	0	7	2		115	1.38
Conference Facility and Clinic	12	0	19	9	3	341	2.38
Main office building (incl Visitors)	17	5	12	4	1	432	2.68
Master Control Room (incl Cleaning Team and Plant labourers)	4	0	3	2	2	99	1.28
Security building to offices	13	0	11	5	1	247	2.03
Security Building to Plant *(incl Logistics)*	1		1		1	27	0.67
Supply Chain Management Store	2		2	1	1	52	0.93
Laboratory	2		3	1	1	57	0.97
Logistics (Weigh Bridge and Bin)	6					60	1.00
Plant Workshop	12		10	4	1	222	1.92
Change house (16 showers)	10	16	7	6	0	675	11.25

Table 5.4: Mining area estimated daily peak flow water demands

Facility	SANS 10252-1:2012 - 4.2.2 Probable (or design) flow demand					From Terminal Fittings (L/min)	Probable Flow Q_p L/s
	Wash-hand basin	Shower	Water closet	Urinal	Sink		
	Design flow rate per fitting (L/min)						
	10	30	5	10	12		
	Number of fittings						
Mining Office (incl Visitors)	6	0	7	2	2	139	1.52
Security Building to Mining Plant	12	0	19	9	3	341	2.38
Discard Handling & Logistics	4	0	3	2	2	99	1.28

Dust Suppression Contractor	13	0	11	5	1	247	2.03
Mining Labourers (Gooseneck)	Filling W/Cart					250	2.04
Mobile Equipment Workshop	4		5	2	1	97	1.27
Sasol	4	0	3	2	2	99	1.28
Shovel Laydown Area	3		3	3	1	87	1.20
Total Diesel Depot incl Total	4	2	4	2	1	152	1.59
Change house (6 showers):	6	6	4	3	0	290	4.83

5.2.7 Residual Pressures

The reticulation system should be designed so that the residual pressure in the reticulation at any point is within the limits given in Table 55 below:

Table 3.5: Residual Pressure Parameters

Type of development	Minimum head under peak demand [m]	Maximum head at static pressure [m]
Dwelling Houses: House connection	24 at main, plus height difference to highest ground level on erf	90

5.2.8 Water storage

The purpose of storing water is to meet pressure balancing requirements and to cater for emergencies, for example fire fighting, planned shutdowns, etc.

The planned bulk water supply is from boreholes and considering the source, the reservoir has been size for 48 hour storage plus 4 hour storage for fire fighting requirements.

Table 5.6 and Table 5.7 summarizes the average daily water demand for water storage based on the expected work force employed on the mine for, in the Plant and Mine areas respectively.

Table 5.6: Plant area Potable Water storage

Site Area	Facility	Contributing population (number)	Units	Average daily flow per capita (l/c/d)	Average daily demand (l/d)	Average daily demand (kl/d)
PLANT	Ablution block - Interlink Trucks	105	105	70	7350	7.35
	Conference Facility and Clinic	100	100	70	7000	7.00
	Main office building	87	87	70	6090	6.09
	Master Control Room	20	20	70	1400	1.40
	Security building to offices	18	18	70	1260	1.26
	Security Building to Plant	4	4	70	280	0.28
	Supply Chain Management Store	12	12	70	840	0.84
	Visitors (DK Allowance)	15	15	70	1050	1.05

	Cleaning Team	9	9	70	630	0.63
	Laboratory	8	8	70	560	0.56
	Logistics (Weigh Bridge and Bin)	12	12	70	840	0.84
	Plant Labourers	24	24	70	1680	1.68
	Plant Workshop	28	28	70	1960	1.96
	Change house (16 showers):	81	81	75	5670	5.67
				Plant sub-total =		37.02

Table 5.7: Mining area Potable Water storage

Site Area	Facility	Contributing population (number)	Average daily flow per capita (l/c/d)	Average daily demand (l/d)	Average daily demand (kl/d)
MINING	Mining Office	12	70	840	0.84
	Security Building to Mining Plant	6	70	420	0.42
	Visitors (DK Allowance)	10	70	700	0.7
	Discard Handling & Logistics	18	70	1260	1.26
	Dust Suppression Contractor	15	70	1050	1.05
	Mining Labourers	318	70	22260	22.26
	Mobile Equipment Workshop	33	70	2310	2.31
	Sasol	30	70	2100	2.1
	Shovel Laydown Area	12	70	840	0.84
	Total	15	70	1050	1.05
	Tyre Storage and pumping	6	70	420	0.42
	Vehicle Wash Bay	6	70	420	0.42
	Change house (6 showers):	453	75	31710	31.71
			Mining sub-total =		67.645

Storage required is based on 48 hours storage time for Potable Water and 4 hours storage time for Fire Water (based on the Moderate-risk fire category), can be summarised in Table 5.8.

Table 5.8: Storage volumes

Water supply	Storage time	Storage capacity (kL)
Potable water	48 hrs	204
Fire water	4 hrs	1440
Total storage capacity =		**1644**

5.2.9 Model

EPANET is a Windows 95/98/NT program that performs extended period simulation of hydraulic and water-quality behaviour within pressurized pipe networks. A network can consist of pipes, nodes (pipe junctions), pumps, valves and storage tanks or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration

of a chemical species throughout the network during a simulation period comprised of multiple time steps.

5.2.10 Results

Results of pipe sizes (inside pipe diameter), flows, pressure heads and pump heads generated from the EPANET model are contained in Appendix C2.

5.2.11 Pump Station Location

The pump station has been placed as near to the reservoir as possible, with the shortest and most direct suction pipe practical.

5.2.12 Pump house

The pump house has been sized to accommodate, all the necessary pumps for firewater and potable water in one pump house. This includes for a jockey pump, duty pumps and a standby diesel pump with fuel tanks and control panels. The selected pump (L 80-400 U1NN-1854 Vogel Pump) specifications can be found in Appendix C7.

Sufficient access has been allowed for inspection and maintenance with enough headroom for an overhead crane or hoist of sufficient capacity to lift the heaviest item of equipment.

5.2.13 Chlorinator

Microorganisms can be found in raw water from rivers, lakes and groundwater. While not all microorganisms are harmful to human health, there are some that may cause diseases in humans. These are called pathogens. Pathogens present in water can be transmitted through a drinking water distribution system, causing waterborne disease in those who consume it.

Chlorination is a chemical disinfection method that uses various types of chlorine or chlorine-containing substances for the oxidation and disinfection of what will be the potable water source.

Potable Water supply from boreholes will be chlorinated before distribution through the potable water network.

5.3 Fire Water

5.3.1 Objective

Water is the most commonly used agent for controlling and fighting a fire, for controlling and/or extinguishing the fire either by itself or combined as foam. Water shall therefore be readily available at all the appropriate locations, at the proper pressure and in the required quantity. The total length of pipelines to provide fire water to all the risk points is about 6.5 km

5.3.2 Layout

Fire-water ring mains of the required capacity have been designed to surround all processing units, storage facilities for flammable liquids, loading facilities for road vehicles, warehouses, workshops, utilities, laboratories and offices. These units are also bounded by service roads for easy access. Areas have been sub-divided into smaller sections, each enclosed by fire-water mains equipped with hydrants and valves.

The basic requirements consist of an independent piping ring main (at buildings) and links fed by permanently installed fire pumps. Pipe diameters varied from 110 mm to 315 mm diameters. All the pipes are below surface.

5.3.3 Demands

Tables 5.9 and 5.10 list the demands and classification of each facility where fire water is required to be supplied.

Table 5.9: Plant area demands

Plant Area Facilities	Fire-risk category	Min design fire flow (l/min)	Min hydrant flow rate/hyd (l/s)	No. of hydrants	Demand (l/s)	Min residual head (m)
Ablution block - Interlink Trucks	Low - G2	500	8.3	1	8	15
Conference Facility and Clinic	Moderate	6000	25.0	4	100	15
Main office building (incl Visitors)	Moderate	6000	25.0	4	100	15
Master Control Room (incl Cleaning Team and Plant labourers)	Moderate	6000	25.0	2	50	15
Security building to offices	Low - G1	900	15.0	2	30	15
Security Building to Plant (incl Logistics)	Low - G3	350	5.8	1	6	15
Supply Chain Management Store	Moderate	6000	25.0	3	75	15
Laboratory	Moderate	6000	25.0	2	50	15
Logistics (Weigh Bridge and Bin)	Low - G3	350	5.8	1	6	15
Plant Workshop	Moderate	6000	25.0	4	100	15
Change house (11 showers)	Low - G1	900	15.0	1	15	15
DRA		4500	25	3	75	80

Table 5.10: Mining area demands

Mining Area Facilities	Fire-risk category	Min design fire flow (l/min)	Min hydrant flow rate/hyd (l/s)	No. of hydrants	Demand (l/s)	Min residual head (m)
Mining Office (incl Visitors)	Moderate	6000	25.0	4	100	15
Security Building to Mining Plant	Low - G3	350	5.8	1	6	15
Mobile Equipment Workshop	Low - G1	900	15.0	1	15	15
Shovel Laydown Area	Low - G1	900	15.0	1	15	15
*Total Diesel Depot incl Sasol	High	12000	125.0	4	125	120
Explosive Management Offices	Low - G2	500	8.3	1	8	15
Tyre Storage and pumping	Low - G2	500	8.3	1	8	15
Vehicle Wash Bay	Low - G1	900	15.0	1	15	15
Change house (16 showers):	Low - G1	900	15.0	1	15	15
**DRA		4500	25	3	75	80

*Water demand as required by Total

**Water demand as required by DRA

5.3.4 Results

The fire water has been modelled using EPANET. Each section of pipeline or possible incident has been modelled separately to check the pipe sizes required to meet the demands.

Results of pipe sizes, flows, pressure heads and pump heads generated from the EPANET model are contained in Appendix C3.

5.3.5 Pump station

The pump house has been size to accommodate a duty pump, standby diesel pump with a fuel tank, jockey pump and control panels. Sufficient access has been allowed for inspection and maintenance with enough headroom for an overhead crane or hoist of sufficient capacity to lift the heaviest item of equipment. The pump has been placed as near to the water source as possible, with the shortest and most direct suction pipe practical.

The selected pump specifications can be found in Appendix C7: 2x Godwin HL130M Electric Fire Water pump sets in parallel to achieve the duty of 125 l/s at 152m head; with 2x Diesel Driven Godwin HL130M Fire Water pump sets in parallel to achieve the duty of 125 l/s @ 152 m head in case of a power outage where the standby pumps will be required.

The jockey pump 46SV8G300T Lowara specifications can also be found in Appendix C7

5.3.6 Storage

Fire water storage is contained in the same tank at Potable Water – please refer to sub-section 5.1.7 for the Fire Water storage component of the tank.

5.4 Start-up Water Requirements

5.4.1 Objective

As shown in the Schematic Water Distribution Network, early water storage for Return Water Dam D5 is supplied from the Farm Dam, together with 5 boreholes which will pump water at a rate of 1.5 l/s each.

Thereafter, water is pumped from Return Water Dam D5 to the Process Water Dam D3. The total length of this pipeline is 6.1 km. The farm dam water pipeline varies from 120 mm to 160 mm diameter. Portions of the pipe is laid above ground and portions below ground specifically where the pipe is at risk of damage by vehicles in the mine area and in the plant area

5.4.2 Water Demand assumptions

The following table lists the start-up water requirements and where water will be pumped to and from.

Table 4: Water Demand for Start-up Water

Description	Daily Capacity (m^3/day)	Remarks
Farm Dam	469	The available water from the farm dam will be pumped to dam D5. From dam D5 water will be pumped to the Process Water Dam D3
5 by Borehole's @1.5l/s per borehole	648	Water from Boreholes will be pumped to Dam D5 using the same pipline for the Farm Dam Water (FDW)
Total Start-up	1117	The total top-up water required is 1152 m^3/day

5.4.3 Results

Results of pipe sizes, flows, pressure heads and pump heads generated from the EPANET model are contained in Appendix C4.

5.4.4 Pump Stations

The purpose of the pump stations is to distribute water between Farm Dam D1 and Return Water Dam D5; and between Return Water Dam D5 and Process Water Dam D3. Consequently, a pump station is required at the Farm Dam and a submersible pumping system will be required at Return Water Dam D5.

The pump house has been sized to accommodate, two duty pumps, and a standby diesel driven pump with a fuel tank, and control panels.

The pump selection can be found in Appendix C4.

5.5 Decant Mine Water:

5.5.1 Objective

The design methodology is based on the Schematic Water Distribution Network for Peak Flow.

Decant water is pumped from 5 decant points to Return Water Dams D5 using the Farm dam pipeline. It is envisaged that when the decant points will be operational the start-up boreholes will be abandoned. Raw water will be drawn from the decant/farm dam pipeline to the Stormwater dam D2-3 for dust suppression ect. The pipelines from the boreholes to where it connects into the farm dam pipeline are above ground.

5.5.2 Results

Results of pipe sizes, flows, pressure heads and pump heads generated from the EPANET model are contained in Appendix C5.

5.5.3 Water Demand assumptions

The following table lists the start-up water requirements and where water will be pumped to and from.

Table5 12: Estimated water Requirements for decant water

Description	Daily Capacity (m^3/day)	Remarks
Eastern Lymph Pit	1200	Decant water will be pumped to the Return water dam via the early start-up pipeline to Return Water Dam D5 and Process Water Dam D3.
Western Lymph Pit	1200	Decant water will be pumped to the Return water dam via the early start-up pipeline to Return Water Dam D5 and Process Water Dam D3.
Total	2600	

5.5.4 Pumps

The pump selection curves and costing is contained in Appendix C7.

5.6 Inpit Stormwater and Stormwater Pipeline.

5.6.1 Objective

The design methodology is based on the Schematic Water Distribution Network for Peak Flow.

In addition to the storm water supplying Stormwater Dam D2-1 / D2-2 / D2-3; Western Lymph Pit 1 and Eastern Lymph Pit 2 provides further inflow into this dam. Water from this dam is pumped over a period of 3 days to Return Water Dam D5, thereafter treated in the Water Treatment Plant.

Water is also pumped from Stormwater Dam D4 into a channel which discharges into Return Water Dam D5.

Pipes varied from 315mm to 400mm diameter.

5.6.2 Water Demand assumptions

The following table lists the Inpit Stormwater requirements and where water will be pumped to and from.

Table 5: Water Demand Inpit Storm water

Description	Daily Capacity (m^3/day)	Remarks
Eastern Lymph Pit	6000	Storm water will be pumped to the Storm water dam D2-2 silt basin. From here storm water will be pumped to the Return Water dam D5
Western Lymph Pit	6000	Storm water will be pumped to the Storm water dam D2-2 silt basin. From here storm water will be pumped to the Return Water dam D5
Total	12000	Flood buffer zone in the dam will be emptied within 3 days after the occurrence of a rainfall event

5.6.3 Results

Results of pipe sizes, flows, pressure heads and pump heads generated from the EPANET model are contained in Appendix C5.

5.6.4 Pump Stations

Diesel pumps distribute water from Western Lymph Pit 1 and Eastern Lymph Pit 2 to Stormwater Dam D2. The pump station at Stormwater Dam D2-1/D2-2/D2-3 pumps excess water from flood buffer zone to Return Water Dam D5. A separate pump, pumps Raw Water to supply points as detailed in Figure 2. Another pump station is also required at Stormwater Dam D4 to pump storm water into a channel

(network E) which discharges to Return Water Dam D5. Pump houses have been sized to accommodate a duty pump and a standby diesel driven pump with a fuel tank, with required control panels.

The selected pump (L 150-315 U1NN-4504 Vogel Pump (located at Stormwater Dam D2) specifications can be found in Appendix C7; together with LS 250-315 S1NL1-1856 Vogel Pump (located at Stormwater Dam D4).

5.7 Raw Water Distribution

5.7.1 Objective

Decant Water and Inpit stormwater discharged into Stormwater Dam D2-2 (operational zone has been allowed for) is required to be distributed to the Dust Supression area, Washbay, Mobile Equipment Workshop and Dust Supression draw-off point. The length of this pipeline is 0.9 km. Water demands at these facilities are indicated in the Schematic Water Distribution Network diagram as summarised in table 5.12 below. The pipeline is 63mm diameter and placed below surface.

5.7.2 Assumptions

An estimated minimum of two and maximum of four trucks/day plus two machines (excavators, front end loaders, or rigid's.) will use the Wash-bay per day. The top-up water consumption for the Wash-bay has been estimated at 18 Kilolitre per day. An elevated storage tank of 10 Kilolitre and a water recycler has been provided to reduce the daily water demand from decant water. Washing time is about 20 to 30min per vehicle.

5.7.3 Water Demand

Table 5.12: Raw water demands

Description	Daily Capacity (m^3/day)	Remarks
Wash bay	18	It is estimate that the daily demand for the wash bay is 160Kl/day. Adding a recycler reduce the demand to 18Kl/day
Dust Suppression Primary Crusher	230	Daily demand provided by DRA
Dust Suppression Roads	40	Daily demand provided by Dustaway.
Mobile Equipment Workshop	2	Allowance for cleaning the floor at least once a week.
Total	290	

5.7.4 Design Results

Results of pipe sizes, flows, pressure heads and pump heads generated from the EPANET model are contained in Appendix C6.

5.7.5 Pump Stations

Raw water is pumped from the pump station at Stormwater Dam D2-2 to the Dust Suppression area, Wash bay, Mobile Equipment Workshop and Dust suppression draw-off point. A draw off point has been provided to fill water bowsers with a capacity of 38kl within 40 minutes

The pump house has been sized to accommodate a duty pump, pipework, valves, water meter with control panels.

The selected pump (L 80-400 U1NN-3004 Vogel Pump located at Stormwater Dam D2) specifications can be found in Appendix C7.

6 Sewer

Sewer lines are provided to all buildings with wet points. The sewer effluent is discharged into a waste water treatment works for treatment. The total length of sewer lines is about 3317m. Treated water will be release back to the return dam D5 with the option of releasing it to the environment when too much water is available in future.

6.1 Design Codes/Guidelines

Table 6.1: Design Guidelines Sewer

Design Requirements for Water and Sewer	Doc No. MGP-EC-SPC-19 Rev No BAR - EXXARO
Water and Sewer Design Specification	Doc No ESP-GM-0007 Rev 0
Guidelines for Human Settlement Planning and Design, Part 10: Sanitation	CSIR Building and Construction Technology

6.2 Sewage Demand

The table below gives average daily sewage design flows based on SANS 10252-1:2012 and as calculated in section 5.2:

Table 6.2: Average Daily Demand (ADD)

Application	Daily design flow
Offices and Administration	70 ℓ/p/d
Day workers	70 ℓ/p/d
Plant workers (Excluding Showers)	70 ℓ/p/d
Plant workers (Showers Only)	75 ℓ/p/d

6.2.1 Peak Factors

Peak time will occur during shift changes when all the showers will be in use. During normal hours peak sewer flow will be intermittently. Hence the maximum peak factor of 3.5 has been used in terms of Guidelines for Human Settlement Planning and Design

6.2.2 Estimated Peak Flow demand

Table 6.3:

Site Area	Facility	Contributing population (number)	Average daily flow per capita (l/c/d)	Peak factor	Peak flow (l/s)
PLANT	Ablution block - Interlink Trucks	52.5	70	3.5	0.800
	Conference Facility and Clinic	100	70	3.5	0.284
	Main office building (incl Visitors)	102	70	3.5	0.289
	Master Control Room (incl Cleaning Team and Plant labourers)	19	70	3.5	0.054
	Security building to offices	9	70	3.5	0.026
	Security Building to Plant (incl Logistics)	2	70	3.5	0.217
	Supply Chain Management Store	12	70	3.5	0.034
	Laboratory	4	70	3.5	0.011
	Logistics (Weigh Bridge and Bin)	6	70	3.5	*0.017*
	Plant Workshop	14	70	3.5	0.040
	Change house (6 showers)			1	8.800
	Waste Water Treatment Plant				0.000
					10.571

Site Area	Facility	Contributing population (number)	Average daily flow per capita (l/c/d)	Peak factor	Peak flow (l/s)
MINING	Mining Office (incl Visitors)	4	70	3.5	0.828
	Security Building to Mining Plant	2	70	3.5	0.006
	Visitors (DK Allowance)	*10*	70	3.5	*0.028*
	Discard Handling & Logistics	10	70	3.5	0.028
	Dust Suppression Contractor	5	70	3.5	0.014
	Mining Labourers (Gooseneck)	106	70	3.5	0.301
	Mobile Equipment Workshop	15	70	3.5	0.043
	Sasol	*0*	70	3.5	*0.000*
	Shovel Laydown Area	4	70	3.5	0.021
	Diesel Depot & Explosive Management Offices	15	70	3.5	0.043
	Tyre Storage and pumping	*0*	70	3.5	*0.000*
	Vehicle Wash Bay	*0*	70	3.5	*0.000*
	Change house (16 showers):			1	11.250
	Waste Water Treatment Plant	2	70	3.5	0.006
					12.567

6.3 Sewer Network

6.3.1 Basic Requirements

The reticulation system should be designed to the basic requirements below:

Table 6.5: Basic Design Parameters Sewer Network

Pipes	
Pipe diameter	Minimum 110 mm diameter
Velocities in Pipes	Minimum 0.7 m/s and should not exceed 1.2 m/s
Min Slope	As per table C.2 from the Guidelines for Human Settlement Planning and Design
Pipe Cover	In Servitudes 1.2 m In Sidewalks 1.4 m below kerb level In roads 1.4m below final roads levels
Bedding	SANS 1200 LB
Pipe materials and Class	PVC pipe class 51S
Manholes	
Location and spacing	At all junctions, changes of grade and direction
Spacing	Maximum distance between manholes 80 m for hand operated rodding equipment
Minimum Internal Dimension	Circular 1 000 mm Rectangular 900 mm
Steep drops	Should be avoided
Materials	Section 3.5 of SANS 1200 LD

6.3.2 Sewer design Software

The software used to model the sewer is PipeMate Version 2012. The purpose of the software is to provide an intuitive graphical approach to sewer and stormwater reticulation design and analysis, whereby basic information pertaining to the reticulation system is gleaned directly from the AutoCAD drawing. In addition, PipeMate gives you final working layout and longitudinal section drawings for the complete network with the minimum amount of manual input. The designer works from within AutoCAD, building the drawing as the design process proceeds.

From this model, it was possible to get required pipe sizes to meet the flow requirements and the velocity.

Design Results are attached to appendix D

7 Waste Water Treatment Works (WWTW)

7.1 Scope

The treatment of sewage is largely a biochemical operation, where chemical transformations of the sewage are carried out by living microorganisms. Different environments favour the growth of different populations of microorganisms and this in turn affects the efficiency, end products, and completeness of treatment of the sewage.

Small plants will generally be modular systems provided by a supplier where the sewage flows and/or site characteristics make septic tanks not feasible. Example of the most popular type of modular systems is activated sludge plants, trickling filter plants and rotating bio-contactor plants. Most modular systems effluent does not meet the requirements of DWA general standard and can therefore not be discharge back into the natural streams without further treatment. The treated effluent from modular systems may be used for irrigation, recycle of flushing systems and dust suppression.

The Water Service Act (Act 108 of 1997) made provisions to prevent any substance other than uncontaminated stormwater from entering any watercourse.

7.2 Design Codes/Guidelines

Table 7.1: Design Guidelines Waste Water Treatment Works

Guidelines for Human Settlement Planning and Design, Part 10: Sanitation	CSIR Building and Construction Technology

7.3 Design Assumptions

The design assumptions used to assess the contributing population is the same as for the sewer system above item 8.

7.4 Estimated Average Dry Weather Flow (ADWF)

The table below gives the estimated ADWF for the plant and mining area

Site Area	Facility	Contributing population (number)	Average daily flow per capita (l/c/d)	Average daily demand (l/d)	Average daily demand (kl/d)
PLANT	Ablution block - Interlink Trucks	105	70	7350	7.35
	Conference Facility and Clinic	100	70	7000	7.00
	Main office building	87	70	6090	6.09
	Master Control Room	20	70	1400	1.40
	Security building to offices	18	70	1260	1.26
	Security Building to Plant	4	70	280	0.28
	Supply Chain Management Store	12	70	840	0.84
	Visitors (DK Allowance)	15	70	1050	1.05
	Cleaning Team	9	70	630	0.63
	Laboratory	8	70	560	0.56
	Logistics (Weigh Bridge and Bin)	12	70	840	0.84
	Plant Labourers	24	70	1680	1.68
	Plant Workshop	28	70	1960	1.96
	Change house (16 showers):	81	80	6480	6.48
			Plant sub-total =		37.42

Site Area	Facility	Contributing population (number)	Average daily flow per capita (l/c/d)	Average daily demand (l/d)	Average daily demand (kl/d)
MINING	Mining Office	12	70	840	0.84
	Security Building to Mining Plant	6	70	420	0.42
	Visitors (DK Allowance)	10	70	700	0.7
	Discard Handling & Logistics	18	70	1260	1.26
	Dust Suppression Contractor	15	70	1050	1.05
	Mining Labourers	318	70	22260	22.26
	Mobile Equipment Workshop	33	70	2310	2.31
	Sasol	30	70	2100	2.1
	Shovel Laydown Area	12	70	840	0.84
	Total	15	70	1050	1.05
	Tyre Storage and pumping	6	70	420	0.42
	Vehicle Wash Bay	6	70	420	0.42
	Change house (6 showers):	453	80	36240	36.24
			Mining sub-total =		69.91

7.5 Package Unit Proposed

ENTIBEC provide a modular system that produces a class 1 water quality. ENTIBEC claimed that effluent from this modular plant complies with DWAF standards and can be discharge back into natural streams.

The 3D view of a typical package plant below shows the various treatments process chambers.

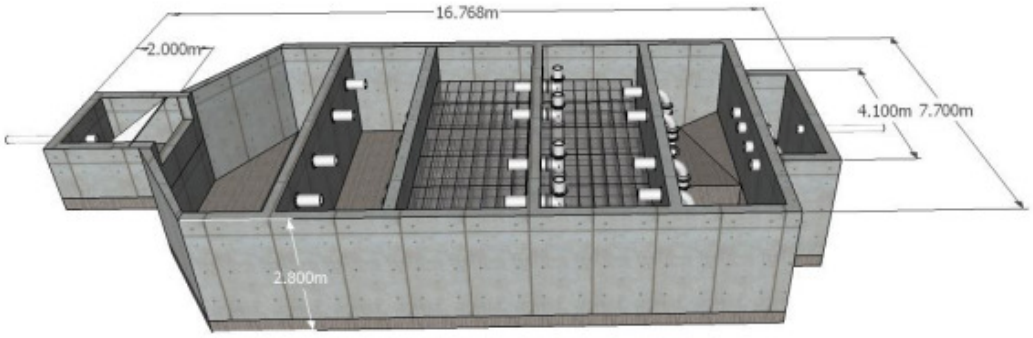


Figure 9.1:3D view of the package plant

Figure 9.2: Section through the package plant

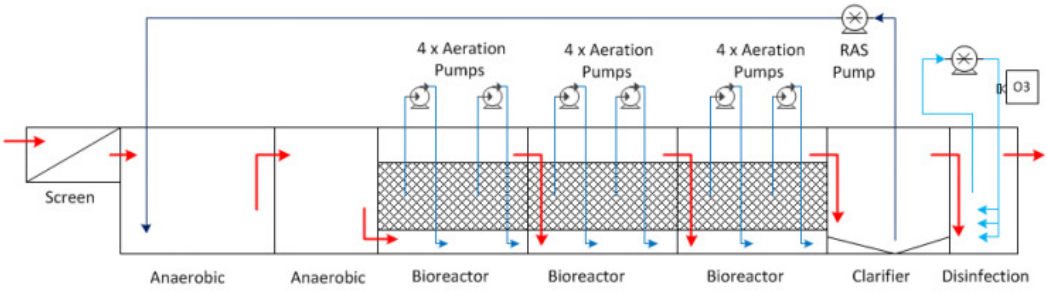


Figure 9.3: Schematic diagram of the WWTW

7.6 Operation Principle of the WWTW

The first chamber allow for screening of the effluent from papers, cloths and other solids. The second and third chambers are anaerobic tanks. The third chamber is the phase where digestion takes place in an aerated environment. Settlement takes place in the fourth chamber. From here the sludge is re-circulated by pumping the sludge to the anaerobic or primary settling tank.

The fifth chamber is the phase where the final effluent is disinfected by either dosing with chlorine or treatment by means or Ultra violet or ozone system. The disinfected effluent will be discharged to the Return Water Dams.

7.7 Advantages of this type of waste water treatment plant.

The plants are not only affordable but also provide final effluent that complies with the strict standards set out by the Department of Water and Forestry (DWAF).

- The plants are easy to operate and do not require permanent staff on site.
- In the majority of cases, grass is planted on top of the plant and only the manhole covers are visible.
- Plants are modular and areas can be isolated for maintenance without disrupting the flow.
- Plants use extremely low electrical demand equipment and therefore save on electricity
- Final effluent quality can be re-used in a number of applications.
- The plants are gravity fed and cannot overflow.
- Because of the design, the plants can be constructed adjacent to the buildings.
- The plants do not generate sewage sludge.
- Plants can operate with either 220 or 380 volts.
- These plants are also safe for people, especially children, and animals as there are no open dams or pits.
- No foul odors.

7.8 Monitoring

It is recommended but also mandatory by law to take regular samples to do analyses, to determine if the quality of water complies with the standards as set out by the Department of Water Affairs (DWA).

7.8.1 Disposal of effluent

The average daily water demand has been estimated at 37,42kℓ/day at the plant area and 69,9kℓ/day at mining area. The final effluent will be discharged into the return storage dam (D5) in the plant area and return water dam D2-2 in the mining area. At some point in time, treated water could be discharged back into the catchment. (When excess water are available)

7.8.2 Disposal of Sludge

According to the manufactures this package plant does not generate sludge. All sludge settled in the clarifier is returned to the second chamber by the RAS pump where the sludge is re-circulated through the plant.

8 Security Fencing

8.1 Objective

Regulation 8 of the National Water Act requires the fencing off of impoundments or dams containing poisonous, toxic or injurious substances.

Security fencing also protects assets from intrusion and potential attacks of vandalism. Security fencing has been provided around the reservoir, sewer treatment works, staff parking and dams.

8.2 Fencing

8.2.1 Stock Proof Fencing

The farm boundaries are currently fenced off with a typical 1.2m high stock proof fence. This fencing will remain in place except around the plant boundaries.

Where the proposed D1770 and D1110 road traverses along farm properties to N4 Highway a new 1.2 m high farm stock proof fence has to be erected either to one side or both side depending on the width of the road reserve to demarcate the national road reserve from the farms.

Table 8.1: Stock Proof fencing

Description	Length (m)
Discard Dump	2858.95
Process Water dam D3	424
Heavy Plant Access Road	873
Discards Link Road	306
Total	4461.95

8.2.2 Razor Wire Fencing

Razor Wire Fencing is provided as per table below:

Table 8.2: Flat wrap fencing

Description	Length (m)
Plant area perimeter fencing plus Mine area road D1770 boundary fencing	6880.85
Stormwater Dam D4	550
Supply Management Store	372
Dam D2-2 and D2-3	1077.35
Dam D2-1	365
total	9245.2

8.2.3 Steel Palisade Fencing

Steel Palisade fencing has been provided at the entrance to the main Security and Offices and the entrance to the mining area.

Table 8.3: Flat wrap fencing

Description	Length (m)
Entrance to Main Security and Offices	552.4
Entrance to Mining area	463.9
Total	1016.3

8.2.4 1.8m Security Fencing

The fence consist of 50 mm diamond mesh and is 1.8 m high.

Table 8.4: Flat wrap fencing

Description	Length (m)
Along Office Access Road	778.76
Entrance to Mining area	350
Diesel Depot	244
Matrix Silo	153
Dividing fence between mining area and change house	222
Total	1969.6

8.2.5 2.4m Security Fencing

The fence consists of diamond mesh fencing of mesh 50mm. The high of the fencing is 2.4m . The posts and standards are cut and set to an angle of 45° to protrude over the outside of the enclosure.

Table 8.5: Flat wrap fencing

Description	Length (m)
Prills Silo	93.6
Explosives Storage Area	361.6
Total	455.2

8.2.6 Electric Fencing

Electric fencing as per SAPS requirements to be erected around the explosive magazine and Prills.

9 Communication Sleeves

The installation of Communications sleeves is done under the civil infrastructure work together with other underground services. The actual installation of the communications systems will be done under a separate contract.

Sleeves (two duct system) will connect all the buildings, communication towers, and plant infrastructure to a central control room. Draw boxes have been placed at 60m centres and at horizontal changes in direction.

Manholes will be sealed against water ingress. Inlet and outlet is place 50 mm above manhole floor/invert. All sleeves will be supplied with draw wires.

10 Buildings

10.1 Plant Area

10.1.1 Main Security & Induction

The security office is located at the entrance adjacent to the Plant Change House. It's a single-storey building with chromadeck roof sheeting

10.1.1.1 Facility

•Offices, reception area, open plan offices ,conference facilities, kitchen, breakaway area and toilet facilities

10.1.1.2 Building Structure

- Facebrick single storey building
- Timber roof trusses with Chromadek IBR metal roof sheets
- Steel window frames
- Plaster & paint finish inside
- Height : 2.8m + roof

10.1.1.3 Areas

TOTAL BUILDING:	440m²

10.1.1.4 Functionality

- Main entrance with reception & waiting area linked with two wings and training facility all natural ventilated
- Internal toilet finishes as well as external

10.1.1.5 Fire Protection

SANS 10400 A	Occupancy G1
SANS 10400 T	4 X 4.5kg DCP
	1 x Firehouse reel

10.1.2 Plant Change House

The change house building is located between the main security & Induction and the conference facility on the western side of the plant area.

10.1.2.1 Facility

- Shower facilities, toilet facilities, changeroom and lockers
- Service area for heatpump, cleaners, storeroom
- Male & female facilities separately

10.1.2.2 Building Structure

- Facebrick single storey building
- Timber roof trusses with Chromadeck IBR roofsheeting
- Steel window frames
- Internal plaster & paint finnish with walltiles floor to ceiling
- Storage tank
- Height of structure: 3,05m + roof

10.1.2.3 Areas

MALE CHANGEROOM:	127m²
FEMALE CHANGEROOM:	54m²
OTHERS:	57m²

10.1.2.4 Functionality

- Separate staff facilities and amenities for men and women
- Communal laundry facilities
- All area with natural ventilation and waterproof finishes

10.1.2.5 Fire Protection

SANS 10400 A	Occupancy B3
SANS 10400 T	4 X 4.5kg DCP

10.1.3 Conference Facility & Clinic

The Conference Facility and Clinic is a single-storey brickwork building located adjacent to the Plant Change House, with lean-to covered patio on two sides of the building:

10.1.3.1 Facility

- Main Open plan multipurpose area
- Toilet facilities

- First aid room
- Kitchen
- Tuck-shop
- Open plan office

10.1.3.2 Building Structure

- Facebrick structure with combination of single storey and double volume area
- Steel trusses at double volume area with Chromadek IBR roof sheeting
- Steel window frames
- Concrete staircase
- Internal walls with plaster & paint finish
- Height Multipurpose area: 4.6m + roof
- Height rest of building: 2.5m + roof

10.1.3.3 Areas

MULTIPURPOSE AREA:	237m²
REST OF BUILDING:	176m²

10.1.3.4 Functionality

- Kitchen facilities
- Open plan Office & Tuckshop serving outside
- Double Volume Conference area, facilitating 90 seats, with elevated stage
- First aid room
- Male & Female toilet facilities
- Walkway around building with covered walkways at entrances of Coference area

10.1.3.5 Fire Protection

SANS 10400 A	Occupancy G1
SANS 10400 T	4 X 4.5kg DCP
	1 X Firehouse reel

10.1.4 Main Office Block

The main office building is a single-storey building with Chromadek roof sheeting. The building has been designed in an H-format; consist of two blocks with a link in-between.

10.1.4.1 Facility

Building divided into two blocks.
First block to house the following:
• Managers Department, Services office,
Offices, Open plan offices, Environmental,
Safety office, Senior Surveyor ,
Plan processors & plans division
Server Room with raised flooring, air condition units etc

• Second block to house financial department

10.1.4.2 Building Structure

• Facebrick single storey building
• Timber roof trusses with Chromadek IBR metal roof sheets
• Steel window frames
• Change rooms tiled finish on walls
• Internal walls Plaster & paint finish
• Height : 2.6m + roof

10.1.4.3 Areas

MAIN BUILDING:	1054m²
FINANCIAL BUILDING:	392m²

10.1.4.4 Functionality

•Offices on outside perimeter with natural ventilation with common facilities in internal spaces
•Reception to service all offices

10.1.4.5 Fire Protection

SANS 10400 A	Occupancy G1
SANS 10400 T	8X 4.5kg DCP
	3 x Firehouse reel
	1 x Hydrant

10.1.5 Laboratory

10.1.5.1 Facility

• Open Sample Air Drying area

- Separate areas for sample preparation, ash analysis, cv analysis, offices, & storeroom
- Each facility with own access to covered walkway linked to open sample air drying area
- Gas bottle storage area

10.1.5.2 Building Structure

OPEN SAMPLE AREA:	• Concrete floor slab
OTHERS:	• Facebrick single storey building • Timber roof structure with Chromadek IBR metal roof sheets • Steel window frames • Internal walls Plaster & paint finish • Height : 2.8m

10.1.5.3 Areas

BUILDING:	235m²
OPEN AREA:	80m²

Functionality

- Natural ventilated laboratory areas with open sample area
- Foyer area as link between open plan office

10.1.5.4 Fire Protection

SANS 10400 A	Occupancy D1
SANS 10400 T	6 X 4.5kg DCP 1 x Firehouse reel Firedetection

10.1.6 Plant Control Room

10.1.6.1 Facility

FIRST FLOOR:	• Main Control room, Instrument room, Workshop, UPS room, Shift foreman office,
GROUND FLOOR:	• Meeting room, Offices , toilet facilities and Kitchen

10.1.6.2 Building Structure

- Double-storey Facebrick building, with outside staircase to First floor
- Timber roof trusses with Chromadek IBR metal roof sheets
- Steel window frames
- Concrete staircase
- Internal walls Plaster & paint finish
- Height : 5.8m + roof

10.1.6.3 Areas

GROUND FLOOR:	140m²
FIRST FLOOR:	134m²

10.1.6.4 Functionality

- Double storey natural ventilated building with services on ground floor and offices on first floor

10.1.6.5 Fire Protection

SANS 10400 A	Occupancy G1
SANS 10400 T	4 X 4.5kg DCP
	1 x Firehouse reel

10.1.7 Plant Workshop

10.1.7.1 Facility

BLOCK A:
- Workshops each with adjacent storeroom, Offices and Caucus

BLOCK B:
- Toolbox storeroom, general storeroom & Counter area
- Toilet & Change room facilities
- Office block with Open plan offices, Offices, Printing area, Boardroom and Archive area

10.1.7.2 Building Structure

BLOCK A:
- Steel structure with sheet metal cladding
- Brickwork infill areas for storerooms office
- Height of structure- 5.86m + roof

BLOCK B:	• Facebrick single storey building • Timber roof trusses with Chromadek IBR metal roof sheets • Steel window frames • Internal walls Plaster & paint finish

10.1.7.3 Areas

WORKSHOP STRUCTURE:	1100m²
OTHER FACILITIES:	740m²

10.1.7.4 Functionality

• Three buildings linked with passage.
• Offices with passage.
•Offices with natural ventilation
store room, toilets and tool store
as link building
• separate building with access to
each workshop from outside
Crane facility

10.1.7.5 Fire Protection

SANS 10400 A	Occupancy B1 and G1
Occupancy G1	4 X 4.5kg DCP
SANS 10400 T	1 x Firehouse reel
Occupancy B1	14 X 9kg DCP
SANS 10400 T	1 x Firehydrant
	4 x Firehose reels

10.1.8 Supply Chain Management

10.1.8.1 Facility

BLOCK A:	• Storage area • Chemical storage area • Receiving and despatch facilities
BLOCK B:	• Office area with storeroom, Open plan office area, offices, filing rooms Meeting room and toilet facilities

10.1.8.2 Building Structure

BLOCK A:	• Steel structure with sheet metal cladding

- Roll up doors
- Height of structure- 5.86m (FFL. to wall plate)

BLOCK B:

- Facebrick single storey building
- Timber roof trusses with Chromadek IBR metal roof sheets
- Steel window frames
- Plaster & paint finish inside

10.1.8.3 Areas

BLOCK A WORKSHOP:	600m²
BLOCK B:	230m²

10.1.8.4 Functionality

- Two buildings linked with access doors.
- Office area with separate entrance and storage area with security control at dispatch

10.1.8.5 Fire Protection

SANS 10400 A	Occupancy G1 and J2
Occupancy G1	2 X 4.5kg DCP
SANS 10400 T	
Occupancy J2	6 X 9kg DCP
SANS 10400 T	2 x Firehose reels

10.1.9 Main 22 Kv Substation

10.1.9.1 Facility

- Structure to house Substation, Switchgear room & Control room
- 3 x Open transformer bays
- Ramp as access to facilities

10.1.9.2 Building Structure

SUBSTATION:

- Facebrick structure on concrete pillars & slab
- Concrete ramp to building level
- Access for services from ground level vertical into building through slab
- Building Height : 5.3m + roof

10.1.9.3 Areas

SUBSTATION BUILDING	235m²
3x TRANSFORMER BAYS:	25m²

10.1.9.4 Functionality

•Building raised from ground level with access for services through slab to first floor

10.1.9.5 Fire Protection

SANS 10400 A	Occupancy D4
SANS 10400 T	2 X 4.5kg DCP
	2x5kg CO2
	1 x Firehouse reel
	Firedetection

10.1.10 Plant Area Weighbridge Building

10.1.10.1 Description of facility

The Weigh Bridge Control room is situated between the security office and the weigh bridge. The building is raised and provided with a platform to a level comfortable for a clerk to communicate with the driver. The building consist of a single room provide with a desk and storage space with two doors.

10.1.10.2 Facility

- Control room with raised floor level and view windows
- Receiving and despatch facilities
- Office area with storeroom, Open plan office area, offices, filing rooms Meeting room and toilet facilities

10.1.10.3 Building Structure

CONTROL ROOM:

- Single level facebrick building, raised 1000mm above natural ground level
- Timber roof trusses with Chromadek IBR metal roof sheets
- Steel window frames
- Plaster & paint finish on internal walls
- Countertops height: 750mm

10.1.10.4 Areas

Area	19m²

10.1.10.5 Functionality

- Building with maximum view panels to outside.
- Building to be raised

10.1.10.6 Fire Protection

SANS 10400 A	Occupancy G1
SANS 10400 T	1 X 4.5kg DCP

10.1.11 Primary & Secondary Crusher Substation

10.1.11.1 Facility

- Structure to house substation as well as switchgear room
- Open transformer bay
- Ramp as access to facilities
- Substation & Switchroom

10.1.11.2 Building Structure

- Structure to house substation as well as switchgear room
- Open transformer bay
- Ramp as access to facilities
- Substation & Switchroom

10.1.11.3 Areas

SUBSTATION & SWITCHR:	133m²
TRANSFORMER BAY:	25m²

10.1.11.4 Functionality

- Building raised from natural ground level with access for cables from below
- Transformer in open yard

10.1.11.5 Fire Protection

SANS 10400 A	Occupancy D4
SANS 10400 T	2 X 4.5kg DCP
	1 x 5kg CO2
	1 x Firehose reel
	Fire detection

10.1.12 Product Handling Substation

10.1.12.1 Facility

- Building raised from natural ground level with access for cables from below
- Transformer in open yard

10.1.12.2 Building Structure

SUBSTATION:	• Facebrick structure on concrete pillars & slab • Concrete ramp to building level • Access for services from ground level vertical into building through slab • Height : 5.8m + roof
TRANSFORMER BAY:	• Facebrick walls with concrete floor slab • Steel gate • Height : 2.75m

10.1.12.3 Areas

SUBSTATION	90m²
TRANSFORMER BAY:	25m²

10.1.12.4 Functionality

- Building raised from natural ground level with access for cables from below
- Transformer in open yard

10.1.12.5 Fire Protection

SANS 10400 A	Occupancy D4
SANS 10400 T	2 X 4.5kg DCP
	1x5kg CO2
	1 x Firehose reel
	Fire detection

10.1.13 ROM Substation

10.1.13.1 Facility

- Building raised from natural ground level with access for cables from below
- Transformer in open yard

10.1.13.2 Building Structure

SUBSTATION:	• Facebrick structure on concrete pillars & slab • Concrete ramp to building level • Access for services from ground level vertical into building through slab • Height : 5.8m + roof
TRANSFORMER BAY:	• Facebrick walls with concrete floor slab • Steel gate • Height : 2.75m

10.1.13.3 Areas

SUBSTATION	90m²
TRANSFORMER BAY:	25m²

10.1.13.4 Functionality

- Building raised from natural ground level with access for cables from below
- Transformer in open yard

10.1.13.5 Fire Protection

SANS 10400 A SANS 10400 T	Occupancy D4 2 X 4.5kg DCP 1 x 5kg CO2 1 x Firehose reel Fire detection

10.1.14 Truck Entrance Security

10.1.14.1 Facility

- Guard house
- Toilet facilities
- Kitchen

• Security office

10.1.14.2 Building Structure

• Facebrick single storey building
• Timber roof trusses with Chromadek IBR metal roof sheets
• Steel window frames
• Plaster & paint finish inside
• Height : 2.8m + roof

10.1.14.3 Areas

TOTAL BUILDING: 44m²

10.1.14.4 Functionality

•Offices on outside perimeter with natural ventilation with common facilities in internal Spaces
•Reception to service all offices
• Guardhouse with waiting area security office
• Toilet & Kitchen link between facilities

10.1.15 Truck Entrance Ablution Block

10.1.15.1 Description of facility

An ablution facility has been provided adjacent to the interlink truck parking area for use by the truck drivers. There are no facilities along the route for the drivers accept at Wonderfontein on the N4. There is also not enough truck parking provided creating a safety risk for trucks entering or leaving this facility onto the N4.

10.1.15.2 Facility

• Security room, toilet facilities & kiosk
• Outside waiting area

10.1.15.3 Building Structure

• Facebrick single storey building
• Timber roof trusses with Chromadek IBR metal roof sheets
• Steel window frames

- Internal walls Plaster & paint finish
- Height : 2.8m + roof

10.1.15.4 Areas

TOTAL BUILDING: 60m²

10.1.15.5 Functionality

- Public toilet facilities for men & woman

with access from outside - outside communal
Wash hand basins & separate kiosk & security

10.1.15.6 Fire Protection

SANS 10400 A	Occupancy G1
SANS 10400 T	1 X 4.5kg DCP

10.2 Mining Area

10.2.1 Mining Area Access Security

10.2.1.1 Facility

- Guard house
- Toilet facilities
- Kitchen
- Security office

10.2.1.2 Building Structure

- Facebrick single storey building
- Timber roof trusses with Chromadek IBR metal roof sheets
- Steel window frames
- Plaster & paint finish inside
- Height : 2.8m + roof

10.2.1.3 Areas

TOTAL BUILDING: 44m²

10.2.1.4 Functionality

•Offices on outside perimeter with natural ventilation with common facilities in internal Spaces
•Reception to service all offices
- Guardhouse with waiting area security office
- Toilet & Kitchen link between facilities

10.2.1.5 Fire Protection

SANS 10400 A	Occupancy G1
SANS 10400 T	1 X 4.5kg DCP

10.2.2 Mining Change House

10.2.2.1 Facility

- Shower facilities, toilet facilities, Change room and lockers
- Service area for heat pump, cleaners, storeroom
- Male & female facilities separate

, laundry room

10.2.2.2 Building Structure

- Facebrick single storey building
- Timber roof trusses with Chromadeck IBR roof sheeting
- Steel window frames
- Internal plaster & paint finish with wall tiles floor to ceiling
- Storage tank
- Height of structure: 3.05m + roof

10.2.2.3 Areas

MALE CHANGEROOM:	230m²
FEMALE CHANGEROOM:	70m²
OTHERS:	60m²

10.2.2.4 Functionality

- Separate staff facilities and amenities for men and women
- Communal laundry facilities
- All areas with natural ventilation and waterproof finishes

10.2.2.5 Fire Protection

SANS 10400 A	Occupancy G1
SANS 10400 T	1 X 4.5kg DCP

10.2.3 Mining Office

10.2.3.1 Facility

- Offices, Open office, Boardroom, Kitchen and toilet facilities

10.2.3.2 Building Structure

- Facebrick single storey building
- Timber roof trusses with Chromadek IBR metal roof sheets
- Steel window frames

- Internal walls Plaster & paint finish

• Height : 2.6m + roof

10.2.3.3 Fire Protection

SANS 10400 A	Occupancy B3
SANS 10400 T	4 X 4.5kg DCP

10.2.3.4 Areas

BUILDING:	337m²

10.2.3.5 Functionality

•Offices on outside perimeter with natural ventilation with common facilities in internal spaces
•Reception to service all offices

10.2.3.6 Fire Protection

SANS 10400 A	Occupancy G1
SANS 10400 T	8X 4.5kg DCP
	3 x Firehouse reel
	1 x Hydrant

10.2.4 Mining Mobile Equipment Workshop

10.2.4.1 Description of facility

The workshop is provided with 6 truck work bays and a lean-to administrative office space and stores. The workshop has been provided with a 10t overhead crane designed to reach all the work bays. The main area consists of steel structure with Chromadek cladding (double volume). The administrative area consists of a face brick building with Chromadek roof sheeting.

10.2.4.2 Facility

BLOCK A:	• Workshop area
BLOCK B:	• Store rooms, Offices, Open Office, Boardroom, Toilet facilities & Tea room

10.2.4.3 Building Structure

BLOCK A:	• Steel structure with sheet metal cladding
	• Roll up doors

- Height of structure- 13.5m + roof

BLOCK B:

- Facebrick single storey building
- Timber roof trusses with Chromadek IBR metal roof sheets
- Steel window frames
- Internal walls Plaster & paint finish

10.2.4.4 Areas

BLOCK A WORKSHOP: 1326m²
BLOCK B: 303m²

10.2.4.5 Functionality

- workshop steel structure with concrete floor with slopes to catchpits. Offices areas link to workshop

10.2.4.6 Fire Protection

SANS 10400 A Occupancy G1	Occupancy G1 & B2 4 X 4.5kg DCP 1 x Firehose reel
SANS 10400 T Occupancy B2	Firehydrant
SANS 10400 T	6 x 9kg DCP 3 x Firehose reel

10.2.5 Shovel Laydown Area

10.2.5.1 Description of facility

Steel structure with Chromadek cladding on two sides with open side facing open concrete hard stand (double volume)

10.2.5.2 Facility

BLOCK A:

- Covered Workspace & Open Hardstand area

BLOCK B:

- Offices, Tea room, Kitchen & toilet facilities

10.2.5.3 Building Structure

BLOCK A:

- Steelstructure with sheet metal cladding
- Roll up doors
- Height of structure- 5.8m + roof

BLOCK B:	• Facebrick single storey building • Timber roof trusses with Chromadek IBR metal roof sheets • Steel window frames • Internal walls Plaster & paint finish

10.2.5.4 Areas

BLOCK A :	470m²
BLOCK B:	78m²

10.2.5.5 Functionality

• Partial open & enclosed workshop area linked to offices with toilet facilities

10.2.5.6 Fire Protection

SANS 10400 A Occupancy G1	Occupancy G1 & B2 1 X 4.5kg DCP
SANS 10400 T Occupancy B2	1 x Firehose reel
SANS 10400 T	2 x 9kg DCP
SANS 10400 A	Occupancy G1 & B2

10.2.6 Tyre Storage

10.2.6.1 Description of facility

The tyre storage is located east of the mobile equipment workshop. It consists of:

- Steel structure with Chromadek cladding on 3 sides with roller-shutter doors.
- Open concrete surface with concrete tyre storage area.
- Single storey face brick building with Chromadek roof sheeting.
- Single storey face brick building consists of 2x offices.

10.2.6.2 Facility

BLOCK A:	• Tyre storage area and Open Hard stand area with Open storage cages
BLOCK B:	• Offices

10.2.6.3 Building Structure

BLOCK A:	• Steel structure with sheet metal cladding

- Roll up doors
- Height of structure- 5.8m + roof

BLOCK B (Offices):

- Facebrick single storey building
- Timber roof trusses with Chromadek IBR metal roof sheets
- Steel window frames
- Internal walls Plaster & paint finish

10.2.6.4 Areas

BLOCK A :	185m²
BLOCK B (Offices):	21m²

10.2.6.5 Functionality

• Open & enclosed tyre storage area linked with two offices - walls to create storage bays

10.2.6.6 Fire Protection

SANS 10400 A	Occupancy J1
SANS 10400 T	2 X 9kg DCP
	1 x Firehose reel

11 Structures

11.1 Structural Design for Buildings, workshops and warehouses

11.1.1 Design Codes/Guidelines

Table 4.7: Design Guidelines for Structures

Design requirements of Steel Structures	Doc No. MGP-O78-000-000-C-SPC-010
Corrosion Protection	Doc No. MGP-O78-000-000-M-SPC-003_AX
Design Requirements for Reinforced Concrete Structures	Doc No. MCG-O78-0000-0000-C-SPC-005
Steel,_FRP_Flooring,_Stairs,_Ladders_and_ Guardrails	AA_SPEC_114005

11.1.2 Ground Profile

It should be noted that the ground conditions are classified as ‘very aggressive’ (J&G Geotechnical report page 11)

The general ground profile for the mining area has been acquired from boreholes taken by Exxaro. The ground profile has been summarised as follows

11.1.2.1 Plant Area

- Thin Layer of topsoil of about 0.3 m average
- A very loose pin hole voided, silty fine sandy colluviums about 1.3 m average thickness.
- Hardpan ferricrete variable in thickness – 1.3 to 1.5 m
- Soft intact, clayey silt with scattered weakly developed Fe/Mn nodules and slickensides. Residual siltstone below the hardpan ferricrete up to 2.8m below NGL
- Very hard Rock Sandstone from 2.8m below the surface.
- Groundwater seepage from about 1.6 m below surface

Initial observations revealed signs of expansive soil layer below the hardpan ferricrete (1,4 m thick). In the absence of tests of the materials it is anticipated that the buildings and floor slabs in warehouses should be designed as raft foundations.

11.1.2.2 Mining Area

- Thin Layer of topsoil of about 0.3 m average
- A very loose pin holed sandy colluvium which vary from 0.3 m up to 1.2 m thick below natural ground level.

- Hardpan ferricrete variable in thickness – 1.2 to 1.4 m

Groundwater level has been noted at 1.6 m below surface

It is concluded that the soils in the mining area is adequate for the design of normal foundations.

11.1.3 Foundations and Ground Floor Slabs

The concrete specification should take into account the aggressive ground conditions. Concrete should be sulphate resisting class 4 with a minimum cement quantity of 420kgs/m^3. Suitable coatings to also be applied such as 1200 gauge membrane

11.1.3.1 Raft Foundations for buildings, workshops and warehouses in the Plant Area

A raft foundation transmits the loads to the ground by means of a reinforced concrete slab that is continuous over the base of the structure. Rafts are designed as inverted flat slabs which are affected by the bearing pressure of the soil.

11.1.3.2 Ground Floor Slab for Workshops and Warehouse in the Mining area

The ground floor slab (slab thickness varies depending on load information) is designed as an industrial workspace, in general the slab is a reinforced cast insitu slab and should be laid on 150mm C3 material, over 300mm of well compacted G5 natural gravel (compacted in 150mm layers) over 300mm of G7 material over virgin bearing strata. A CBR value of 5% or greater should be achieved by the virgin bearing strata

11.1.3.3 Foundations

Foundations for buildings should be designed according SANS 10400 Part H (Deemed to Satisfy Rules) in the mining area. Foundations in the plant area will consist of a raft slab.

The foundations for Workshops and warehouses are to be reinforced or mass concrete. They should be excavated and cast on virgin bearing strata with a capacity of not less than 75kN/m^2

11.1.4 Steelwork – Superstructure for Workshop and Warehouses

The extent of new steelwork superstructure works is basically as described on the drawings and sketches.

11.1.4.1 Loading

The loading is assumed on information described SANS 0160.

The dead load over the main shed roof assumes a light weight roof build up with 0.75kN/m^2 live load allowance

11.1.4.2 Primary Steelwork

The Primary Steelwork drawings have been issued in line with the architects drawings that were available. The primary frame for the Mobile Equipment Workshop was not possible to be constructed in single sections, so lattice columns have been provided. A pinned roof truss is also provided to minimize complicated construction joints.

In addition to the primary structural steelwork shown on the drawings an allowance should be made for framing requirements to louvers and doors.

Many items will be defined by or required in support of other packages of work, such as cladding and building services, whose precise requirements will not be known until later in the design stage:

- Connection and Base plate details
- Cleats, lugs and brackets for attachments
- Additional services or drainage openings in slabs and walls
- All steelwork to be S355.
- Additional trimmer steelwork will be required around openings through the structure for building services etc that are not currently shown on the drawings. *An allowance should be made at this stage.*
- General secondary steelwork such as stairs (if necessary to access crane etc) hand railing, signage brackets etc to be developed during the next stage of design.

11.1.4.3 Cladding

Detail and requirements of the cladding system are still in development, an allowance should be made for purlins as shown on the drawings although these do not reflect a detailed design (tie bars and sag rods etc are to be developed in the detailed steelwork design phase).

11.1.4.4 Stability

The frames are designed as a braced portal. Roof plan bracing is shown indicatively, location and geometry of bracing may vary. Gable wall bracing is shown in both gable walls. .

11.1.4.5 Paint Specification and Fire Protection

Steelwork paint and fire specification to be according Exxaro standard specifications. All steelwork to be galvanised.

11.1.4.6 Connections

All connections are assumed to be standard connections, unless indicated otherwise. An allowance for connections should be made at this stage.

11.1.4.7 Cast-in holding down bolts for structural steel frames

Assume for costing that all steel columns require a minimum of 8 no. M20 Grade 8.8 holding down bolts. Allow for 500mm embedment with 100x100x20 thick washer plates on each bolt.

11.2 Heavy vehicle Wash bay

11.2.1 Vehicles to be cleaned

Caterpillar 773 and 740 articulated dump trucks, and dozers. The bay must accommodate one vehicle at one time. All silt and wash water to accumulate in one silt trap with storm water capacity and hydrocarbon filter system. Pumps to be supplied with raw water fed from one 10,000liter reservoirs positioned close to wash bay pump house to be supplied from the mine. All steelwork to be hot dipped galvanised with all installation welds to be cold galvanised. Raw water will be supplied from storm water dam D2-2.

11.2.2 Description of facility

The wash bay is situated west of the mobile equipment workshop.

The washday comprises of:

- Wash bay Equipment
- Raw Water take-off
- Walk Way
- Controls
- Silt trap
- Wash bay Sump, Grid Covers, Spares and Manholes
- Hydrocarbon System
- Channels
- Remediation slab

11.2.2.1 Wash bay Equipment

Six high pressure, high volume water pumps will be mounted inside an enclosed pump location, with two pumps supplying water to the two sliding rails and one pump supplying the two hand held guns at spillway level. The centrifugal pump

will be feeding the spillway cleaning system all mounted onto one common channel iron base, in turn bolted down onto the concrete floor of the pump house.

The three high pressure main water pumps will be connected to the main suction pipe leading from the two10 000liter reservoir tanks mounted to the one side of the pump room. The pump units will be connected through double braid hydraulic hoses and fittings plus all stainless steel ball valves and non-return valves mounted to the manifold. The main manifold will be manufactured to accommodate all four pumps complete with all fittings.

The two 80mm and two 50mm main delivery lines will be schedule 40 high pressure pipes complete with all flanges, T-pieces and elbows all welded and bolted together to your specifications.

These pipes will be mounted inside three 400mm diameter HDPE pipe sleeves complete with mounting brackets and clamps. Access man-holes will be supplied along the pipe sleeves positioned at each walkway with galvanised cover grating.

Two 50mm pipes will lead off from the main supply line and in turn branch out into 25mm lines feeding the two high volume slide rail guns. The two hand held guns will be supplied with automatic retractable hose reels positioned midway on either side of each spillway mounted onto galvanised brackets and bolted to the walkway structure. Each walkway will be fitted with two high volume, high pressure carriage mounted lances, with full swivel and tilt running on an eight sealed bearing fabricated carriage intern running on two sixteen meter 100mmx10mm square tubing rails. Each rail will be supported by eight channel iron brackets mounted to the main walkway structure. Each rail will be supplied with one hose basket ensuring no fouling of hose on walkway. The two high volume slide rail guns mounted on the walkway allows the operator to clean inside buckets and main upper structures of the vehicles. The two hand held guns allows easy cleaning of vehicle chassis and wheel arches from ground level. One hot water pump system with degreaser will be fitted at end of pump base frame inside pump enclosure.

The high volume close coupled centrifugal pump and motor will be mounted at the end of the pump enclosure complete with suction and delivery hose with pressure regulator supplying separate high volume low pressure water to the fire hydrant type guns mounted at each end of the spillway.

One 250liter/min sump pump will be mounted in the clean water sump section of the silt sump pumping clean water back to the main reservoir complete with hoist and block and tackle unit. One diaphragm positive displacement air pump will be mounted at the first stage at the silt trap allowing easy water removal from sump as and when silt is to be removed by the front end loader.

The main sump pump will be controlled through one level probe mounted inside the sump and main reservoir.

One mini drain pump will be fitted inside the pipe trench controlling water build-up inside pipe sleeves. This unit is supplied with a level control float switch. The discharge pipe will exit onto the walkway slab.

All guns and lances at spillway can only be used by one operator at one time.

11.2.2.2 Fire Hydrants

The two fire hydrant connections will be mounted at both ends of the spillway delivering high volume raw water to the two hand held 19mm adjustable guns fitted to two heavy duty hose reels fitted with twenty meters 32mm re-inforced Escback hose. Each fire hose gun take-off point will be supplied with a remote stop start push button station.

11.2.2.3 Walkway

The galvanized 20.5 meter long by 1.5m wide by 4.0m high walkways will be manufactured from 203 x 127 x 8 channel iron beams cut, welded and bolted together in sections to form the whole walkway.

Each walkway will be fitted with one stairway complete with galvanised angle iron handrails and kick plates and Chromadek IBR screen. All steelwork will be hot dip galvanised and all railing to the Anglo specification for wash bays .Solid bar stanchions and rails. (SANS 1200A and AH SANS 10104)

11.2.2.4 Control Philosophy

All pumps are timer controlled to prohibit pumps from running unattended. Pumps will be fed from a motor control centre with suitable rated motor starters. One flow switch will be mounted in the suction line prohibiting the pumps from running without water, plus one glycerine filled pressure gauge enabling proper pressure setting on pump units. The four main supply lines will be fitted with 0-70bar pressure switches prohibiting over pressure of lines due to blockage and malfunctioning of pressure release valves. The main supply cables will run behind pumps mounted onto cable racks fitted to the pump enclosure side wall. At each walkway end, hose reel and spillway cleaning outlet, one remote stop start station will be fitted enabling the operator to control the pumps individually. One power circuit controlled by a day/night switch with manual/automatic selector switch will be fitted to supply all lighting for the HDV and LDV wash bay. F. Silt Trap

The silt trap will be supplied with galvanised grating, handrails and frame to cover the whole trap area prohibiting entry of paper and large waste. Three manhole covers for access to electrical sleeves to be cast into the concrete spillways and three manhole covers for access to pipe work sleeves to be cast, fabricated and

supplied. These will be fitted at various strategic points as shown on the drawings.

The silt trap will be supplied with galvanised grating, handrails and frame to cover the whole trap area prohibiting entry of paper and large waste. Three manhole covers for access to electrical sleeves to be cast into the concrete spillways and three manhole covers for access to pipe work sleeves to be cast, fabricated and supplied. These will be fitted at various strategic points as shown on the drawings.

11.2.2.5 Wash bay Sump, Grid Covers, Spares and Manholes

Each wash bay sump clean water and dirty water section will be covered with a galvanised steel frame and Rectagrid panels complete with access doors for cleaning and servicing of sump pump and hydrocarbon skimmer system. The spillway channels through the walkway areas will be supplied with Rectagrid panels ensuring safe walkway areas. Six 300mm 304 stainless steel overflow pipes and four sets 22kg fabricated rail will be supplied to be fitted into the concrete work by the civil contractor. Six 1.3m square concrete manhole covers with lids to be supplied and positioned by the civil contractor.

11.2.2.6 Hydrocarbon System

The hydrocarbon unit is per Hydraspin system Model type HS 25- 25M3/HR and is a centrifuge oil separator 15m3/hr capacity

11.3 Light Vehicle Wash bay

11.3.1 Description of facility

The wash bay is situated west of the mobile equipment workshop.

The wash bay comprises of:

- Wash bay slab
- Silt trap
- Channels
- Oil separator (≤ m3/hr centrifuge type system)

The wash bay equipment will be consisting of mobile pressure washer ideal for the wash of LDV's and or other equipment.

11.4 Explosives Storage Magazines and Pril Silo

11.4.1 Description of facility

The explosive magazines consist of portable magazine container surrounded by artificial barricades. Artificial barricades are provided in the form of retaining walls backfilled with an artificial compacted mound of earth.

The Pril Silo consist of a bunded concrete slab, concrete channel with a 100mm diameter drain pipe with four column foundations.

The magazines and Pril Silo are fenced off with 2.4m security and electric fencing with one entrance gate for each facility. The Pril Silo is separately enclosed adjacent to the Explosive magazines.

A gravel access road is provided to each facility.

No security facility is required. Security will inspect the facility on a regular basis.

11.4.2 Dimensions of building

The space allows for the portable magazines to fit inside the artificial barricades which measure internally 6000 x 6000mm.

The 200 mm thick Pril silo slab measures 12000 x 11780mm

11.5 Matrix Silo

The Matrix Silo consist of a bunded concrete slab, concrete channel with a 100 diameter drain pipe with four column foundations

The 200 mm thick Pril silo slab measures 12000 x 11780mm

Sasol will complete the installation with silos, pumps and tanks as required.

11.5.1 Description of facility

The Matrix Silo consist of a bunded concrete slab, concrete channel with a 100mm diameter drain pipe with four column foundations

Due to the low volume of the facility diesel will be filled with a browser.

A gravel access road and a water connection have been provided.

11.5.2 Dimensions of building

The 200 mm thick Matrix slab measures 12000 x 11780mm. A 200mm thick slab has been provided adjacent to the Matrix slab which measures 14000 x 4000mm for diesel and water storage tanks.

11.6 Gas Storage

The gas storage consists of open store, build-up with one meter perimeter brick wall, IBR sheeting and Platex welded mesh. The store is a divided with a brick wall to separate empties and fulls. The floor is cast in concrete.

Gas stores are placed at:

- The workshop
- Supply Management Store
- Mobile Equipment Workshop

11.7 Hazardous Store

The Hazardous Store consists of an IBR cladded open store 2.4 metres high. The top 500mm of the buildings are cladded with Platex welded mesh. The stores are placed at the plant workshop:

11.8 Compressor Room

The compressor room consists of an IBR cladded 2.4 metres high building. The building has been provided with a double door and crawler beam for easy access in the event of a breakdown or maintenance purposes. .The floor area measured 2, 8 by 2.6 m which is enough space to house a compressor with a working pressure of 11 bar. The compressor room is situated on the western side of the mobile equipment workshop

The compressor room will supply air the workshop and wash bay.

11.9 Shift Change Temporary Buildings

11.9.1 Description of facility

The shift change area consists of 3 x multiple office portable units, open covered area and include ablution faculties. A 5000 litre tank has been provided for potable water supply to the ablution facilities. Potable water will be supplied by water carts as and when required. A portable conservancy tank of the Calcamite type has been provided. The tank will be emptied as and when required with a honeysuckle and discharged in the WWTW for further treatment.

11.9.2 Dimensions of building

The dimensions are as follow:

Description	Floor space (m^2)	Type
2 x Multi Office Units	44	Modified Containers
1 x Multi Office Units	15	Modified Containers
Ablution Facilities	15	Modified Containers
Covered Area	72	2 x Carports of 6x6m

11.10 Filter Plant and Thickener Slab

Although the plant will have its own sumps, the area adjacent to the washing plant, thickener and filter presses could potentially be wet areas. It can be stated that this area will be water logged with serious maintenance issues to the engineering unit. In order to address these, the complete area will be surfaced with concrete.

12 Weighbridges

12.1.1 Description of facility

Three weighbridges are required; one to weigh empty trucks and two to weigh fully loaded trucks.

The weighbridge structure has been designed in accordance with drawings received from the Trek Scale Company.

A weighbridge consist out of three concrete plinths measuring 3170mm x 800mm x 400mm deep and two concrete plinths measuring 3170mm x 1200mm x 400mm deep. The plinths and ramps are steel reinforced. The area between the plinths will be paved with segmented paving blocks

Guardrails consist of structural steel components i.e. H-columns with lipped channels demarcating the sides of the weighbridge to guide trucks onto the bridge. Armco Guardrails is not recommended at any weighbridge

Stormwater run-off discharges into the drainage system adjacent to the weigh bridge.

The weighbridge deck consist of:

- Surface Mounted Multi Deck Road weighbridge to weigh 60,000kg x 20kg complete with Multi Range Digital Indicator, Powercells and Steel Platforms for weighing of Axle loads and combination of total vehicle mass.
- Mettler Toledo Digital Indicator Model IND 780.
- Four only steel platforms as follows:
    - 3m x 3m
    - 6m x 3m
    - 7m x 3m
    - 6m x 3m

- Sixteen (16) only Metler Toledo PDX 30 Ton Hermetically sealed, stainless steel digital powercells with braided cable and water tight connectors (IP68/IP69K). Protected against lightning strikes up to 50 000 amperes.
- One (1) only standard lightning protection in accordance with Mettler Toledo specifications.

12.1.2 Dimensions of Weighbridge

A weighbridge is 22.0m long by 3.2m wide.

12.1.3 SANS Approval's

The weighbridge will be SANS 1649 and 1838 approved. Approved for trade and road ordinance requirements.

12.1.4 Tyre Topping up Facility

12.1.4.1 Description of facility

The tyre topping up facility is located south of the Shovel laydown building. It consists of:

- Two rows of tyres about 10m centre to centre and stacked in three layers filled with sand.
- 250 mm thick reinforced concrete surface in the top up area.
- Nitrogen topping-up container placed on top of reinforced concrete sleepers.

13 Pollution Control Dams

13.1 Terminology

A number of terms in this section are used to describe certain activities. The terms are generally used in the description of the designs of dams, but are not solely limited to this application. The terms are defined as:

DWA – Departement of water affairs

GCL – Geosynthetic clay liner

GN704 – Government Notice No. 704, National Water Act, 1998 (Act No. 36 of 1998)

HDPE – High Density Polyethylene

ICOLD - International Commission on Large Dams

PCD – Pollution Control Dam

RDF – Recommended Design Flood

SEF – Safety evaluation flood

SANCOLD - International Commission on Large Dams

Clean water - Water that has not been affected by pollution.

Dirty water - Water that contains waste.

Groundwater - Water that occurs in the voids of saturated rock and soil material beneath the ground surface is referred to as groundwater and the body within which the groundwater is found is referred to as an aquifer.

Seepage - The act or process involving the slow movement of water or another fluid through a porous material like soil, slimes or discard.

Catchment - is defined as the area of land that contains a river system and its associated coastal waters. Catchment boundaries are often formed by high ground separating them, at a line known as a watershed.

Pollution - Pollution means the direct or indirect alteration of physical, chemical or biological properties of a water resource.

APP – Approval Professional Person

13.2 General

Dam D5, D4 and D2-2 position related to drainage requirements and restricted localities cannot be balanced in terms of cut to fill.

13.3 Design Codes/Guidelines

Table 13.1: Design Guidelines/Reports for Pollution Control Dams

Government Notice No. 704 (GN 704)	Regulations on use of water for minning and related activities aimed at the protection of water source
Best Practice Guidelines – A4	Pollution Control Dams
The Dam Safety Regulations	Government Notice R 1560 of 25 July 1986
National Enviromental Management Act, 1998	Act No. 36 of 1998
Mineral and Petroleum Resource Development Act, 2002 (Act 28 of 2002)	Act 28 of 2002
Concept Design Report – Storm water Management and Dams	JG No 002802 of 19 August 2011
Surface Water Assesment	Golder Report No 12433-9312-1 of November 2009
Surface Water Assesment	Golder Report No 12433-9312-2 of February 2011
Belfast Colliery Project – Update of Water Balance	Golder Report No 11613853-11116-1 of December 2011
SANS 10409:2005	Design, Selection and Installation of Geomembranes

13.4 Pollution Control Dams

The table below summarises the various PCD's , together with the primary functions and operation philosophy for each type of dam to be designed.

Table 13.3.1 Summary of the various types of dams

Dam	Description	PCD Type	Primary function	Operations
*D2-1	Mine Haul roads	Storm water	Retention of dirty storm water	-Accommodate dirty water inflow -Return of dirty water to dam D2-2 at a controlled manner -Will be emptied within 3 days after 1:50 year storm event
D2-2	Storm water dam	Storm water	Retention of dirty storm water	-Received dirty water from the plant workshop, diesel depot and tip and crusher ramp -All dirty water will be pumped via a pump line to dam D5. -Dam together with dam D2-1 and D2-3 will be pumped emptied --Temporary store water for dust suppression, and cleaning
**D2-3	Discard Dump Storm water	Storm water	Retention of dirty storm water	-Accommodate dirty water inflow from the discard dump. -Return of dirty water to dam D2-2 at a controlled manner -Will be emptied within 3 days storm event
D3	Process Water Dam	Process Water Dam	Store top-up water for coal washing plant	Receive dirty water from mine activities for the process plant
D4	Plant Storm water Dam	Storm water	Retention of dirty storm water	Received dirty water from the plant area -All dirty water will be pumped via a pump line to dam D5. -Will be emptied within 3 days after storm event
D5	Return Water Dam	Return Water	Storage of dirty water primary to treatment	-Received in-pit storm water, from dam D2-2 and D4 -received decant water from western and eastern lymph. -Water will be treated in a water treatment plant prior to release
D7	Slurry dam	Slurry Dam	Storage of slurry from filter plant	-Silt will be removed to to discard dump- - Excess water will be discharged via drainage system to dam D4, pumped to dam D5

*In the event of a 1:50 year flood Dam D2-1will contain the flood and will gradually gravitated via a pipeline to network G which discharge into dam D2-1.

Form Dam D2-1 the stormwater will be pumped to dam D5. A sluice valve will be placed into the pipeline to control the discharge into dam D2-1.

**Dam D2-3 will be emptied in the event of a 1:50 year flood a pipeline to into dam D2-1. Form Dam D2-1 the storm water will be pumped to dam D5. A sluice valve will be placed into the pipeline to control the discharge into dam D2-1

13.5 Dam Safety Criteria

13.5.1 Classification of dam

Dams are classed as small, medium or large, depending on the height of the wall. The table below gives a breakdown of the classification in terms of the National Water Act.

Table 13.4.1: Classifications of dams.

Classification of dams with a safety risk				
Hazard Potential Rating		Size Classification		
Rating	Impact	Small Dam(Wall Height< 12m)	Medium Dam (>12m and <30m)	Large Dam (Wall height >30m)
Low	No potential loss of life Minimum economic loss No potential adverse impact on resource quality	Category 1	Category II	Category III
Significant	Potential loss of life <10 Significant potential economic loss Significant adverse Impact on the resource quality	Category II	Category II	Category III
High	Potential loss of life <10 Great potential economic loss Severe potential adverse Impact on the resource quality	Category II	Category II	Category III

The potential negative impact on resource quality is regarded as significant or severe. If the dam is smaller than 50 000m^3 and the wall equal or less than 5m the dam rating is low and fall into category 1 of the above table.

The table below gives the wall heights of the various dams and the category it falls into.

Table 13.4.2: Dam Category

Dam	Description	Wall Height	Dam Capacity (m^3)	Impact on resource quality	Category
D1	Existing Farm Dam (Lower)	4	138 200	No impact	I
	Existing Farm Dam (Upper)	4	67 000	No impact	I
D2-1	Mine Haul roads	2.8	7 000	Significant	I
D2-2	Storm water dam	4.8	19 000	Significant	I
D2-3	Discard Dump Storm water	4.8	42 000	Significant	I
D3	Process Water Dam	3.86	10 846	Significant	I
D4	Plant Storm water Dam	4.8	31 200	Significant	I
D5	Return Water Dam	8.8	520 000	Significant	II
D7	Slurry Dam		4 300	Significant	I

13.5.2 Approval to Construct

For category II dams the APP must apply for authorisation to impound. This involves the submission of an operation and maintenance manual and emergency preparedness plan together with an application form DW 696E

13.5.3 Dam safety Inspections

In terms of the sub clause 117 of the National Water Act dam safety inspections must be done by an APP for dams with a safety risk as define in the act.

13.6 Design Assumptions

13.6.1 Capacity requirement and Freeboard

The capacity requirement for the Return Water Dam has been obtained from the Golder Associates Technical Memorandum dated 29 Jul 2013. The Storm water dam capacity has been calculated not to overflow once in 50 years. The min free board requirements have been obtained from GN 704 of 800mm. The freeboard, for the purposes of this report, has been limited to 800mm. The basis for the freeboard calculations are based a design flood of 1:50 with an assumed wind velocity of 80km/hr and a spillway coefficient of discharge of 1.76. The former defines the ‘dry’ free board and the latter the ‘wet’. The figure below specifically illustrates the various operating levels for pollution control dams. In the case of a pollution control dam the normal operating level is made up of process waters and the flood buffer zone is the volume of the 1:50yr flood. The normal operating procedure will ensure that the level of these dams is maintained at or below this capacity which ensures that the flood is contained within the dam, prior to transfer to the main holding dam. The spillway is in effect an emergency out let in the event of some operating failure or larger return period floods. See Fig 13.1 A4: Best Practise Guidelines – Aug 2007 page 22

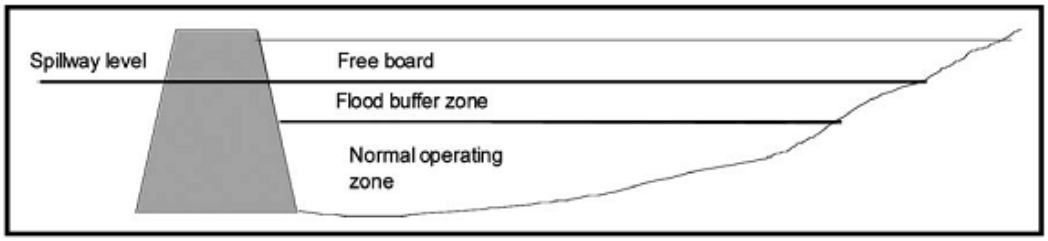


Figure 13.1: Definition of Freeboard

The table below summarises the capacity and freeboard requirement for each dam.

The upper and lower farm dam volumes have been determined using the following formula:

$$Q = HA/3.$$ Where

- Q is dam volume measured in m^3
- A is the water surface area measured in m^2 and
- H is the downstream wall height measured in m

The farm dam water surface area has been obtained and measured from aerial photos and the downstream depth determined during a site visit. The Farm dam data is recorded in item 13.6.1 and 13.7.1.

Table 13.5.1: Dam Storage and freeboard requirements

Dam	Description	Catchment (m^2)	Dam Capacity (m^3)	Allowance for Silting (m^3)	Freeboard (m)	Dam Volume incl. Freeboard (m^3)
D1	Farm Dam (Lower)	Not Determine	138 200		Not known	
	Farm Dam (Upper)	Not Determine	67 000		Not Known	
D2-1	Mine Haul roads	93 300	7 000	250	0.8	10 620
D2-2	Storm water dam	167 650	19 000	1000	0.8	24 400
D2-3	Discard Dump Storm water	525 114	42 000	1000	0.8	52 900
D3	Process Water Dam	N/A	10 846	500	0.8	15 100
D4	Plant Storm water Dam	385 775	31 200	1000	0.8	39 600
D5	Return Water Dam	N/A	520 000	1000	0.8	585 050
D7	Slurry dam	N/A	4300		Not Applicable	

The table below summarise the dry freeboard calculations for dams provided with a spillway. (For calculations see appendix F) The following formula has been used to calculate the dry freeboard:

H=C*(0.00514*L^0.47)*V^1.06 where

- H is the dry freeboard measured in meters:
- C is the spillway coefficient
- L is the fetch distance in meters and
- V is the assumed wind velocity in Km/hr

Table 13.5.2: Design Freeboard (1:100 year event)

Dam	Description	Design Flood (m^3/s)	Spillway Length (m)	Flood Rise (m)	Wave Height (m)	Total Freeboard. (m)	Design Freeboard (m)
D2-1	Mine Haul roads	1.2	1.5	0.59	0.18	0.77	0.8
D2-2	Storm water dam	8	14	0.51	0.28	0.79	0.8
D2-3	Discard Dump Storm water	4.3	6	0.55	0.2	0.75	0.8
D5	Return Water Dam	5.9	20	0..3	0.48	0.78	0.8

13.6.2 Crest Width

The crest width is selected taking into account the depth of the dam. The crest width (Cw) has been calculated using the formula Cw (m) = 0.4H+1 for dams exceeding 5m in depth. The table below gives the selected crest width for each dam.

Table 13.5.3: Selected Crest Width

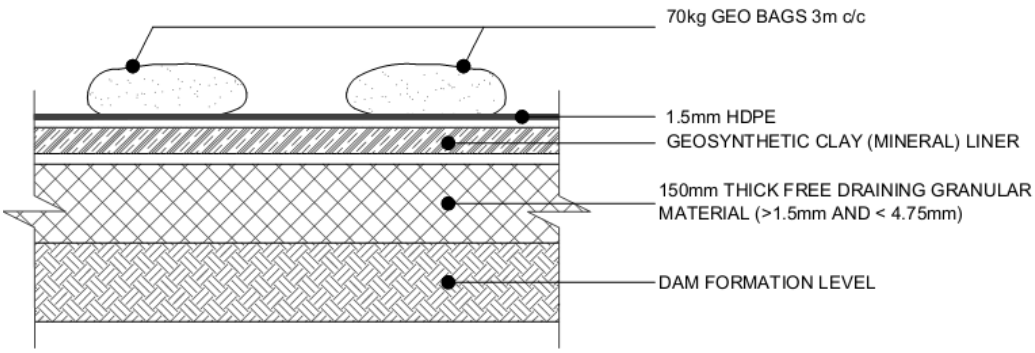
Dam	Description	Crest Width (m)
D1	Existing Farm Dam (Lower)	4
	Existing Farm Dam (Upper)	4
D2-1	Mine Haul roads	3
D2-2	Mining Area Storm water	3
D2-3	Discard Dump Storm water	5
D3	Process Water Dam	3
D4	Plant Storm water Dam	3
D5	Return Water Dam	5

To reduce erosion the crest has been sloped at 2% cross fall to drain water towards the dam via the upstream embankment

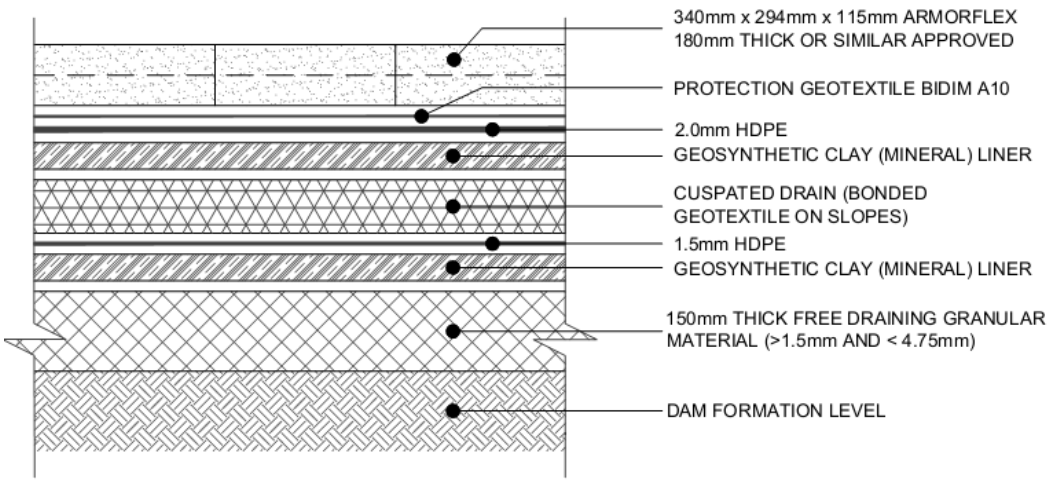
13.6.3 Dam Liner Systems

PCD liner systems is design according SANS 10409:2005

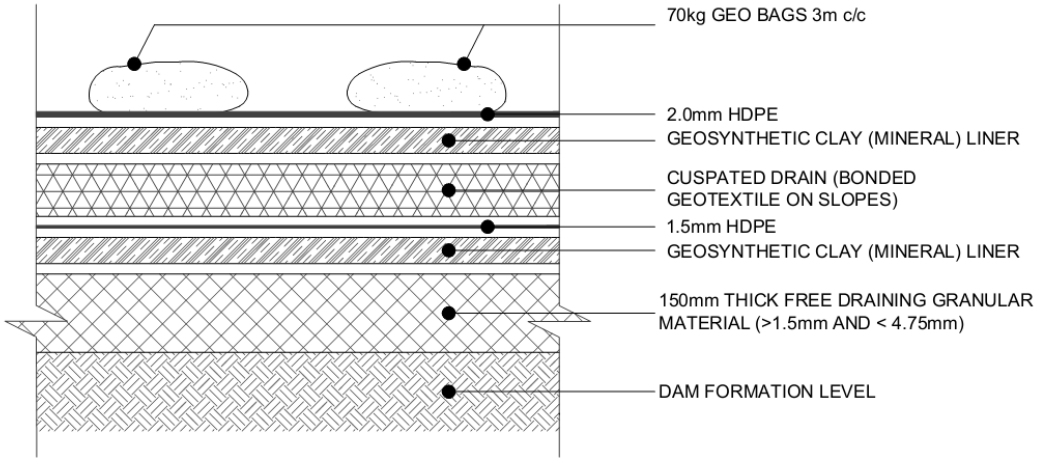
Geomembrane liners are used as a secure impermeable flexible barrier to prevent contamination of the sol, groundwater and environment. The primary liner function is the containment of hazardous liquid and the protection of valuable water source. The various types of linings are shown below.



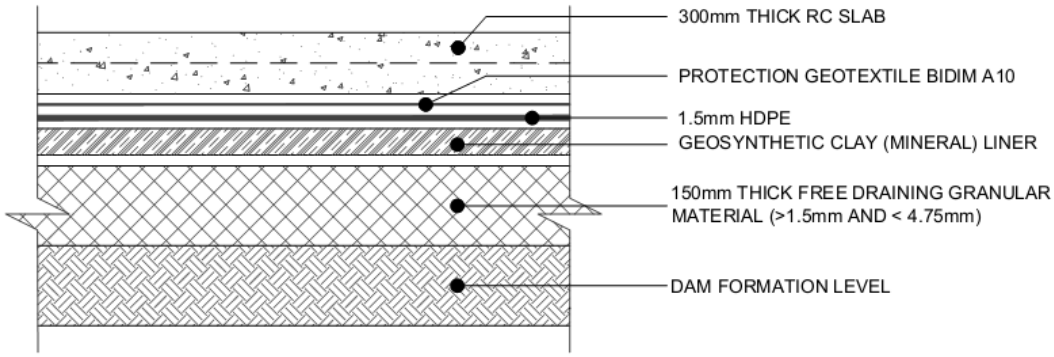
Lining Type 1



Lining Type 2



Lining Type 3



Lining Type 4

The table 13.5.4 below recorded the type liner to be used in the various type of PCD's liner

Table 13.5.4: Liner type application for the various PCD's

Dam	Description	Lining Type

D2-1	Discards and Mine Haul roads	1
D2-2	Mining Area Storm water	2
D2-3	Discard Dump Storm water	3
D3	Process Water Dam	3
D4	Plant Storm water Dam	2
D5	Return Water Dam	3
D7	Slurry dam	4

13.6.4 Spillways

Spillways are structures constructed to provide safe release of flood waters from a dam. The spillways for the various PCD are design to safely passing the appropriate spillway design flood for a 100-year recurrence interval.

The chute type spillway is used and is concrete lined. Energy dissipation in the form of concrete blocks is provided on the downstream slope. A stilling chamber is provided at the terminus of the outlet spillway to further dissipate energy and prevents erosion. The table 13.5.5 below summarised the design data for the spillways.

Table 13.5.5: Spillway Data

Dam	Description	
D2-1	Mine Haul roads	Side Channel with a Chute Spillway and dissipaters
D2-2	Storm water dam	Chute Spillway with dissipaters
D2-3	Discard Dump Storm water	Chute Spillway with dissipaters
D3	Process Water Dam	No Spillway provided.
D4	Plant Storm water Dam	The 100-year recurrence will flow via a concrete lined trapezoidal storm water channel to dam D5.
D5	Return Water Dam	Chute Spillway with dissipaters
D7	Slurry dam	Used for slurry storage. No spillway required

13.6.5 Subsoil drainage

Subsoil water is known as groundwater and is the portion of rainwater which is absorbed into the ground. Groundwater will level or standing water is refer to as the water table. The water table is the level at which rainwater lies under the ground and remains at that level depending on the amount of rainfall, and the proximity and level of water courses.

Subsoil drainage is provided below dam linings to alleviate ground water pressures likely to cause the liner to lift up. A subsoil drain also has a dual function namely as a leak detection system for hazardous water leaking trough the liners and to drain groundwater.

A subsoil drain consists of a number of drains which run parallel to each other in a herringbone or grid pattern. Fig13.2. below show a typical subsoil drain composition.

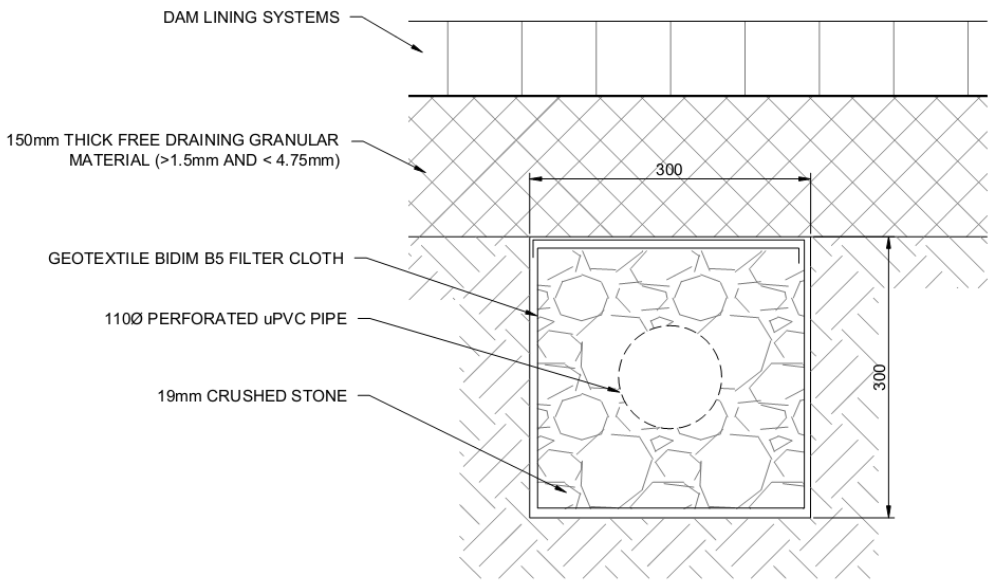


Fig 13.2 Subsoil Drainage composition

The spacing of a subsoil drain is dictated by the groundwater conditions and the depth of the liner. For dams deeper than 5 m a grid spacing of 4 metres has been used. The table below summarised the grid spacing for the various dams. This will be amended pending geotechnical and piezometer-analysis during detailed design.

Table 13.5.6: Subsoil Drainage Grid Spacing.

Dam	Description	Grid Spacing (m)
D2-1	Mine Haul roads	20
D2-2	Storm water dam	20
D2-3	Discard Dump Storm water	20
D3	Process Water Dam	20

D4	Plant Storm water Dam	20
D5	Return Water Dam	4
D7	Slurry dam	20

The subsoil drainages system discharge into a sump and pumped back into the dam using controlled submersible pumps.

13.6.6 Embankments

No geotechnical investigations have been carry out at this stage of the project.

The basis for the design of the embankments is assumed to be conservative;

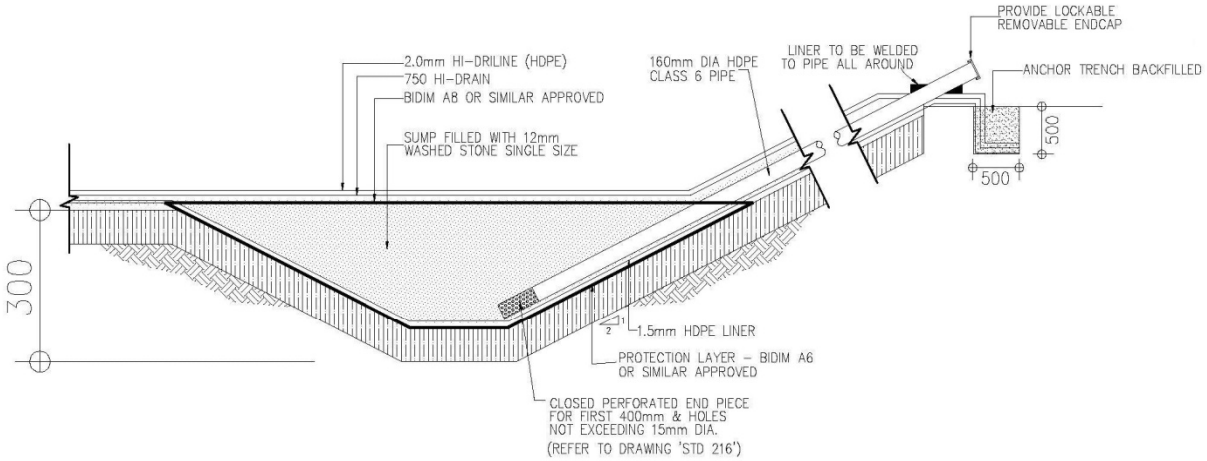
Maximum dam height	9m
Upstream slope	3:1
Downstream Slopes	2.1
Crest Width	see Above Table 13.5.2
Compaction	98% standard Proctor

Embankments will be homogeneous with well graded gravels of moderate PI.

The D/S slopes will be grassed and the U/S slope will be protected by HDPE liner. Toe drains will be integrated with the surface water drainage for the site.

13.6.7 Leak Detection for composite liners.

The sketch below (annexure A) shows a typical configuration for a system that can be placed between dual geomembrane liners. The perforated pipe can be inspected through a removable end cap to check for possible leaks. The dam can be divided in zones to isolate areas to determine in which zone the leak occur.


PROVIDE LOCKABLE
REMOVABLE ENDCAP
2.0mm HI-DRILINE (HDPE)
750 HI-DRAIN
BIDIM A8 OR SIMILAR APPROVED
160mm DIA HDPE
CLASS 6 PIPE
LINER TO BE WELDED
TO PIPE ALL AROUND
ANCHOR TRENCH BACKFILLED
SUMP FILLED WITH 12mm
WASHED STONE SINGLE SIZE
500
500
300
1.5mm HDPE LINER
PROTECTION LAYER - BIDIM A6
OR SIMILAR APPROVED
CLOSED PERFORATED END PIECE
FOR FIRST 400mm & HOLES
NOT EXCEEDING 15mm DIA.
(REFER TO DRAWING 'STD 216')

ANNEXURE A

13.7 Lower Farm Dam in Klein Komati River

13.7.1 Preliminary Data

Dam No & Name:	DAM 1 (Lower)
Date of Inspection:	15th June 2012
Persons Present:	James Hampton, Jaco Rossouw and Nompumelelo Ntuli
Location:	Belfast
Distance to:	12km to Belfast on N4
Name of River:	Klein Komati
Construction Dates:	Not Known
Full Supply Level (FSL):	1777.5 masl
Catchment Area	13.8 Km2
Capacity at FSL	Not known
Surface Area at FSL:	103 650 m2
Height of Main Dam Wall:	3-4.5m
Maximum Water Depth:	3-4m
Crest length of main dam:	300 m
Spillway length: approx as not well define	30 m
Fetch	630 m
Reservoir Water Level (RWL):	Not known
Rainfall Gauge:	N/A
Age of Dam	Not known but the embankment erosion it would appear to be older than 15 years.

13.7.2 General

This site visit was commissioned to assess the safety of two dams within the Belfast Project boundary. The dam waterway is intended to remain throughout the life of the mine.

This inspection was based on visual observations only, with no design or as built documentation or drawings available. There was no site survey available consequently Google was used to estimate lengths and elevations.

13.7.3 Type of Main Dam

The overall dam comprises the following sections of approximate lengths: A 348 m long earth embankment, with drift causeway type of spillway approximate width 15 m length the spill crest partially defined by a series of concrete lintel type beams running parallel to the flow.

13.7.4 Type of Spillway

As described above an earth/ founded spillway, grass lined which ramped down to a series of lintel type beams which define the full supply level (FSL). The spillway acts a

drift for a vehicle track crossing and is approximately trapezoid in shape. The spillway return is stable and runs into a small depression before it exits into a large wetland. It is estimated at 30m with a total free board of 1m.

Photograph 1 Spillway Return

13.7.4.1 Outlets Works

There was no outlet pipe observed nor did there appear to be one.

13.7.4.2 Saddle Dams

There are no saddle dams.

13.7.4.3 Sedimentation

There was no visible indication of the state of sedimentation, however this catchment has a number of small dams upstream with Dam #2 being almost in the tail water of #1. This would suggest that with upstream dams acting to a certain extent as silt traps, the effect of sedimentation would be delayed.

13.7.4.4 Geology

Refer to the previous reports Appendix G Concept Design Report Stormwater Management September 2011. As a surface observation the the dam walls appear to have been constructed with a variable selection of fine grained silty sands.

13.7.5 Comments On The Earth Embankment

13.7.5.1 General

The history of the earth embankments is not known but visual observation indicate the dam to have been constructed to a crest width of approximately 3.5m to 4m, with a downstream slope of about 1v:1.5h and an upstream slope similarly approximately about 1v:1.5h. This slope is considered under normal circumstances to be unstable but for this height of wall is generally accepted. However the observed livestock erosion has considerably increased the potential for embankment failure. This is particularly true in the event of an overtopping of the embankment in the event of a large flood or upstream dam break.

13.7.5.2 Crest

Photograph 2 Right Bank Crest

Note the good reed collection on the upstream and the tree line on the downstream and the crest definition. The upstream slope was has been partially eroded by wave action. It clear that there is a prevailing wind approximately NW to the East West alignment of the wall. The crest definition has been affected by upstream and downstream erosion but there were no observed discontinuous settlement or depressions. This suggests the dam wall is reasonably well consolidated both by age and trafficking. The crest width varies from 2.5 to 3,5m. The upstream face .was eroded both by the wind wave action as well as livestock presumably watering from the dam crest. There was no fencing isolating the dam

Photograph 3 Crest Upstream Erosion

The maximum cut back observed was 0.75m. The downstream face has well defined cattle eroded pathways extending both up to the crest and along the toe of the embankment.

No significant termite activity was observed in the grassed embankment.

The downstream toe has a number of mature trees growing at the toe of the dam

Photograph 4 Downstream Toe

13.7.6 Embankment Slopes

13.7.6.1 Upstream and Down Stream Slopes

The upstream and downstream slope, as previously mentioned, was probably constructed to a 1.5 slope but as a consequence of the erosion is very variable.

13.7.7 Technical Notes Relating To Vegetation And Animals On Earth Embankment Dams

The negative aspects of bushes and trees and long grass growing on an embankment dam are as follows:

(i) they obscure the observation of slumps, movements, erosion, rip-rap failure (rocks disintegrate), seepage, etc;

(ii) when a tree or large bush dies, the roots rot and this promotes the development of possible piping failure. In addition, the bowl of a large tree creates large damage if the tree is blown over.

Accordingly, bushes and small young trees should be removed from an embankment dam and for a width along the downstream t 5 m.

Ant activity and that of any other burrowing animals should be terminated. Cattle, sheep, goats, etc should not be allowed to cross over dam embankments and cause eroded pathways.

13.7.8 Comments On The Spillway

13.7.8.1 Spillway

The spillway is 30m length with a 1m freeboard on a 13.8km2 catchment. The spillway is not in a state to take any form of recognised return period however there was no evidence of over topping of the embankment but this may have been to a certain extent masked by the livestock paths and gullies. It is recommended that the embankment be repaired and grass maintained by preventing travel on and off the embankment slopes.

It should be noted that over topping on this shallow type embankment, but well grassed and maintained, will result in minimal damage.

The spillway discharge return runs into a vlei and appears to be stable.

13.7.9 Comments On Access Road

The access road is adequate.

13.7.10 Colour Photographs

A number of digital photographs were taken. Selected photographs are included in this report.

13.7.11 Recommended Maintenance Works

13.7.11.1 Earth Embankments

(i) Remove bushes and small trees from the embankments.

(ii) Install the upstream and downstream fences and prevent the access of domestic animals onto the embankments.

(iii) Repair erosion damage caused by animals. Eradicate ant activity. Regularly inspect and maintain the wall.

(iv) Maintain a watch on the upstream crests of the earth embankments in order to discern any gradual slumping of the earth fill', especially during high reservoir water levels.

13.7.11.2 Spillway

The spillway is inadequately wide or has inadequate freeboard or a combination of both. It is considered that if the embankment slopes are repaired, grassed, protected and maintained, that the necessity to increase the capacity of the spillway is not necessary.

13.8 Upper Farm Dam in Klein Komati River

13.8.1 Preliminary Data

Dam No & Name:	DAM 2
Date of Inspection:	15th June 2012
Persons Present:	James Hampton, Jaco Rossouw and Nompumelelo Ntuli
Location:	Belfast
Distance to:	12km to Belfast on N4
Name of River:	Klein Komati
Construction Dates:	Not known
Full Supply Level (FSL):	1780 masl
Catchment Area	11.9 Km2
Capacity at FSL	Not known
Surface Area at FSL:	67 000 m2
Height of Main Dam Wall:	2-3m
Maximum Water Depth:	2-3m
Crest length of main dam:	200 m
Spillway Shape	Approx Trapezoid 20m; 9.6m; 1.1m
Reservoir Water Level (RWL):	Not known
Rainfall Gauge:	N/A

13.8.2 General

This site visit was commissioned to assess the safety of two dams within the Belfast Project boundary. The dam waterway is intended to remain throughout the life of the mine.

This inspection was based on visual observations only, with no design or as built documentation or drawings available. There was no site survey available consequently Google was used to estimate lengths and elevations.

Type of Main Dam

Photograph 5 Embankment Dam 2

The overall dam comprises the following sections of approximate lengths: A 200 m long earth embankment, with drift causeway type of spillway approximate width 15 m length the spill crest partially defined by a series of concrete lintel type beams running parallel to the flow.

13.8.2.1 Type of Spillway

As described above an earth/ founded spillway, grass lined which ramped down to a series of lintel type beams which define the full supply level (FSL). The spillway acts a drift for a vehicle track crossing and is approximately trapezoid in shape. The spillway return is stable and runs into a small depression before it exits into a large wetland. It is estimated at 30m with a total free board of 1m.

Photograph 6 Spillway Return into Tail Water of Dam 1

13.8.2.2 Outlets Works

There was an outlet pipe structure observed but this appeared to be dysfunctional and may have been a siphon arrangement.

13.8.2.3 Saddle Dams

There are no saddle dams.

13.8.2.4 Sedimentation

There was no visible indication of the state of sedimentation and it was difficult to get to the tail water; there are a number of small dams upstream; this would suggest that to a certain extent as silt traps are installed upstream and the total effect of sedimentation would be delayed. No measurements were taken.

13.8.2.5 Geology

Refer to the previous reports Appendix G Concept Design Report Stormwater Management September 2011. As a surface observation the the dam walls appear to have been constructed with a variable selection of fine grained silty sands.

13.8.3 Comments On The Earth Embankment

13.8.3.1 General

The history of the earth embankments is not known but visual observation indicate the dam to have been constructed to a crest width of approximately 4m, with a downstream slope of about 1v:1.5h and an upstream slope similarly approximately about 1v:1.5h. This slope is considered under normal circumstances to be unstable but for this height of wall is generally accepted. There was limited observed livestock erosion and the slopes appeared in good condition.

13.8.3.2 Crest

Note the good reed collection on the upstream and the tree line on the downstream and the relatively good crest definition. The upstream slope was had limited erosion by wave action. There was no observed discontinuous settlement or depressions observed. This suggests the dam wall is reasonably well consolidated both by age and trafficking. The crest width of 4m was consistent. There was no fencing isolating the dam

No significant termite activity was observed in the grassed embankment.

The downstream toe has a number of mature trees growing at the toe of the dam on the left bank. The toe generally was covered in a reed bed presumably formed as part of the Dam 1 tail waters.

13.8.3.3 Embankment Slopes

The upstream and downstream slopes, as previous mentioned were constructed to a 1.5 slopes.

13.8.3.4 Technical Notes Relating To Vegetation And Animals On Earth Embankment Dams

The negative aspects of bushes and trees and long grass growing on an embankment dam are as follows:

(iii) they obscure the observation of slumps, movements, erosion, rip-rap failure (rocks disintegrate), seepage, etc;

(iv) when a tree or large bush dies, the roots rot and this promotes the development of possible piping failure. In addition, the bowl of a large tree creates large damage if the tree is blown over.

Accordingly, bushes and small young trees should be removed from an embankment dam and for a width along the downstream t 5 m.

Ant activity and that of any other burrowing animals should be terminated. Cattle, sheep, goats, etc should not be allowed to cross over dam embankments and cause eroded pathways.

13.8.4 Comments On The Spillway

13.8.4.1 Spillway

The spillway is a 20m by 9m trapezoid shape with a 1.1m freeboard on a 12km2 catchment. The spillway is not in a state to take any form of recognised return period however there was no evidence of over topping of the embankment.

It should be noted that over topping on this shallow type embankment with a well grassed and maintained wall, will result in minimal damage.

The spillway discharge return runs into a well reed covered tail water and appears to be stable.

13.8.4.2 Comments On Access Road

The access road is adequate.

13.8.5 Colour Photographs

A number of digital photographs were taken. Selected photographs are included in this report.

13.8.6 Recommended Maintenance Works

The following maintenance works should be undertaken:

13.8.6.1 Earth Embankments

(v) Remove bushes and small trees from the embankments.

(vi) Install the upstream and downstream fences and prevent the access of domestic animals onto the embankments.

(vii) Repair any erosion damage caused by animals. Eradicate ant activity. Regularly inspect and maintain the wall.

(viii) Maintain a watch on the upstream crests of the earth embankments in order to discern any gradual slumping of the earthfill, especially during high reservoir water levels.

13.8.6.2 Spillway

The spillway is inadequately wide or has inadequate freeboard or a combination of both. It is considered that if the embankment slopes are repaired, grassed, protected and maintained that the necessity to increase the capacity

13.9 Requirements for the Longterm Rehabilitation of Existing Dams

In order to ensure the long term safety of these dams it is suggested that the following be carried out:

A. Clear the sites

B. Survey the dams

C. Identify suitable borrow area for embankment materials and rip rap

D. Carry out a detailed rehabilitation work design for the embankments and the spillways.

E. Compile an estimate of quantities and tender documentation.

It has been suggested that that at this stage of this development that a provisional sum be provided. The variables for rehabilitation works, particularly without accurate survey and investigations, are very uncertain. The form of contract and contractor selection can also affect costs greatly.

Appendix A

Stormwater Management

A1 Rainfall Estimate results (Smithers and Schulze)

RAINFALL ESTIMATE																		
User selection has the following criteria:																		
Coordinates: Latitude: 25 degrees 41 minutes; Longitude: 30 degreess 2 minutes																		
Durations requested: 5 m, 10 m, 15 m, 30 m, 45 m, 1 h, 1.5 h, 2 h, 4 h, 1 d, 2 d, 3 d, 7 d																		
Return Periods requested: 2 yr, 5 yr, 10 yr, 20 yr, 50 yr, 100 yr, 200 yr																		
Block Size requested: 2 minutes																		
Data extracted from Daily Rainfall Estimate Database File																		
The six closest stations are listed																		
Station Name		SAWS	Distance	Record	Latitude		Longitude		MAP	Altitude	Duration	Return Period (years)						
		Number	(km)	(Years)	(−)	(')	(−)	(')	(mm)	(m)	(m/h/d)	2U	5U	10U	20U	50U	100U	200U
BELFAST (POL)		0517072_W	0	94	25	41	30	2	782	1899	1 d	48.1	63.8	75.2	86.8	103	117	131
											2 d	61	79.4	91.9	105	122	135	149
											3 d	70.3	91	105	118	135	149	162
											7 d	94.8	122	139	155	177	192	207
LEEUWBANK		0516767_W	14.1	29	25	46	29	56	705	1840	1 d	53.4	70.9	83.6	96.5	115	130	146
											2 d	70.1	91.2	106	120	140	155	171
											3 d	78.2	101	116	131	150	166	180
											7 d	99.9	128	146	164	186	202	219
BOSPOORT		0516701_W	14.4	50	25	41	29	54	712	1600	1 d	48	63.7	75.1	86.7	103	117	131
											2 d	60.8	79	91.5	104	121	134	148
											3 d	69.2	89.5	103	116	133	146	159
											7 d	93.8	120	137	154	175	190	205
ELANDSFONTEIN		0517275_W	16.6	41	25	35	30	9	771	1911	1 d	54.2	71.9	84.8	97.9	116	132	148
											2 d	69.4	90.3	105	119	138	153	169

											3 d	79.6	103	119	134	153	169	183
											7 d	107	137	157	175	199	217	234
WONDERFONTEIN (SKL)		0516708_W	20.5	78	25	48	29	53	697	1780	1 d	48.6	64.5	76	87.8	104	118	133
											2 d	61.3	79.7	92.3	105	122	135	150
											3 d	71.9	93.1	107	121	138	152	166
											7 d	97	124	142	159	181	196	212
MACHADODORP		0517430_W	23.5	96	25	40	30	15	790	1554	1 d	53.8	71.4	84.2	97.2	115	131	147
											2 d	67.2	87.4	101	115	134	148	164
											3 d	76.3	98.7	114	128	147	161	176
											7 d	101	130	148	166	189	205	222
Gridded values of all points within the specified block																		
Latitude	Longitude	MAP	Altidude	Duration	Return Period (years)													
(−) (')	(−) (') (mm)		(m)	(m/h/d)	2U	5U	10U	20U	50U	100U	200U							
25 42	30 3	822	1899	5 m	10.6	14.1	16.6	19.2	22.8	25.8	29							
				10 m	15.5	20.6	24.3	28.1	33.3	37.7	42.4							
				15 m	19.4	25.7	30.3	35	41.6	47	52.9							
				30 m	24.5	32.5	38.3	44.3	52.6	59.5	66.9							
				45 m	28.1	37.3	44	50.8	60.3	68.3	76.7							
				1 h	31	41.1	48.5	56	66.5	75.3	84.6							
				1.5 h	35.6	47.2	55.7	64.3	76.3	86.4	97.1							
				2 h	39.2	52.1	61.4	70.9	84.1	95.2	107							
				4 h	47.1	62.5	73.7	85.1	101	114.3	128.5							
				1 d	65.4	86.8	102	118	140	158.7	178.4							
				2 d	75.9	101	119	137	163	184.3	207.2							
				3 d	82.9	110	130	150	178	201.1	226.1							

				7 d	10.3	146	173	199	236	267.6	300.8							
25 40	30 1	783	1844	5 m	10.5	14	16.5	19	22.6	25.5	28.7							
				10 m	15.5	20.5	24.2	27.9	33.2	37.5	42.2							
				15 m	19.2	25.5	30.1	34.7	41.2	46.7	52.4							
				30 m	24.4	32.4	38.2	44.1	52.3	59.2	66.5							
				45 m	28	37.2	43.9	50.6	60.1	68	76.5							
				1 h	30.9	41.1	48.4	55.9	66.4	75.1	84.4							
				1.5 h	35.6	47.2	55.6	64.3	76.3	86.3	97.1							
				2 h	38.8	51.4	60.7	70.1	83.2	94.1	105.8							
				4 h	46.8	62	73.1	84.5	100	113.5	127.6							
				1 d	64.1	85	100	116	137	155.5	174.8							
				2 d	75.5	100	118	136	162	183.1	205.8							
				3 d	80.7	107	126	146	173	196	220.3							
				7 d	7.4	142	168	194	230	260.6	292.9							
25 41	30 2	782	1862	5 m	10.5	13.9	16.4	19	22.5	25.5	28.7							
				10 m	15.4	20.4	24.1	27.8	33	37.3	42							
				15 m	19.2	25.5	30	34.7	41.2	46.6	52.4							
				30 m	24.3	32.2	38	43.8	52	58.9	66.2							
				45 m	27.8	36.9	43.5	50.3	59.7	67.6	75.9							
				1 h	30.7	40.7	48	55.4	65.8	74.5	83.7							
				1.5 h	35.2	46.7	55	63.6	75.5	85.4	96							
				2 h	38.7	51.3	60.5	69.9	83	93.9	105.6							
				4 h	46.7	61.9	73	84.3	100	113.3	127.4							
				1 d	63.9	84.7	99.9	115	137	155	174.3							
				2 d	74.1	98.3	116	134	159	179.9	202.1							
				3 d	80.4	107	126	145	173	195.3	219.5							
				7 d	6.9	142	167	193	229	259.5	291.6							
25 42	30 1	783	1859	5 m	10.5	14	16.5	19	22.6	25.6	28.8							

				10 m	15.4	20.4	24.1	27.8	33	37.3	42							
				15 m	19.2	25.5	30.1	34.8	41.3	46.7	52.5							
				30 m	24.3	32.2	38	43.9	52.1	59	66.3							
				45 m	27.8	36.9	43.5	50.3	59.7	67.6	75.9							
				1 h	30.7	40.7	48	55.4	65.8	74.4	83.6							
				1.5 h	35.1	46.6	55	63.5	75.4	85.3	95.9							
				2 h	38.9	51.5	60.8	70.2	83.3	94.3	106							
				4 h	46.8	62.1	73.2	84.6	100	113.7	127.7							
				1 d	64.4	85.4	101	116	138	156.2	175.6							
				2 d	74.1	98.3	116	134	159	179.8	202.1							
				3 d	81.1	108	127	147	174	196.9	221.3							
				7 d	7.9	143	169	195	231	261.9	294.4							
25 42	30 2	779	1871	5 m	10.5	13.9	16.4	19	22.5	25.5	28.6							
				10 m	15.4	20.4	24.1	27.8	33	37.3	42							
				15 m	19.2	25.4	30	34.6	41.1	46.6	52.3							
				30 m	24.3	32.2	38	43.8	52	58.9	66.2							
				45 m	27.9	36.9	43.6	50.3	59.7	67.6	76							
				1 h	30.7	40.7	48	55.5	65.9	74.5	83.8							
				1.5 h	35.2	46.7	55.1	63.6	75.6	85.5	96.1							
				2 h	38.7	51.3	60.5	69.8	82.9	93.8	105.5							
				4 h	46.7	61.9	73	84.3	100	113.3	127.3							
				1 d	63.8	84.6	99.8	115	137	154.9	174.1							
				2 d	74.2	98.5	116	134	159	180.2	202.6							
				3 d	80.3	107	126	145	172	194.8	219							
				7 d	6.7	142	167	193	229	259.1	291.2							
25 41	30 3	782	1887	5 m	10.5	13.9	16.4	18.9	22.4	25.4	28.5							
				10 m	15.3	20.3	24	27.7	32.9	37.2	41.8							
				15 m	19.1	25.4	29.9	34.5	41	46.4	52.2							

				30 m	24.2	32.1	37.8	43.7	51.9	58.7	66							
				45 m	27.7	36.8	43.4	50.1	59.5	67.3	75.7							
				1 h	30.6	40.6	47.8	55.2	65.6	74.2	83.4							
				1.5 h	35.1	46.5	54.9	63.4	75.2	85.1	95.7							
				2 h	38.5	51	60.2	69.5	82.5	93.4	105							
				4 h	46.5	61.7	72.7	84	99.7	112.9	126.9							
				1 d	63.2	83.8	98.8	114	136	153.3	172.3							
				2 d	73.5	97.5	115	133	158	178.3	200.5							
				3 d	79.4	105	124	143	170	192.7	216.5							
				7 d	5.4	140	165	191	226	255.9	287.7							
25 42	30 0	754	1860	5 m	10.4	13.8	16.3	18.8	22.3	25.3	28.4							
				10 m	15.3	20.3	23.9	27.6	32.8	37.1	41.7							
				15 m	19.1	25.3	29.8	34.4	40.9	46.3	52							
				30 m	24.1	32	37.7	43.5	51.7	58.5	65.7							
				45 m	27.6	36.7	43.2	49.9	59.3	67.1	75.4							
				1 h	30.5	40.4	47.7	55	65.3	73.9	83.1							
				1.5 h	34.9	46.3	54.7	63.1	74.9	84.8	95.3							
				2 h	38.3	50.9	60	69.3	82.2	93.1	104.6							
				4 h	46.4	61.6	72.7	83.9	99.6	112.7	126.7							
				1 d	62.9	83.5	98.4	114	135	152.7	171.6							
				2 d	73	96.8	114	132	157	177.1	199.1							
				3 d	78.8	105	123	142	169	191.4	215.1							
				7 d	4.7	139	164	189	225	254.2	285.7							
25 43	30 4	774	1920	5 m	10.4	13.8	16.3	18.8	22.3	25.2	28.4							
				10 m	15.2	20.2	23.8	27.5	32.7	37	41.6							
				15 m	19	25.3	29.8	34.4	40.8	46.2	52							
				30 m	24.1	31.9	37.6	43.4	51.6	58.4	65.6							
				45 m	27.6	36.6	43.1	49.8	59.1	66.9	75.2							

				1 h	30.4	40.3	47.5	54.9	65.1	73.7	82.8							
				1.5 h	34.8	46.2	54.4	62.9	74.6	84.5	95							
				2 h	38.3	50.8	59.9	69.1	82.1	92.9	104.4							
				4 h	46.4	61.5	72.6	83.8	99.5	112.6	126.5							
				1 d	62.7	83.1	98	113	134	152.1	170.9							
				2 d	72.4	96	113	131	155	175.7	197.5							
				3 d	78.5	104	123	142	168	190.5	214.1							
				7 d	4.2	138	163	188	224	252.9	284.3							
25 40	30 2 751	751	1875	5 m	10.3	13.7	16.2	18.7	22.1	25.1	28.2							
				10 m	15.2	20.2	23.8	27.5	32.6	36.9	41.5							
				15 m	19	25.1	29.7	34.2	40.7	46	51.7							
				30 m	24	31.8	37.5	43.3	51.4	58.2	65.4							
				45 m	27.5	36.5	43	49.7	59	66.7	75							
				1 h	30.3	40.2	47.4	54.7	65	73.6	82.7							
				1.5 h	34.8	46.1	54.4	62.8	74.5	84.4	94.8							
				2 h	38	50.4	59.4	68.6	81.5	92.2	103.6							
				4 h	46.1	61.2	72.2	83.4	99	112	125.9							
				1 d	61.7	81.8	96.5	111	132	149.7	168.3							
				2 d	71.8	95.3	112	130	154	174.4	196							
				3 d	77	102	121	139	165	186.9	210.1							
				7 d	2.2	136	160	185	219	248	278.7							
25 41	30 1	753	1862	5 m	10.4	13.8	16.3	18.8	22.3	25.2	28.4							
				10 m	15.2	20.1	23.7	27.4	32.6	36.9	41.4							
				15 m	19	25.3	29.8	34.4	40.8	46.2	51.9							
				30 m	24	31.8	37.5	43.3	51.4	58.2	65.4							
				45 m	27.4	36.4	42.9	49.5	58.8	66.5	74.8							
				1 h	30.2	40	47.2	54.5	64.7	73.2	82.3							
				1.5 h	34.5	45.8	54	62.3	74	83.7	94.1							

				2 h	38.3	50.7	59.8	69.1	82	92.9	104.4							
				4 h	46.4	61.5	72.5	83.8	99.4	112.6	126.5							
				1 d	62.6	83.1	97.9	113	134	152	170.8							
				2 d	71.4	94.7	112	129	153	173.2	194.7							
				3 d	78.4	104	123	142	168	190.3	213.9							
				7 d	4.1	138	163	188	223	252.7	284							
25 43	30 2	749	1884	5 m	10.4	13.8	16.2	18.7	22.2	25.2	28.3							
				10 m	15.2	20.2	23.8	27.5	32.6	36.9	41.5							
				15 m	19	25.2	29.7	34.3	40.8	46.1	51.9							
				30 m	24	31.8	37.6	43.4	51.5	58.3	65.5							
				45 m	27.5	36.5	43	49.7	59	66.8	75.1							
				1 h	30.3	40.2	47.4	54.8	65	73.6	82.7							
				1.5 h	34.8	46.1	54.4	62.8	74.5	84.4	94.8							
				2 h	38.2	50.6	59.7	68.9	81.8	92.6	104.1							
				4 h	46.3	61.4	72.4	83.6	99.3	112.4	126.3							
				1 d	62.3	82.6	97.4	113	134	151.1	169.9							
				2 d	72.1	95.6	113	130	155	174.9	196.6							
				3 d	77.9	103	122	141	167	189	212.4							
				7 d	3.4	137	162	187	222	250.9	282							
25 39	30 1	738	1875	5 m	10.3	13.7	16.1	18.6	22.1	25	28.1							
				10 m	15.2	20.1	23.7	27.4	32.5	36.8	41.4							
				15 m	18.9	25.1	29.6	34.2	40.6	45.9	51.6							
				30 m	23.9	31.7	37.4	43.2	51.3	58	65.2							
				45 m	27.4	36.4	42.9	49.5	58.8	66.5	74.8							
				1 h	30.2	40.1	47.2	54.5	64.8	73.3	82.4							
				1.5 h	34.6	45.9	54.2	62.5	74.2	84	94.5							
				2 h	37.9	50.2	59.2	68.4	81.2	91.9	103.3							
				4 h	46.1	61.1	72	83.2	98.8	111.8	125.6							

				1 d	61.4	81.4	96	111	132	148.9	167.4							
				2 d	71.3	94.6	112	129	153	173.2	194.6							
				3 d	76.6	102	120	138	164	185.8	208.8							
				7 d	1.5	135	159	183	218	246.3	276.8							
25 43	30 0	726	1860	5 m	10.3	13.7	16.1	18.6	22.1	25	28.1							
				10 m	15.1	20	23.6	27.3	32.4	36.7	41.2							
				15 m	18.9	25.1	29.6	34.2	40.6	45.9	51.6							
				30 m	23.8	31.6	37.3	43.1	51.1	57.9	65							
				45 m	27.3	36.2	42.7	49.3	58.5	66.3	74.5							
				1 h	30.1	39.9	47	54.3	64.5	73	82							
				1.5 h	34.4	45.7	53.8	62.2	73.8	83.5	93.9							
				2 h	37.9	50.3	59.3	68.4	81.2	91.9	103.3							
				4 h	46.1	61.2	72.1	83.3	98.9	111.9	125.8							
				1 d	61.5	81.5	96.2	111	132	149.2	167.7							
				2 d	70.6	93.7	111	128	152	171.5	192.7							
				3 d	76.6	102	120	138	164	185.9	208.9							
				7 d	1.7	135	159	184	218	246.7	277.3							
25 43	30 3	755	1934	5 m	10.3	13.7	16.2	18.7	22.2	25.1	28.2							
				10 m	15.1	20.1	23.7	27.3	32.4	36.7	41.3							
				15 m	19	25.1	29.7	34.2	40.6	46	51.7							
				30 m	23.9	31.7	37.3	43.1	51.2	57.9	65.1							
				45 m	27.3	36.2	42.7	49.3	58.6	66.3	74.5							
				1 h	30.1	39.9	47	54.3	64.5	73	82							
				1.5 h	34.4	45.6	53.8	62.1	73.8	83.5	93.8							
				2 h	38	50.4	59.4	68.6	81.5	92.2	103.6							
				4 h	46.2	61.3	72.2	83.4	99	112.1	126							
				1 d	61.8	82	96.7	112	133	150	168.6							
				2 d	70.7	93.8	111	128	152	171.6	192.9							

				3 d	77.1	102	121	139	165	187.2	210.4							
				7 d	2.3	136	160	185	219	248.3	279.1							
25 39	30 3	728	1871	5 m	10.2	13.5	16	18.4	21.9	24.8	27.9							
				10 m	15.1	20	23.6	27.3	32.4	36.6	41.2							
				15 m	18.8	24.9	29.4	34	40.3	45.6	51.3							
				30 m	23.8	31.5	37.2	43	51	57.7	64.9							
				45 m	27.3	36.2	42.7	49.3	58.5	66.2	74.4							
				1 h	30.1	39.9	47.1	54.3	64.5	73	82.1							
				1.5 h	34.5	45.8	54	62.3	74	83.8	94.2							
				2 h	37.5	49.8	58.7	67.8	80.5	91.1	102.4							
				4 h	45.8	60.7	71.6	82.7	98.2	111.1	124.9							
				1 d	60.1	79.8	94.1	109	129	145.9	164							
				2 d	70.4	93.4	110	127	151	170.9	192.1							
				3 d	74.7	99.1	117	135	160	181.4	203.9							
				7 d	98.9	131	155	179	212	240.1	269.8							
25 40	30 3	743	1902	5 m	10.2	13.6	16	18.5	22	24.9	27.9							
				10 m	15	19.9	23.5	27.1	32.2	36.5	41							
				15 m	18.8	25	29.5	34	40.4	45.7	51.4							
				30 m	23.7	31.4	37.1	42.8	50.8	57.5	64.7							
				45 m	27.1	36	42.4	49	58.1	65.8	74							
				1 h	29.8	39.6	46.6	53.9	64	72.4	81.4							
				1.5 h	34.1	45.2	53.4	61.6	73.1	82.8	93							
				2 h	37.6	49.9	58.9	68	80.7	91.4	102.7							
				4 h	45.9	60.9	71.8	82.9	98.4	111.3	125.1							
				1 d	60.5	80.2	94.6	109	130	146.8	165							
				2 d	69.1	91.6	108	125	148	167.7	188.5							
				3 d	75.2	99.8	118	136	161	182.6	205.3							
				7 d	99.6	132	156	180	214	241.8	271.8							

25 40	30 4	748	1923	5 m	10.2	13.6	16	18.5	22	24.9	27.9							
				10 m	15	20	23.5	27.2	32.3	36.5	41							
				15 m	18.8	25	29.5	34	40.4	45.7	51.4							
				30 m	23.7	31.5	37.1	42.9	50.9	57.6	64.7							
				45 m	27.2	36	42.5	49.1	58.2	65.9	74.1							
				1 h	29.9	39.6	46.7	54	64.1	72.5	81.5							
				1.5 h	34.2	45.4	53.5	61.8	73.4	83	93.3							
				2 h	37.6	49.9	58.9	68	80.7	91.4	102.7							
				4 h	45.9	60.9	71.8	82.9	98.4	111.4	125.2							
				1 d	60.5	80.3	94.6	109	130	146.9	165.1							
				2 d	69.4	92.1	109	125	149	168.5	189.4							
				3 d	75.3	99.9	118	136	161	182.7	205.4							
				7 d	99.7	132	156	180	214	242	272							
25 40	30 0	702	1860	5 m	10.2	13.5	15.9	18.4	21.8	24.7	27.8							
				10 m	15	19.9	23.5	27.1	32.2	36.5	41							
				15 m	18.8	24.9	29.3	33.9	40.2	45.5	51.2							
				30 m	23.7	31.4	37	42.8	50.8	57.5	64.6							
				45 m	27.1	36	42.4	49	58.2	65.8	74							
				1 h	29.9	39.6	46.7	53.9	64	72.5	81.5							
				1.5 h	34.2	45.4	53.5	61.8	73.4	83	93.3							
				2 h	37.4	49.6	58.5	67.5	80.2	90.8	102							
				4 h	45.7	60.7	71.5	82.6	98.1	111	124.7							
				1 d	59.9	79.4	93.7	108	128	145.4	163.4							
				2 d	69.3	92	109	125	149	168.3	189.2							
				3 d	74.2	98.4	116	134	159	180.1	202.4							
				7 d	98.2	130	154	177	211	238.4	268							
25 41	30 4	729	1920	5 m	10.2	13.5	15.9	18.4	21.8	24.7	27.7							
				10 m	15	19.8	23.4	27	32.1	36.3	40.8							

				15 m	18.7	24.9	29.3	33.9	40.2	45.5	51.1							
				30 m	23.6	31.3	36.9	42.6	50.6	57.3	64.4							
				45 m	27	35.8	42.2	48.8	57.9	65.5	73.6							
				1 h	29.7	39.4	46.5	53.6	63.7	72.1	81							
				1.5 h	34	45.1	53.2	61.4	72.9	82.5	92.7							
				2 h	37.3	49.5	58.4	67.4	80.1	90.6	101.8							
				4 h	45.6	60.5	71.4	82.4	97.9	110.8	124.5							
				1 d	59.5	79	93.1	108	128	144.5	162.4							
				2 d	68.3	90.6	107	123	147	165.8	186.4							
				3 d	73.8	97.9	115	133	158	179	201.2							
				7 d	97.6	129	153	176	209	236.8	266.2							
25 42	30 4	732	1923	5 m	10.2	13.5	16	18.4	21.9	24.8	27.8							
				10 m	15	19.9	23.4	27	32.1	36.3	40.8							
				15 m	18.8	24.9	29.4	33.9	40.3	45.6	51.3							
				30 m	23.6	31.3	36.9	42.7	50.6	57.3	64.4							
				45 m	27	35.8	42.2	48.8	57.9	65.5	73.6							
				1 h	29.7	39.4	46.4	53.6	63.6	72	81							
				1.5 h	33.9	45	53.1	61.3	72.7	82.3	92.5							
				2 h	37.4	49.7	58.6	67.6	80.3	90.9	102.1							
				4 h	45.7	60.7	71.5	82.6	98.1	111	124.8							
				1 d	60	79.6	93.9	108	129	145.7	163.7							
				2 d	68.4	90.7	107	124	147	165.9	186.5							
				3 d	74.4	98.7	116	134	160	180.6	203							
				7 d	98.5	131	154	178	211	239.1	268.8							
25 43	30 1	707	1890	5 m	10.2	13.5	15.9	18.4	21.9	24.7	27.8							
				10 m	15	19.9	23.4	27.1	32.1	36.4	40.9							
				15 m	18.8	24.9	29.4	33.9	40.3	45.6	51.2							
				30 m	23.6	31.4	37	42.7	50.7	57.4	64.5							

				45 m	27	35.9	42.3	48.9	58	65.7	73.8							
				1 h	29.8	39.5	46.6	53.8	63.8	72.2	81.2							
				1.5 h	34.1	45.2	53.3	61.5	73	82.7	92.9							
				2 h	37.4	49.7	58.6	67.6	80.3	90.9	102.1							
				4 h	45.8	60.7	71.6	82.7	98.2	111.1	124.9							
				1 d	60.1	79.7	94	109	129	145.8	163.9							
				2 d	68.8	91.3	108	124	148	167.1	187.8							
				3 d	74.4	98.7	116	134	160	180.5	202.9							
				7 d	98.6	131	154	178	211	239.3	269							
25 39	30 0	699	1880	5 m	10.2	13.5	15.9	18.3	21.8	24.6	27.7							
				10 m	15	19.9	23.4	27	32.1	36.3	40.8							
				15 m	18.7	24.8	29.3	33.8	40.2	45.5	51.1							
				30 m	23.6	31.3	36.9	42.6	50.6	57.3	64.4							
				45 m	27	35.8	42.2	48.8	57.9	65.5	73.7							
				1 h	29.7	39.4	46.5	53.7	63.7	72.1	81.1							
				1.5 h	34	45.1	53.2	61.4	72.9	82.6	92.8							
				2 h	37.3	49.4	58.3	67.3	79.9	90.4	101.6							
				4 h	45.6	60.5	71.4	82.4	97.8	110.7	124.5							
				1 d	59.5	79	93.1	108	128	144.5	162.4							
				2 d	68.5	90.9	107	124	147	166.4	187							
				3 d	73.6	97.6	115	133	158	178.6	200.8							
				7 d	97.4	129	152	176	209	236.3	265.6							
25 41	30 0	690	1878	5 m	10.1	13.4	15.8	18.3	21.7	24.6	27.6							
				10 m	14.9	19.8	23.3	27	32	36.2	40.7							
				15 m	18.7	24.8	29.2	33.8	40.1	45.4	51							
				30 m	23.5	31.2	36.8	42.5	50.5	57.1	64.2							
				45 m	26.9	35.7	42.1	48.6	57.7	65.3	73.4							
				1 h	29.6	39.3	46.3	53.5	63.5	71.9	80.8							

				1.5 h	33.9	45	53	61.2	72.7	82.2	92.4							
				2 h	37.2	49.3	58.1	67.1	79.7	90.2	101.4							
				4 h	45.6	60.5	71.3	82.3	97.7	110.6	124.3							
				1 d	59.2	78.6	92.7	107	127	143.8	161.6							
				2 d	68	90.2	106	123	146	165	185.4							
				3 d	73.1	97	114	132	157	177.5	199.5							
				7 d	96.8	129	152	175	208	235	264.2							
25 39	30 2	694	1896	5 m	10.1	13.4	15.8	18.2	21.6	24.5	27.5							
				10 m	14.9	19.8	23.3	26.9	31.9	36.2	40.6							
				15 m	18.6	24.7	29.2	33.7	40	45.2	50.9							
				30 m	23.5	31.1	36.7	42.4	50.3	57	64							
				45 m	26.9	35.6	42	48.5	57.6	65.2	73.3							
				1 h	29.5	39.2	46.2	53.4	63.4	71.7	80.6							
				1.5 h	33.8	44.8	52.9	61.1	72.5	82.1	92.2							
				2 h	37	49.1	57.8	66.8	79.3	89.8	100.9							
				4 h	45.4	60.2	71	82	97.4	110.2	123.9							
				1 d	58.5	77.6	91.5	106	126	142	159.7							
				2 d	67.4	89.4	105	122	144	163.5	183.8							
				3 d	72.1	95.7	113	130	155	175	196.7							
				7 d	95.3	126	149	172	204	231.2	259.9							
25 39	30 4	668	1935	5 m	9.9	13.2	15.5	17.9	21.3	24.1	27.1							
				10 m	14.8	19.6	23.2	26.7	31.8	35.9	40.4							
				15 m	18.5	24.5	28.9	33.3	39.6	44.8	50.3							
				30 m	23.3	30.9	36.5	42.1	50	56.6	63.6							
				45 m	26.7	35.4	41.8	48.2	57.3	64.8	72.9							
				1 h	29.4	39	46	53.2	63.1	71.4	80.3							
				1.5 h	33.7	44.8	52.8	60.9	72.3	81.9	92							
				2 h	36.3	48.2	56.9	65.7	77.9	88.2	99.2							

				4 h	44.9	59.6	70.3	81.2	96.4	109.1	122.6							
				1 d	56.2	74.6	88	102	121	136.5	153.4							
				2 d	65.9	87.5	103	119	141	160	179.9							
				3 d	68.5	90.9	107	124	147	166.3	187							
				7 d	90.3	120	141	163	194	219.2	246.4							

A2 Channel Peak Flow Calculations

Description of catchments	**Belfast**	Weather Service Station	**Belfast**
River detail	**Network A**	Weather Station Number	0517072 W
Calculated by	NG Duvenage	Coordinates Latitude	25° 40'
Date	2013/09/17	Longitude	30° 01'

Catchment	Channel	Area		Length (m)			Slope (m/m)			Concentration time (seconds)				Distribution Factors		Run-off Coeficient		Point Rainfall		Point intensity		Peak Flow (m^3/s)	
		A (m^2)	ΣA (m^2)	L_0	L_c	$L_{Channel}$	S_0	S_c	$S_{Channel}$	T_0	T_c	$T_{channel}$	ΣT	Rural a	Urban ß	C_{10}	C_{50}	I_{10} mm	I_{50} mm	I_{10} (mm/hr)	I_{50} (mm/hr)	Q_{10}	Q_{50}
ST1	A1	14763.9	14763.9	260			57.778	0.000		1703			28	1.0		0.39	0.39	37	51	99	136	0.158	0.217
ST2	A2	12445.9	27209.8			71			200			48	29	0.5	0.5	0.44	0.44	38	52	96	132	0.319	0.438
ST3		19204.1	46414.0			107			200			71	30	0.7	0.3	0.42	0.42	38	53	92	126	0.497	0.683
ST4	A3	12445.9	58859.9			195			200			130	33	0.6	0.4	0.44	0.44	39	54	88	121	0.627	0.861
ST5	A4	18708.7	77568.6			155			200			103	34	0.4	0.6	0.45	0.45	40	55	84	115	0.814	1.117
ST6	A5	44790.9	122359.5			306			200			204	38	0.3	0.7	0.47	0.47	41	57	78	107	1.244	1.707
Netw B		111858.9	234218.4										38	0.1	0.9	0.48	0.48	41	57	76	105	2.401	3.294
ST8	A6	8932.0	243150.4			135			200			84	39	0.2	0.8	0.48	0.48	42	57	74	102	2.407	3.302
Netw C		65376.5	308526.9										39	0.1	0.9	0.48	0.48	42	57	74	101	3.054	4.189
ST9	A7	3309.0	311835.9			78			200			49	40	0.1	0.9	0.48	0.48	42	58	73	100	3.046	4.177
Netw D		48265.9	360101.8										40	0.1	0.9	0.49	0.49	42	58	72	99	3.515	4.820
ST10	A8	14896.0	374997.8			163			126			102	42	0.1	0.9	0.49	0.49	43	59	71	97	3.578	4.905
ST11	A9	10777.0	385774.8			67			400			42	42	0.1	0.9	0.49	0.49	43	59	61	105	3.174	5.495

Description of catchments	**Belfast**	Weather Service Station	**Belfast**
River detail	**Network B**	Weather Station Number	0517072 W
Calculated by	NG Duvenage	Coordinates Latitude	25° 40'
Date	2013/09/17	Longitude	30° 01'

Catchment	Channel	Area		Length (m)			Slope (m/m)			Concentration time (seconds)				Distribution Factors		Run-off Coeficient		Point Rainfall		Point intensity		Peak Flow (m^3/s)	
		A (m^2)	ΣA (m^2)	L_0	L_c	$L_{Channel}$	S_0	S_c	$S_{Channel}$	T_0	T_c	$T_{channel}$	ΣT	Rural a	Urban ß	C_{10}	C_{50}	I_{10} mm	I_{50} mm	I_{10} (mm/hr)	I_{50} (mm/hr)	Q_{10}	Q_{50}
PW1	B1	5862.0	5862.0	40		260	50	92		687		130	14		1.0	0.50	0.50	29	40	163	223	0.132	0.182
PW2	B2(CULV)	2934.9	8796.9			15			50			8	14	0.3	0.7	0.46	0.46	29	40	159	219	0.180	0.248
PW2	B3		8796.9			5			47			3	14	0.3	0.7	0.47	0.47	29	40	159	218	0.181	0.249
PW3	B4	8147.8	16944.7			61			61			32	14	0.7	0.3	0.42	0.42	29	40	150	206	0.299	0.410
PW4	B5	16745.5	33690.2			52			200			35	15	0.8	0.2	0.41	0.41	30	42	147	202	0.564	0.774
PW5	B5	33275.2	66965.4						200				15	0.9	0.1	0.40	0.40	30	42	144	198	1.070	1.469
ST7	B6	44893.5	111858.9			351			200			219	19	0.5	0.5	0.44	0.44	32	45	122	168	1.671	2.295

Description of catchments	**Belfast**	Weather Service Station	**Belfast**
River detail	**Network C**	Weather Station Number	0517072 W
Calculated by	NG Duvenage	Coordinates Latitude	25° 40'
Date	2013/09/17	Longitude	30° 01'

Catchment	Channel	Area		Length (m)			Slope (m/m)			Concentration time (seconds)				Distribution Factors		Run-off Coeficient		Point Rainfall		Point intensity		Peak Flow (m^3/s)	
		A (m^2)	ΣA (m^2)	L_0	L_c	$L_{Channel}$	S_0	S_c	$S_{Channel}$	T_0	T_c	$T_{channel}$	ΣT	Rural a	Urban ß	C_{10}	C_{50}	I_{10} mm	I_{50} mm	I_{10} (mm/hr)	I_{50} (mm/hr)	Q_{10}	Q_{50}
PL1	C1	11297.3	11297.3	199		93	56.943	0.000	93.3	1499		58	26	1.0		0.39	0.39	36	50	106	145	0.129	0.177
PL2	C2	12575.2	23872.5										26	1.0		0.39	0.39	36	50	103	142	0.267	0.367
PL3	C3	8646.8	32519.3			115			70			77	27	0.7	0.3	0.42	0.42	37	50	99	136	0.375	0.515
PL4	C4	17703.3	50222.6			138			200			92	29	0.5	0.5	0.45	0.45	38	52	95	131	0.596	0.818
PL5	C5	8432.7	58655.3										29	0.4	0.6	0.46	0.46	38	52	95	130	0.704	0.967
PL6	C6	6721.2	65376.5			127			90			85	30	0.5	0.5	0.45	0.45	38	53	92	126	0.745	1.024

Description of catchments	**Belfast**	Weather Service Station	**Belfast**
River detail	**Network D**	Weather Station Number	0517072 W
Calculated by	NG Duvenage	Coordinates Latitude	25° 40'
Date	2013/09/17	Longitude	30° 01'

Catchment	Channel	Area		Length (m)			Slope (m/m)			Concentration time (seconds)				Distribution Factors		Run-off Coeficient		Point Rainfall		Point intensity		Peak Flow (m^3/s)	
		A (m^2)	ΣA (m^2)	L_0	L_c	$L_{Channel}$	S_0	S_c	$S_{Channel}$	T_0	T_c	$T_{channel}$	ΣT	Rural a	Urban ß	C_{10}	C_{50}	I_{10} mm	I_{50} mm	I_{10} (mm/hr)	I_{50} (mm/hr)	Q_{10}	Q_{50}
DS1		22163.9	22163.9	192			60.667	0.000		1495			25	1.0		0.39	0.39	36	49	106	146	0.255	0.350
DS2	D1	5014.0	27177.9			119			81			80	26	1.0		0.39	0.39	36	50	102	140	0.300	0.412
DS3		6884.0	34061.9										26	0.8	0.2	0.41	0.41	36	50	101	139	0.394	0.541
DS4	D2	14204.0	48265.9			66			76			44	27	0.9	0.1	0.41	0.41	37	50	99	136	0.537	0.738
			48265.9										27	1.0		0.39	0.39						
DS1		22163.9	22163.9	183		159	200.000	0.000	200.0	1932		99	34		1.0	0.50	0.50	40	55	88	121	0.271	0.372

Description of catchments	**Belfast**	Weather Service Station	**Belfast**
River detail	**Network E**	Weather Station Number	0517072 W
Calculated by	NG Duvenage	Coordinates Latitude	25° 40'
Date	2013/09/17	Longitude	30° 01'

Catchment	Channel	Area		Length (m)			Slope (m/m)			Concentration time (seconds)				Distribution Factors		Run-off Coeficient		Point Rainfall		Point intensity		Peak Flow (m^3/s)	
		A (m^2)	ΣA (m^2)	L_0	L_c	$L_{Channel}$	S_0	S_c	$S_{Channel}$	T_0	T_c	$T_{channel}$	ΣT	Rural a	Urban ß	C_{10}	C_{50}	I_{10} mm	I_{50} mm	I_{10} (mm/hr)	I_{50} (mm/hr)	Q_{10}	Q_{50}
DSC1		424175.0	424175.0	484	373		60.500	46.625		2302	25		39		1.0	0.50	0.50	42	57	73	100	4.312	5.914
DSC2	E1	15411.5	439586.5			82			200			55	40	0.0	1.0	0.50	0.50	42	58	72	99	4.368	5.990
DSC3	E2	24145.9	463732.4			265			56			177	43	0.1	0.9	0.49	0.49	43	59	69	95	4.357	5.973
DSC4	E3	20437.3	484169.8			136			60			91	44	0.1	0.9	0.49	0.49	44	60	67	92	4.433	6.076
DSC5	E4	40944.6	525114.4			105			32			70	45	0.1	0.9	0.49	0.49	44	60	66	90	4.720	6.469

Description of catchments	**Belfast**	Weather Service Station	**Belfast**
River detail	**Network F**	Weather Station Number	0517072 W
Calculated by	NG Duvenage	Coordinates Latitude	25° 40'
Date	2013/09/17	Longitude	30° 01'

Catchment	Channel	Area		Length (m)			Slope (m/m)			Concentration time (seconds)				Distribution Factors		Run-off Coeficient		Point Rainfall		Point intensity		Peak Flow (m^3/s)	
		A (m^2)	ΣA (m^2)	L_0	L_c	$L_{Channel}$	S_0	S_c	$S_{Channel}$	T_0	T_c	$T_{channel}$	ΣT	Rural a	Urban ß	C_{10}	C_{50}	I_{10} mm	I_{50} mm	I_{10} (mm/hr)	I_{50} (mm/hr)	Q_{10}	Q_{50}
CP1	F1	9517.0	9517.0	117		114	48.548	0.000	86.4	1126		57	20	1.0		0.39	0.39	33	45	127	174	0.130	0.179
CP2	F2	8563.0	18080.0			29			48			19	20	1.0		0.39	0.39	36	53	134	197	0.263	0.387
CP3	F3	24653.0	42733.0			161			41			107	22	1.0		0.39	0.39	38	56	126	185	0.583	0.855
CP4	F4	14996.0	57729.0			51			30			34	22	1.0		0.39	0.39	38	56	122	178	0.760	1.116
CP5	F5	29039.0	86768.0			120			26			80	24	0.7	0.3	0.42	0.42	40	58	118	173	1.205	1.769

Description of catchments	**Belfast**	Weather Service Station	**Belfast**
River detail	**Network G**	Weather Station Number	0517072 W
Calculated by	NG Duvenage	Coordinates Latitude	25° 40'
Date	2013/09/17	Longitude	30° 01'

Catchment	Channel	Area		Length (m)			Slope (m/m)			Concentration time (seconds)				Distribution Factors		Run-off Coeficient		Point Rainfall		Point intensity		Peak Flow (m^3/s)	
		A (m^2)	ΣA (m^2)	L_0	L_c	$L_{Channel}$	S_0	S_c	$S_{Channel}$	T_0	T_c	$T_{channel}$	ΣT	Rural a	Urban ß	C_{10}	C_{50}	I_{10} mm	I_{50} mm	I_{10} (mm/hr)	I_{50} (mm/hr)	Q_{10}	Q_{50}
HR1	CULV	65868.0	65868.0	313			54.790	0.000		1836			31	0.8	0.2	0.41	0.41	39	53	91	125	0.683	0.938
HR2	G1	27459.0	93327.0			184			30			123	33	0.9	0.1	0.40	0.40	39	54	86	118	0.903	1.239
HR3		8886.0	102213.0										33	0.8	0.2	0.41	0.41	39	54	86	118	1.006	1.381
HR4	G2	44072.0	146285.0			431			134			287	37	0.7	0.3	0.42	0.42	41	56	77	106	1.324	1.817
NETW F		86768.0	233053.0										37	0.6	0.4	0.43	0.43	41	56	76	104	2.109	2.893
MEY	G3	40944.0	273997.0			159			400			106	39	0.5	0.5	0.45	0.45	42	57	74	101	2.512	3.445
NETW E	G4	525114.4	799111.4			20			400			10	39	0.5	0.5	0.44	0.44	42	57	70	97	6.902	9.466

LOYD DAVIES METHOD

Description of catchments	**Belfast**	Weather Service Station	**Belfast**
River detail	**Network H**	Weather Station Number	0517072 W
Calculated by	NG Duvenage	Coordinates Latitude	25° 40'
Date	2013/09/17	Longitude	30° 01'

Catchment	Channel	Area		Length (m)			Slope (m/m)			Concentration time (seconds)				Distribution Factors		Run-off Coeficient		Point Rainfall		Point intensity		Peak Flow (m^3/s)	
		A (m^2)	ΣA (m^2)	L_0	L_c	$L_{Channel}$	S_0	S_c	$S_{Channel}$	T_0	T_c	$T_{channel}$	ΣT	Rural a	Urban ß	C_{10}	C_{50}	I_{10} mm	I_{50} mm	I_{10} (mm/hr)	I_{50} (mm/hr)	Q_{10}	Q_{50}
CLEAN W	H	108727.0	108727.0	965			68	0		3260			54	1.0		0.39	0.39	47	64	62	85	0.729	0.999

A3 Channel Hydraulics

Description of Channel		NETWORK A TO NETWORK D															
Calculated by		NG Duvenage								**Date**	2013/09/17						
Physical characteristics										**Results**							
From chainage to Chainage	Channel lining	Channel Design Flow (Q)	Manning	Channel slope	Slope left (1:?)	Slope right (1:?)	Flow Depth of channel (y)	Channel width (b)	Channel Depth	The wetted perimeter (P)	The flow area (A)	Hydraulic Raduis (R)	Width at top of channel	Velocity (v)	Flow in channel (Q)	Froude number (Fr)	Freeboard
		m^3/s	n-value	1 / m	z	z	m	m	mm	m	m^2	m	m	m/s	m^3/s		m
NETWORK A																	
A1	Lined	0.22	0.014	200.0	3.00	3.00	0.15	1.50	184	2.45	0.29	0.12	2.40	1.22	0.36	1.12	0.034
A2 Culv	Lined	0.22	0.014	200.0	0.00	0.00	0.15	1.50	185	1.80	0.23	0.13	1.50	1.26	0.28	1.04	0.035
A2	Lined	0.44	0.014	200.0	3.00	3.00	0.18	1.50	221	2.64	0.37	0.14	2.58	1.36	0.50	1.15	0.041
A3	Lined	0.86	0.014	200.0	3.00	3.00	0.25	1.50	308	3.08	0.56	0.18	3.00	1.62	0.91	1.20	0.058
A4	Lined	1.12	0.014	200.0	3.00	3.00	0.28	1.50	345	3.27	0.66	0.20	3.18	1.73	1.13	1.22	0.065
A4 Culv	Lined	1.12	0.014	150.0	0.00	0.00	0.30	1.80	381	2.40	0.54	0.23	1.80	2.16	1.16	1.26	0.081
A5	Lined	1.70	0.014	200.0	3.00	3.00	0.35	1.50	432	3.71	0.89	0.24	3.60	1.95	1.74	1.25	0.082
A6	Lined	3.30	0.014	200.0	3.00	3.00	0.49	1.50	606	4.60	1.46	0.32	4.44	2.34	3.41	1.31	0.116
A6 CULV	Lined	3.30	0.014	150.0	0.00	0.00	0.49	2.40	627	3.38	1.18	0.35	2.40	2.88	3.39	1.32	0.137
A7	Lined	4.18	0.014	200.0	3.00	3.00	0.54	1.50	668	4.92	1.68	0.34	4.74	2.47	4.17	1.32	0.128
A8	Lined	4.91	0.014	102.0	3.00	3.00	0.50	1.50	659	4.66	1.50	0.32	4.50	3.32	4.98	1.84	0.159

A8 Culvert	Lined	4.91	0.014	102.0	0.00	0.00	0.56	2.40	750	3.52	1.34	0.38	2.40	3.72	5.00	1.59	0.190
A9	Lined	5.45	0.014	100.0	3.00	3.00	0.52	1.50	688	4.79	1.59	0.33	4.62	3.43	5.45	1.86	0.168
A9	Lined	5.45	0.014	1000.0	3.00	3.00	0.34	14.80	399	16.95	5.38	0.32	16.84	1.05	5.65	0.59	0.059
SILT BASIN																	
Silt Basin 1:50	Lined	4.73	0.020	10000.0	4.00	4.00	0.60	15.00	691	19.95	10.44	0.52	19.80	0.32	3.39	0.14	0.091
Silt Basin 1:2	Lined	2.46	0.020	10000.0	4.00	4.00	0.50	15.00	576	19.12	8.50	0.44	19.00	0.29	2.47	0.14	0.076
Spillway	Lined	5.88	0.014	100.0	3.00	3.00	0.25	8.00	342	9.58	2.19	0.23	9.50	2.67	5.83	1.77	0.092
NETWORK B																	
B1	Lined	0.13	0.014	100.0	3.00	3.00	0.11	1.50	143	2.20	0.20	0.09	2.16	1.45	0.29	1.52	0.033
B2 Culvert	Lined	0.18	0.014	50.0	0.00	0.00	0.11	1.50	161	1.72	0.17	0.10	1.50	2.12	0.35	2.04	0.051
B3	Lined	0.18	0.014	47.0	3.00	3.00	0.10	1.50	138	2.10	0.17	0.08	2.07	1.94	0.33	2.17	0.043
B4	Lined	0.30	0.014	61.0	3.00	3.00	0.12	1.50	167	2.26	0.22	0.10	2.22	1.95	0.44	1.97	0.047
B5	Lined	1.10	0.014	200.0	3.00	3.00	0.28	1.50	345	3.27	0.66	0.20	3.18	1.73	1.13	1.22	0.065
B6	Lined	1.67	0.014	200.0	3.00	3.00	0.34	1.50	419	3.65	0.86	0.23	3.54	1.92	1.65	1.25	0.079
NETWORK C																	
C1	Lined	0.13	0.014	93.0	3.00	3.00	0.08	1.50	104	2.01	0.14	0.07	1.98	1.25	0.17	1.50	0.024
C1 Culvert	Lined	0.13	0.014	100.0	0.00	0.00	0.08	1.50	104	1.66	0.12	0.07	1.50	1.24	0.15	1.40	0.024
C2	Lined	0.27	0.014	70.0	3.00	3.00	0.10	1.50	136	2.13	0.18	0.08	2.10	1.64	0.30	1.79	0.036
C2 Culvert	Lined	0.27	0.014	70.0	0.00	0.00	0.11	1.50	151	1.72	0.17	0.10	1.50	1.79	0.29	1.72	0.041
C3	Lined	0.38	0.014	70.0	4.00	4.00	0.13	1.50	169	2.53	0.25	0.10	2.50	1.82	0.46	1.84	0.044
C4	Lined	0.60	0.014	200.0	3.00	3.00	0.22	1.50	271	2.89	0.48	0.16	2.82	1.51	0.72	1.18	0.051

C5	Lined	0.70	0.014	200.0	3.00	3.00	0.24	1.50	295	3.02	0.53	0.18	2.94	1.59	0.85	1.19	0.055
C6	Lined	0.75	0.014	90.0	3.00	3.00	0.20	1.50	265	2.76	0.42	0.15	2.70	2.14	0.90	1.73	0.065
NETWORK D																	
D1	Lined	0.30	0.014	81.0	3.00	3.00	0.12	1.50	160	2.26	0.22	0.10	2.22	1.69	0.38	1.71	0.040
D2	Lined	0.54	0.014	76.0	3.00	3.00	0.16	1.50	216	2.51	0.32	0.13	2.46	2.06	0.65	1.83	0.056
D3	Lined	0.27	0.014	200.0	3.00	3.00	0.18	1.50	221	2.64	0.37	0.14	2.58	1.36	0.50	1.15	0.041
OVERFLOW CHANNEL FROM DAM D4 (1:100 FLOOD) NETWORK E																	
E	Lined	5.88	0.014	1000.0	3.00	3.00	0.93	1.50	1087	7.38	3.99	0.54	7.08	1.50	5.98	0.64	0.157

Description of Channel				NETWORK E TO NETWORK H													
Calculated by				NG Duvenage						**Date**		2013/09/17					
Physical characteristics										**Results**							
From chainage to Chainage	Channel lining	Channel Design Flow (Q)	Manning	Channel slope	Slope left (1:?)	Slope right (1:?)	Flow Depth of channel (y)	Channel width (b)	Channel Depth	The wetted perimeter (P)	The flow area (A)	Hydraulic Raduis (R)	Width at top of channel	Velocity (v)	Flow in channel (Q)	Froude number (Fr)	Freeboard
		m^3/s	n-value	1 / m	z	z	m	m	mm	m	m^2	m	m	m/s	m^3/s		m
NETWORK E																	
E1	Lined	6.00	0.014	200.0	3.00	3.00	0.59	2.00	734	5.73	2.22	0.39	5.54	2.69	5.98	1.35	0.144
E1 CULV	Lined	6.00	0.014	100.0	0.00	0.00	0.63	2.40	844	3.66	1.51	0.41	2.40	3.96	5.99	1.59	0.214
E2	Lined	6.00	0.014	60.0	3.00	3.00	0.44	2.00	640	4.78	1.46	0.31	4.64	4.18	6.11	2.38	0.200
E2	Lined	6.00	0.014	400.0	3.00	3.00	0.66	2.50	792	6.67	2.96	0.44	6.46	2.07	6.14	0.98	0.132
E3	Lined	6.10	0.014	60.0	3.00	3.00	0.44	2.00	640	4.78	1.46	0.31	4.64	4.18	6.11	2.38	0.200
E4	Lined	6.50	0.014	32.0	3.00	3.00	0.39	2.00	668	4.47	1.24	0.28	4.34	5.36	6.63	3.21	0.278
NETWORK F																	
F1	Lined	0.13	0.014	86.0	3.00	3.00	0.10	1.50	132	2.13	0.18	0.08	2.10	1.48	0.27	1.61	0.032
F2	Lined	0.26	0.014	48.0	3.00	3.00	0.10	1.50	145	2.13	0.18	0.08	2.10	1.98	0.36	2.16	0.045
F3	Lined	0.58	0.014	41.0	3.00	3.00	0.15	1.50	228	2.45	0.29	0.12	2.40	2.70	0.79	2.47	0.078
F4	Lined	0.76	0.014	30.0	3.00	3.00	0.17	1.50	283	2.58	0.34	0.13	2.52	3.39	1.16	2.94	0.113
F5 Culv	Lined	1.20	0.014	50.0	0.00	0.00	0.26	1.80	391	2.32	0.47	0.20	1.80	3.47	1.63	2.17	0.131

F5	Lined	1.20	0.014	26.0	0.00	0.00	0.25	1.50	448	2.00	0.38	0.19	1.50	4.59	1.72	2.93	0.198
NETWORK G																	
CULV	Lined	0.94	0.030	50.0	0.00	0.00	0.35	1.50	428	2.20	0.53	0.24	1.50	1.81	0.95	0.98	0.078
G1	Lined	1.40	0.014	30.0	3.00	3.00	0.20	1.50	335	2.76	0.42	0.15	2.70	3.71	1.56	3.00	0.135
G2	Lined	1.80	0.014	135.0	3.00	3.00	0.34	1.50	433	3.65	0.86	0.23	3.54	2.34	2.00	1.52	0.093
G3	Lined	3.40	0.014	400.0	3.00	3.00	0.60	1.50	716	5.29	1.98	0.37	5.10	1.85	3.67	0.95	0.116
G4	Lined	9.50	0.014	400.0	3.00	3.00	0.66	4.50	797	8.67	4.28	0.49	8.46	2.23	9.53	1.00	0.137
CLEAN WATER CHANNEL																	
H CULV	Lined	1.00	0.014	68.0	0.00	0.00	0.25	1.50	349	2.00	0.38	0.19	1.50	2.84	1.06	1.81	0.099
H	Lined	1.00	0.014	68.0	3.00	3.00	0.20	1.50	276	2.76	0.42	0.15	2.70	2.46	1.04	2.00	0.076
CULVERT AT MINE ACCESS ROAD CONNECTING DISCARDS WITH PCD																	
DISCARDS CULV	Lined	5.50	0.014	68.0	0.00	0.00	0.58	2.10	821	3.26	1.22	0.37	2.10	4.49	5.47	1.88	0.241

RATIONAL METHOD								
Description of catchments	**Belfast Mine**			Weather Service Station		**Belfast**		
River detail	**Plant Catchment**			Weather Station Number		0517072 W		
Calculated by	NG Duvenage			Coordinates	Latitude	25° 40'		
Date	2013/10/27				Longitude	30° 01'		
Physical characteristics								
Size of catchments (A)	0.39	km²		Rainfall region				
Overland flow (L_0)	0.26	km		**Area distribution factors**				
Defined watercourse (L_c)	0.000	km		Rural a	Urban ß	Lakes ɣ		
Average Slope overland flow	0.02	m / m		0.5	0.5			
Average slope watercourse flow	0.00	m / m						
Dolomite area (D%)		%						
Mean annual precipitation (MAP)	700	mm						
Rural C_1				Urban C_2				
Surface slope	**%**	**Factor**	**Cs**	**Description**		%	Factor	C_2
Vleis and pans (<3%)	100			**Lawns**				
Flat areas (3 tot 10%)				Sandy, flat (2%)			0.10	
Hilly (10 tot 30%)				Sandy, steep (7%)			0.20	
Steep areas (>30%)				Heavy soil, flat (2%)			0.17	
Total	100		0.030	Heavy soil, steep (7%)			0.35	
Permeability	**%**	**Factor**	**Cp**	**Residential Areas**				
Very permeable				Houses			0.50	
Permeable				Apartments			0.70	
Semi-permeable				**Industry**				
Impermeable	100			Terraces, Gravel Roads		95	0.50	0.475
Total	100		0.260	Heavy industry			0.90	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation				City centre			0.95	
Light bush and farm-lands				Suburban			0.70	
Grass lands				Streets		5	0.95	0.0475
No vegetation	100			Maximum flood			1.00	
Total	100		0.280	**Total (C_2)**		100	-	0.5225
Values for r				**Time of concentration**				
Paved Areas			0.02	Overland flow T= $0.604(rL/S^{0.5})^{0.467}$			0.54	Hours
Clean compacted soil			0.1	Defined watercourse T=$(0.87L^2/1000S)^{0.385}$			0.00	Hours
Sparse grass over rough surface			0.3	Channel Flow			0.24	Hours
Medium grass cover			0.4	Total Tc			0.78	Hours
Thick grass cover			0.8					
Value of r			0.40					

Run-off coefficient						
Return period (years),T	**2**	**5**	**10**	**20**	**50**	**100**
Run-off coefficient, C1(C1=Cs+Cp+Cv)	0.57	0.57	0.57	0.57	0.57	0.57
Adjusted for dolomite areas, Cid	0.57	0.57	0.57	0.57	0.57	0.57
Adjustment factor for final saturation Ft	0.50	0.55	0.60	0.67	0.83	1.00
Adjusted run-off coefficient Cit (=Cid x Ft)	0.29	0.31	0.34	0.38	0.47	0.57
Combined run-off coefficient Ct (=aCit+ßC2+gC3)	0.40	0.42	0.43	0.45	0.50	0.55
Rainfall						
Return period (years),T	**2**	**5**	**10**	**20**	**50**	**100**
Point rainfall (mm) Pt	28.29	37.55	44.30	51.15	60.71	68.77
Point intensity I (mm/hour)	36.13	47.95	56.57	65.31	77.53	87.81
Are reduction factor (%) ARFt	1.14	1.14	1.14	1.14	1.14	1.14
Average Intensity (mm/hour)	41.34	54.87	64.72	74.73	88.71	100.47
Peak Flow Q=CIA/3.6 (m3/s)	1.79	2.46	3.00	3.62	4.73	5.88
Runoff Volume Sv = 3600Q3Tc/2	7563	10393	12678	15313	20011	24871
24 Hr Rainfall	71	94	111	128	152	172
PCD Dam Volume	11043	15158	18493	22347	29190	36245

RATIONAL METHOD								
Description of catchments	**Belfast Mine**			Weather Service Station		**Roodepoort**		
River detail	**Haul Rds Area**			Weather Station Number		0516554 W		
Calculated by	NG Duvenage			Coordinates	Latitude	25° 44'		
Date	2012/06/27				Longitude	29° 48'		
Physical characteristics								
Size of catchments (A)	0.09	km²		Rainfall region				
Overland flow (L_0)	0.35	km		**Area distribution factors**				
Defined watercourse (L_c)	0.000	km		Rural a		Urban ß		Lakes ɣ
Average Slope overland flow	0.02	m / m		1				
Average slope watercourse flow	0.00	m / m						
Dolomite area (D%)		%						
Mean annual precipitation (MAP)	700	mm						
Rural C_1				Urban C_2				
Surface slope	**%**	**Factor**	**Cs**	**Description**		%	Factor	C_2
Vleis and pans (<3%)	100			**Lawns**				
Flat areas (3 tot 10%)				Sandy, flat (2%)			0.10	
Hilly (10 tot 30%)				Sandy, steep (7%)			0.20	
Steep areas (>30%)				Heavy soil, flat (2%)			0.17	
Total	100		0.030	Heavy soil, steep (7%)			0.35	
Permeability	**%**	**Factor**	**Cp**	**Residential Areas**				
Very permeable				Houses			0.50	
Permeable				Apartments			0.70	
Semi-permeable				**Industry**				
Impermeable	100			Terraces, Gravel Roads		95	0.50	0.475
Total	100		0.260	Heavy industry			0.90	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation				City centre			0.95	
Light bush and farm-lands				Suburban			0.70	
Grass lands				Streets		5	0.95	0.0475
No vegetation	100			Maximum flood			1.00	
Total	100		0.280	**Total (C_2)**		100	-	0.5225
Values for r				**Time of concentration**				
Paved Areas			0.02	Overland flow T= $0.604(rL/S^{0.5})^{0.467}$			0.61	Hours
Clean compacted soil			0.1	Defined watercourse T=$(0.87L^2/1000S)^{0.385}$			0.00	Hours
Sparse grass over rough surface			0.3	Channel Flow			0.15	Hours
Medium grass cover			0.4	Total Tc			0.76	Hours
Thick grass cover			0.8					
Value of r			0.40					

Run-off coefficient						
Return period (years),T	**2**	**5**	**10**	**20**	**50**	**100**
Run-off coefficient, C1(C1=Cs+Cp+Cv)	0.57	0.57	0.57	0.57	0.57	0.57
Adjusted for dolomite areas, Cid	0.57	0.57	0.57	0.57	0.57	0.57
Adjustment factor for final saturation Ft	0.50	0.55	0.60	0.67	0.83	1.00
Adjusted run-off coefficient Cit (=Cid x Ft)	0.29	0.31	0.34	0.38	0.47	0.57
Combined run-off coefficient Ct (=aCit+ßC2+gC3)	0.29	0.31	0.34	0.38	0.47	0.57
Rainfall						
Return period (years),T	**2**	**5**	**10**	**20**	**50**	**100**
Point rainfall (mm) Pt	27.86	36.98	43.62	50.37	59.79	67.71
Point intensity I (mm/hour)	36.45	48.39	57.08	65.90	78.23	88.60
Are reduction factor (%) ARFt	1.20	1.20	1.20	1.20	1.20	1.20
Average Intensity (mm/hour)	43.77	58.10	68.53	79.13	93.93	106.38
Peak Flow Q=CIA/3.6 (m3/s)	0.32	0.47	0.61	0.78	1.15	1.57
Runoff Volume Sv = 3600Q3Tc/2	1335	1949	2507	3233	4754	6487
24 Hr Rainfall	74	98	116	134	159	180
PCD Dam Volume	1968	2870	3693	4762	7003	9549

RATIONAL METHOD								
Description of catchments	**Belfast Mine**			Weather Service Station		**Roodepoort**		
River detail	**Mobile Equipment Area**			Weather Station Number		0516554 W		
Calculated by	NG Duvenage			Coordinates	Latitude	25° 44'		
Date	2012/06/27				Longitude	29° 48'		
Physical characteristics								
Size of catchments (A)	0.17	km²		Rainfall region				
Overland flow (L_0)	0.12	km		**Area distribution factors**				
Defined watercourse (L_c)	0.000	km		Rural a	Urban ß	Lakes ɣ		
Average Slope overland flow	0.02	m / m		0.5	0.5			
Average slope watercourse flow	0.00	m / m						
Dolomite area (D%)		%						
Mean annual precipitation (MAP)	700	mm						
Rural C_1				Urban C_2				
Surface slope	**%**	**Factor**	**Cs**	**Description**		%	Factor	C_2
Vleis and pans (<3%)	100			**Lawns**				
Flat areas (3 tot 10%)				Sandy, flat (2%)			0.10	
Hilly (10 tot 30%)				Sandy, steep (7%)			0.20	
Steep areas (>30%)				Heavy soil, flat (2%)			0.17	
Total	100		0.030	Heavy soil, steep (7%)			0.35	
Permeability	**%**	**Factor**	**Cp**	**Residential Areas**				
Very permeable				Houses			0.50	
Permeable				Apartments			0.70	
Semi-permeable				**Industry**				
Impermeable	100			Terraces, Gravel Roads		95	0.50	0.475
Total	100		0.260	Heavy industry			0.90	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation				City centre			0.95	
Light bush and farm-lands				Suburban			0.70	
Grass lands				Streets		5	0.95	0.0475
No vegetation	100			Maximum flood			1.00	
Total	100		0.280	**Total (C_2)**		100	-	0.5225
Values for r				**Time of concentration**				
Paved Areas			0.02	Overland flow T= $0.604(rL/S^{0.5})^{0.467}$			0.36	Hours
Clean compacted soil			0.1	Defined watercourse T=$(0.87L^2/1000S)^{0.385}$			0.00	Hours
Sparse grass over rough surface			0.3	Channel Flow			0.10	Hours
Medium grass cover			0.4	Total Tc			0.46	Hours
Thick grass cover			0.8					
Value of r			0.40					

Run-off coefficient						
Return period (years),T	**2**	**5**	**10**	**20**	**50**	**100**
Run-off coefficient, C1(C1=Cs+Cp+Cv)	0.57	0.57	0.57	0.57	0.57	0.57
Adjusted for dolomite areas, Cid	0.57	0.57	0.57	0.57	0.57	0.57
Adjustment factor for final saturation Ft	0.50	0.55	0.60	0.67	0.83	1.00
Adjusted run-off coefficient Cit (=Cid x Ft)	0.29	0.31	0.34	0.38	0.47	0.57
Combined run-off coefficient Ct (=aCit+ßC2+gC3)	0.40	0.42	0.43	0.45	0.50	0.55
Rainfall						
Return period (years),T	**2**	**5**	**10**	**20**	**50**	**100**
Point rainfall (mm) Pt	23.82	31.59	37.23	43.06	51.13	57.83
Point intensity I (mm/hour)	51.80	68.71	80.97	93.65	111.20	125.78
Are reduction factor (%) ARFt	1.16	1.16	1.16	1.16	1.16	1.16
Average Intensity (mm/hour)	60.18	79.82	94.07	108.79	129.19	146.12
Peak Flow Q=CIA/3.6 (m3/s)	1.13	1.55	1.89	2.29	2.99	3.72
Runoff Volume Sv = 3600Q3Tc/2	2810	3858	4702	5689	7436	9229
24 Hr Rainfall	74	98	116	134	159	180
PCD Dam Volume	5009	6875	8384	10128	13236	16438

RATIONAL METHOD								
Description of catchments	**Belfast Mine**			Weather Service Station		**Roodepoort**		
River detail	**Mining Catchment Discard**			Weather Station Number		0516554 W		
Calculated by	NG Duvenage			Coordinates	Latitude	25° 44'		
Date	2013/10/27				Longitude	29° 48'		
Physical characteristics								
Size of catchments (A)	0.53	km²		Rainfall region				
Overland flow (L_0)	0.48	km		**Area distribution factors**				
Defined watercourse (L_c)	0.373	km		Rural a	Urban ß	Lakes ɣ		
Average Slope overland flow	0.02	m / m		0.5	0.5			
Average slope watercourse flow	0.02	m / m						
Dolomite area (D%)		%						
Mean annual precipitation (MAP)	783	mm						
Rural C_1				Urban C_2				
Surface slope	**%**	**Factor**	**Cs**	**Description**		%	Factor	C_2
Vleis and pans (<3%)	100			**Lawns**				
Flat areas (3 tot 10%)				Sandy, flat (2%)			0.10	
Hilly (10 tot 30%)				Sandy, steep (7%)			0.20	
Steep areas (>30%)				Heavy soil, flat (2%)			0.17	
Total	100		0.030	Heavy soil, steep (7%)			0.35	
Permeability	**%**	**Factor**	**Cp**	**Residential Areas**				
Very permeable				Houses			0.50	
Permeable				Apartments			0.70	
Semi-permeable				**Industry**				
Impermeable	100			Terraces, Gravel Roads		95	0.50	0.475
Total	100		0.260	Heavy industry			0.90	
Vegetation	**%**	**Factor**	**Cv**	**Business**				
Thick bush and plantation				City centre			0.95	
Light bush and farm-lands				Suburban			0.70	
Grass lands				Streets		5	0.95	0.0475
No vegetation	100			Maximum flood			1.00	
Total	100		0.280	**Total (C_2)**		100	-	0.5225
Values for r				**Time of concentration**				
Paved Areas			0.02	Overland flow T= $0.604(rL/S^{0.5})^{0.467}$			0.73	Hours
Clean compacted soil			0.1	Defined watercourse T=$(0.87L^2/1000S)^{0.385}$			0.14	Hours
Sparse grass over rough surface			0.3	Channel Flow			0.10	Hours
Medium grass cover			0.4	Total Tc			0.97	Hours
Thick grass cover			0.8					
Value of r			0.40					

Run-off coefficient						
Return period (years),T	**2**	**5**	**10**	**20**	**50**	**100**
Run-off coefficient, C1(C1=Cs+Cp+Cv)	0.57	0.57	0.57	0.57	0.57	0.57
Adjusted for dolomite areas, Cid	0.57	0.57	0.57	0.57	0.57	0.57
Adjustment factor for final saturation Ft	0.50	0.55	0.60	0.67	0.83	1.00
Adjusted run-off coefficient Cit (=Cid x Ft)	0.29	0.31	0.34	0.38	0.47	0.57
Combined run-off coefficient Ct (=aCit+ßC2+gC3)	0.40	0.42	0.43	0.45	0.50	0.55
Rainfall						
Return period (years),T	**2**	**5**	**10**	**20**	**50**	**100**
Point rainfall (mm) Pt	23.48	31.14	36.70	42.44	50.40	57.00
Point intensity I (mm/hour)	24.27	32.19	37.93	43.87	52.09	58.91
Are reduction factor (%) ARFt	1.14	1.14	1.14	1.14	1.14	1.14
Average Intensity (mm/hour)	27.62	36.63	43.17	49.92	59.28	67.05
Peak Flow Q=CIA/3.6 (m3/s)	1.63	2.23	2.72	3.29	4.30	5.34
Runoff Volume Sv = 3600Q3Tc/2	8498	11668	14220	17203	22490	27911
24 Hr Rainfall	74	98	116	134	159	180
PCD Dam Volume	15689	21533	26262	31724	41458	51488

A4 Flood Line results

A5 Silt Basin Settling velocity results

SILT TRAP DESIGN			
Description	Silt Basin Dam D4		
Calculated By	NGD		
Date	2013/09/17		
Physical characteristics			
Horizontal velocity	V_h	0.32	m/s
Flow depth :	H	0.6	m
Silt trap length :	L	200	m
Gravity:	g	9.81	m^2/s
Water Viscosity:	μ	1.00E-06	m^2/s
Specific Gravity: (Coal)	s	1.3	
Results			
Settling Velocity:	V_p	0.00096	m/s
Particle Diameter Settling out:	D	77	micron

SILT TRAP DESIGN			
Description	Silt Basin Dam D2-2		
Calculated By	NGD		
Date	2013/09/17		
Physical characteristics			
Horizontal velocity	V_h	0.46	m/s
Flow depth :	H	0.5	m
Silt trap length :	L	72	m
Gravity:	g	9.81	m^2/s
Water Viscosity:	μ	1.00E-06	m^2/s
Specific Gravity: (Silt)	s	2.6	
Results			
Settling Velocity:	V_p	0.00319	m/s
Particle Diameter Settling out:	D	61	micron

A6 Summary of Storm water Design Results and Catchment Details

Appendix B

Roads And Stormwater

B1 High Level Pavement Comparison Cost

HIGH LEVEL PAVEMENT COMPARISON COST												
Road Description				Standard	Chemical Modified	Tensar – TriAx option	PC Grid option		Standard	Modified	Tensar – TriAx	PC Grid
Item	Ref.	Description	Unit	Qty	Qty	Qty	Qty	Rates	Option 1-A	Option 1-B	Option 2	Option 3
		BASE COURSE										
		Import G5 from Comercial Source and compact to 93% mod. AASHTO density	m^3	9747.00		5287.50		520.31	R 5,071,461.57		R 2,751,139.13	
	8.3.1	Construct gravel subbase with G8 material from borrow pits in all materials	m^3		9747.00			24.63		R 240,068.61		
		Stabilizing	m^3		9747.00			9.18		R 89,477.46		
	8.3.8	Stabilizing agent Ecobond	t									
		Portland cement	t		779.76			1700.60		R 1,326,059.86		
		Polypavement	t									
		Tensar TX 160	m^2			20600.00		59.45			R 1,224,670.00	
		SURFACE COURSE										
		Import from commercial source G4 material and compact to 98% mod. AASHTO density	m^3	12720.00	6090.00	9000.00		521.31	R 6,631,063.20	R 3,174,777.90	R 4,691,790.00	
		Import from commercial source G6 material and compact to 98% mod. AASHTO density	m^3				19620.00	430.00				R 8,436,600.00
	8.3.1	Construct gravel subbase with material from borrow pits in all materials	m^3		6270.00			41.07		R 257,508.90		
		Stabilizing	m^3		6270.00			9.18		R 57,558.60		
	8.3.8	Stabilizing agent Road lime	t									
		Portland cement	t		501.60			1700.60		R 853,020.96		
	8.3.9	Overhaul (Exeeding 2Km)	$m^3.km$					6.20				
		Tensar TX 160	m^2			21400.00		59.45			R 1,272,230.00	
		PC Grid 2 layers	m^2				43600.00	44.95				R 1,959,820.00
									R 11,702,524.77	**R 5,998,472.29**	**R 9,939,829.13**	**R 10,396,420.00**

Appendix C

Water Management

C1 Design Requirements

Basic Design Requirements for Water Pipelines

Pipes

Pipe diameter	Minimum 40 mm diameter
Velocities in Pipes	Minimum 0,6 m/s and should not exceed 1,2 m/s
Min Slope	0,3% pipes < 200 mm and 0,2% pipes > 200 mm diameter
Pipe Cover	Minimum of 1000mm
Pipe Type	PVC-U pipe class PN 12

Valves and Other Fittings

Valves	To isolate pipes in sections for repair work Not more than four valves need to be closed to isolate a section of the network. Not more than 600m apart

Air-valves

Locality	At high points to release air in system Not required where air in the system can be released from taps during filling Provided at points to suit the longitudinal section of the pipe Should be sized according to the air flow rate

Scour Valves

Placing of scour valves	To be put at low points of the system, to be able to clean out the system without pumping

Scour Outlets

Provide Open drain	To lead the washout water to a suitable water course
Possible downstream scour	Erosion protective measures should be implemented
Size	Size to permit complete draining of a section of the main within 2 hours

Marker Posts

Placing of Marker Posts	Along the pipeline to facilitate location of the route At all pipe bends and junctions Road crossings
Anchorage and thrust blocks	
Anchorage	Provide where pipeline changes vertical more than 10º or on steep slopes
Thrust Blocks	Provide where pipeline changes horizontal more than 10º or on steep slopes, and at blank ends.

Surge Control

Pressure Surges	The system will be check for possible pressure surges.

Valve Chambers

Working Space	Allow enough space to remove valve
Roof Slab	Design to allow for the removal and replacement of valves
Differential settlement	Make provision between valve chamber and pipeline
Venting	Provide adequate air flow for air-valve chambers

C2 Potable Water

C2.1 EPANET results

Page 1 11/20/2013 5:57:31 PM

```
******************************************************************
*                    E P A N E T                                 *
*                Hydraulic and Water Quality                     *
*                Analysis for Pipe Networks                      *
*                    Version 2.0                                 *
******************************************************************
```

Input File: PW Opt 1_Rev1.NET

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
p1	n1	n2	5.846	35.4
p3	n5	n6	13.61	181.6
p4	n7	n8	93.68	35.4
p5	n8	n9	24.05	35.4
p7	n9	n10	52	35.4
p10	n14	n15	4.85	79.8
p11	n16	n17	4.14	113.4
p13	n9	n18	3.247	35.4
p14	n10	n19	74.91	35.4
p15	n21	n20	9.80	35.4
p16	n19	n21	50.71	35.4
p19	n24	n25	52.675	35.4
p22	n30	n31	18.68	35.4
p23	n32	n33	14.90	35.4
p24	n35	n34	37.21	35.4
p25	n36	n38	43.327	79.8
p28	n38	n13	11.6	35.4
p30	n40	n41	89.67	55.8
p31	n43	n42	55.30	35.4
p32	n44	n45	6.927	35.4
p33	n47	n46	49.217	55.8
p43	n55	n7	88.439	35.4
p47	n36	n14	55.03	145.2
p48	n58	n36	590.22	145.2
p49	n59	n58	136.817	145.2
p50	n30	n59	99.41	145.2
p51	n60	n30	274.20	145.2
p52	n60	n61	190.89	181.6
p54	n61	n62	141.96	181.6
p55	n6	n63	33.53	55.8
p56	n6	n33	73.27	181.6
p57	n64	n65	12.87	35.4
p58	n60	n2	28.17	145.2
p59	n2	n17	21.11	145.2

p60	n17	n66	33.92	66.4
p62	n41	n44	100.5	55.8
p63	n23	n44	48.73	35.4

Page 2 prueba

Link - Node Table: (continued)

Link ID	Start Node	End Node	Length m	Diameter mm
p68	n23	n43	199.6	35.4
p69	n69	n68	7.93	35.4
p74	n72	n66	9.92	66.4
p75	n62	n47	253.727	55.8
p77	n69	n62	112.3	181.6
p78	n73	n69	55.48	181.6
p83	n76	n73	15.51	35.4
p85	n63	n77	13.315	55.8
p86	n77	n64	54.09	55.8
p87	n64	n78	34.72	55.8
p88	n78	n79	46.16	55.8
p89	n79	n80	31.26	55.8
1	1	2	1	181.6
3	n55	n3	28.228	35.4
4	n55	n14	87.219	55.8
5	n39	3	38.9214	55.8
6	3	4	108.609	35.4
7	4	5	5.048	35.4
9	n63	6	120.575	35.4
10	6	7	6.758	35.4
11	n33	n75	66.89	181.6
12	n75	n35	138.76	35.4
13	n75	n73	244.751	181.6
14	n38	8	14.823	55.8
15	8	9	49.257	35.4
16	8	n24	68.671	55.8
17	n24	n37	27.123	55.8
18	n37	n39	89.132	55.8
19	3	10	35.7771	55.8
20	10	11	16.8875	35.4
21	10	n40	47.5274	55.8
8	n46	12	112.065	55.8
22	n46	14	11.945	35.4
23	12	13	32.293	35.4
2	2	n5	#N/A	#N/A Pump

Energy Usage:

Pump	Usage Factor	Avg. Effic.	Kw-hr /m3	Avg. Kw	Peak Kw	Cost /day
2	100.00	75.00	0.13	14.61	14.61	0.00

Demand Charge: 0.00
Total Cost: 0.00

Page 3 prueba
Node Results:

Node ID	Demand LPS	Head m	Pressure m	Quality
n1	0.22	1817.09	39.81	0.00
n2	0.00	1817.10	39.86	0.00
n3	1.00	1808.19	38.25	0.00
n5	0.00	1823.10	39.37	0.00
n6	0.00	1823.00	39.39	0.00
n7	0.00	1808.64	38.49	0.00
n8	0.00	1808.02	36.52	0.00
n9	0.00	1807.86	35.68	0.00
n10	0.00	1807.76	34.49	0.00
n13	0.99	1809.40	41.52	0.00
n14	0.00	1809.88	40.68	0.00
n15	11.25	1809.57	40.47	0.00
n16	8.42	1817.00	40.00	0.00
n17	0.00	1817.03	40.01	0.00
n18	0.19	1807.85	35.60	0.00
n19	0.00	1807.61	34.08	0.00
n20	0.20	1807.50	33.01	0.00
n21	0.00	1807.52	32.90	0.00
n23	0.00	1803.96	40.67	0.00
n24	0.00	1808.48	41.54	0.00
n25	0.20	1808.38	40.76	0.00
n30	0.00	1815.41	38.75	0.00
n31	0.19	1815.38	38.46	0.00
n32	0.20	1822.46	40.31	0.00
n33	0.00	1822.49	40.63	0.00
n34	0.20	1821.69	38.09	0.00
n35	0.00	1821.76	38.78	0.00
n36	0.00	1810.10	42.13	0.00
n37	0.00	1808.14	41.56	0.00
n38	0.00	1809.83	42.17	0.00
n39	0.00	1806.99	40.76	0.00
n40	0.00	1805.77	41.70	0.00
n41	0.00	1805.07	40.68	0.00
n42	0.40	1802.25	37.10	0.00
n43	0.00	1802.62	40.01	0.00
n44	0.00	1804.29	40.63	0.00
n45	1.03	1804.02	40.10	0.00
n46	0.00	1817.57	39.06	0.00
n47	0.00	1817.84	38.26	0.00
n55	0.00	1809.23	38.99	0.00
n58	0.00	1813.89	40.19	0.00
n59	0.00	1814.77	39.38	0.00

n60	0.00	1817.21	39.51	0.00
n61	0.00	1818.38	40.14	0.00
n62	0.00	1819.25	40.22	0.00
n63	0.00	1822.60	37.80	0.00
n64	0.00	1822.23	36.26	0.00

Page 4 prueba

Node Results: (continued)

Node ID	Demand LPS	Head m	Pressure m	Quality	
n65	0.39	1822.14	36.09	0.00	
n66	0.00	1816.51	39.98	0.00	
n68	0.19	1819.98	39.21	0.00	
n69	0.00	1819.99	39.26	0.00	
n72	3.24	1816.36	39.85	0.00	
n73	0.00	1820.36	39.28	0.00	
n75	0.00	1822.03	41.02	0.00	
n76	0.23	1820.32	39.18	0.00	
n77	0.00	1822.53	37.55	0.00	
n78	0.00	1822.13	35.92	0.00	
n79	0.00	1822.01	35.34	0.00	
n80	0.80	1821.93	34.96	0.00	
2	0.00	1787.99	4.26	0.00	
3	0.00	1806.49	40.60	0.00	
4	0.00	1806.20	40.02	0.00	
5	0.24	1806.19	39.78	0.00	
6	0.00	1820.88	37.95	0.00	
7	0.60	1820.78	37.78	0.00	
8	0.00	1809.54	42.11	0.00	
9	0.24	1809.41	40.87	0.00	
10	0.00	1806.14	40.94	0.00	
11	0.20	1806.11	40.84	0.00	
12	0.00	1817.13	40.63	0.00	
13	0.99	1815.96	39.92	0.00	
14	0.20	1817.55	39.10	0.00	
1	-31.85	1788.00	0.00	0.00	Reservoir

Link Results:

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
p1	-0.22	0.22	2.21	Open
p3	31.85	1.23	7.76	Open
p4	0.40	0.40	6.64	Open
p5	0.40	0.40	6.64	Open
p7	0.20	0.21	1.92	Open
p10	11.25	2.25	62.02	Open
p11	-8.42	0.83	6.54	Open
p13	0.19	0.20	1.79	Open

p14	0.20	0.21	1.92	Open
p15	0.20	0.21	1.93	Open
p16	0.20	0.21	1.92	Open
p19	0.20	0.20	1.86	Open
p22	0.19	0.20	1.76	Open
p23	-0.20	0.21	1.94	Open
p24	0.20	0.21	1.94	Open

Page 5 prueba

Link Results: (continued)

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
p25	3.31	0.66	6.44	Open
p28	0.99	1.01	36.35	Open
p30	1.43	0.59	7.78	Open
p31	0.40	0.41	6.73	Open
p32	1.03	1.05	38.87	Open
p33	1.19	0.49	5.54	Open
p43	0.40	0.40	6.64	Open
p47	12.65	0.76	4.17	Open
p48	15.96	0.96	6.42	Open
p49	15.96	0.96	6.42	Open
p50	15.96	0.96	6.42	Open
p51	16.15	0.98	6.56	Open
p52	-28.03	1.08	6.13	Open
p54	-28.03	1.08	6.13	Open
p55	1.79	0.73	11.82	Open
p56	30.05	1.16	6.97	Open
p57	0.39	0.40	6.55	Open
p58	11.88	0.72	3.71	Open
p59	11.66	0.70	3.59	Open
p60	3.24	0.94	15.15	Open
p62	1.43	0.59	7.78	Open
p63	-0.40	0.41	6.73	Open
p68	0.40	0.41	6.73	Open
p69	0.19	0.20	1.76	Open
p74	-3.24	0.94	15.15	Open
p75	1.19	0.49	5.54	Open
p77	29.22	1.13	6.62	Open
p78	29.42	1.14	6.70	Open
p83	-0.23	0.23	2.44	Open
p85	1.19	0.49	5.57	Open
p86	1.19	0.49	5.56	Open
p87	0.80	0.33	2.65	Open
p88	0.80	0.33	2.65	Open
p89	0.80	0.33	2.65	Open
1	31.85	1.23	7.74	Open
3	1.00	1.02	36.74	Open
4	-1.40	0.57	7.44	Open
5	1.87	0.77	12.81	Open

6	0.24	0.25	2.68	Open
7	0.24	0.25	2.65	Open
9	0.60	0.61	14.27	Open
10	0.60	0.61	14.27	Open
11	29.85	1.15	6.88	Open
12	0.20	0.21	1.93	Open
13	29.65	1.14	6.80	Open
14	2.32	0.95	18.99	Open
15	0.24	0.25	2.68	Open

Page 6 prueba

Link Results: (continued)

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
16	2.07	0.85	15.46	Open
17	1.87	0.77	12.81	Open
18	1.87	0.77	12.82	Open
19	1.63	0.67	9.91	Open
20	0.20	0.20	1.87	Open
21	1.43	0.59	7.78	Open
8	0.99	0.41	3.95	Open
22	0.20	0.20	1.87	Open
23	0.99	1.01	36.20	Open
2	31.85	0.00	-35.11	Open Pump

C3 Fire Water

C3.1 EPANET results

Page 1 11/20/2013 5:58:41 PM

```
******************************************************************
*                    E P A N E T                 *
*              Hydraulic and Water Quality             *
*              Analysis for Pipe Networks              *
*                   Version 2.0                  *
******************************************************************

Input File: FW Opt1 Scen1_Diesel depot_315mm.NET
Link - Node Table:
------------------------------------------------------------------
Link      Start     End       Length  Diameter
ID        Node      Node         m       mm
------------------------------------------------------------------
p1        n1        n2         43.17     286
p2        n2        n3         10.07     286
p3        n3        n4         66.94     286
p4        n4        n5         8.101     286
p5        n5        n6         47.19     286
p6        n6        n7          4.54     286
p7        n7        n8         74.08     286
p9        n11       n12        20.51     286
p10       n12       n13          94      286
p11       n13       n14        10.77     286
p12       n14       n15        52.38     286
p17       n20       n21        40.39     286
p18       n21       n22        39.35     286
p23       n28       n29        22.98     286
p24       n29       n30        32.91     286
p25       n30       n31        6.972     286
p30       n40       n41        16.81     286
p31       n42       n43        20.79     286
p32       n43       n44        104.5     286
p33       n14       n45         71.6     286
p34       n45       n44         12.6     286
p36       n48       n49        40.04     286
p37       n49       n50        41.19     286
p39       n23       n51        46.57     286
p42       n55       n56        82.69     286
p43       n56       n47        48.65     286
p44       n47       n53        38.68     286
p45       n53       n11        244.3     286
p46       n11       n42        84.24     286
p47       n42       n40        53.35     286
p48       n40       n57        32.34     286
p49       n57       n58        26.35     286
p50       n58       n59         19.6     286
```

p51	n59	n10	20.2	286
p52	n10	n60	17.66	286
p53	n60	n61	36.63	286
p54	n61	n62	46.23	286

Page 2 prueba

Link - Node Table: (continued)

Link ID	Start Node	End Node	Length m	Diameter mm
p57	n65	n39	77.64	286
p58	n39	n36	32.27	286
p59	n36	n34	51.31	286
p60	n34	n66	66.71	286
p61	n66	n67	161.4	286
p62	n67	n32	84.63	286
p63	n32	n28	93.71	286
p64	n28	n68	43.78	286
p65	n68	n69	595.1	286
p66	n69	n70	136.4	286
p67	n70	n26	91.91	286
p68	n26	n48	234.1	286
p69	n48	n20	46.57	286
p70	n20	n55	335.8	286
p71	n55	n8	440.9	286
p72	n8	n1	9.55	286
p74	n72	n73	3.603	286
p75	n73	n74	20.11	286
p76	n74	n31	20.07	286
p78	n76	n77	425	286
p79	n77	n78	38.35	286
p80	n78	n65	46.33	286
p81	n65	n79	37.04	286
p82	n79	n80	147.9	286
p83	n80	n72	16.62	286
p84	n72	n81	38.73	286
p85	n81	n68	24.16	286
1	1	2	1	286
4	n32	3	41.41	286
6	n29	4	21.61	286
7	n74	5	4.12	286
9	n73	6	4.351	286
11	n81	7	4.349	286
13	n29	8	4.348	286
15	n30	9	4.35	286
17	n39	10	7.911	286
19	n36	11	6.487	286
21	n34	12	6.488	286
23	n76	13	50.6	286
25	n49	14	8.214	286
27	n50	15	8.215	286

29	n21	16	8.214	286
31	n22	17	8.214	286
33	n1	18	6.715	286
35	n2	19	6.715	286
37	n5	20	6.713	286
39	n6	21	6.714	286

Page 3 prueba

Link - Node Table: (continued)

Link ID	Start Node	End Node	Length m	Diameter mm
41	n15	22	11.26	286
43	n13	23	11.25	286
45	n45	24	10.53	286
47	n43	25	11.26	286
49	n12	26	11.26	286
51	n10	27	8.214	286
53	n62	28	30.94	286
55	n53	29	34.83	286
57	n47	30	5.283	286
59	n56	31	12.27	286
61	n26	32	12.09	286
63	n50	33	55.697	286
64	33	n51	6.166	286
65	33	37	8.159	286
66	n22	39	55.697	286
67	39	n23	6.166	286
68	39	40	8.159	286
2	2	n41	#N/A	#N/A Pump

Energy Usage:

Pump	Usage Factor	Avg. Effic.	Kw-hr /m3	Avg. Kw	Peak Kw	Cost /day
2	100.00	75.00	0.55	248.33	248.33	0.00

Demand Charge: 0.00
Total Cost: 0.00

Node Results:

Node ID	Demand LPS	Head m	Pressure m	Quality
n1	0.00	1934.37	157.58	0.00
n2	0.00	1934.37	158.00	0.00
n3	0.00	1934.37	158.23	0.00
n4	0.00	1934.37	159.37	0.00
n5	0.00	1934.37	159.37	0.00

n6	0.00	1934.37	159.37	0.00
n7	0.00	1934.37	159.37	0.00
n8	0.00	1934.37	157.53	0.00
n10	0.00	1939.80	154.57	0.00
n11	0.00	1938.80	157.91	0.00
n12	0.00	1938.82	157.83	0.00
n13	0.00	1938.95	156.21	0.00
n14	0.00	1938.96	156.16	0.00

Page 4 prueba

Node Results: (continued)

Node ID	Demand LPS	Head m	Pressure m	Quality
n15	0.00	1938.96	155.57	0.00
n20	0.00	1930.78	153.02	0.00
n21	0.00	1930.74	153.60	0.00
n22	0.00	1930.71	154.13	0.00
n23	0.00	1930.65	154.90	0.00
n26	0.00	1927.99	151.36	0.00
n28	0.00	1919.02	149.81	0.00
n29	0.00	1919.02	150.24	0.00
n30	0.00	1919.03	150.57	0.00
n31	0.00	1919.04	150.61	0.00
n32	0.00	1918.45	148.19	0.00
n34	0.00	1918.73	152.35	0.00
n36	0.00	1918.77	152.43	0.00
n39	0.00	1918.80	152.46	0.00
n40	0.00	1939.80	156.22	0.00
n41	0.00	1939.98	156.25	0.00
n42	0.00	1939.23	156.79	0.00
n43	0.00	1939.21	156.48	0.00
n44	0.00	1939.07	154.62	0.00
n45	0.00	1939.05	154.91	0.00
n47	0.00	1935.77	154.79	0.00
n48	0.00	1930.49	153.27	0.00
n49	0.00	1930.52	153.94	0.00
n50	0.00	1930.56	154.66	0.00
n51	0.00	1930.61	155.23	0.00
n53	0.00	1936.18	155.05	0.00
n55	0.00	1934.37	155.35	0.00
n56	0.00	1935.25	154.92	0.00
n57	0.00	1939.80	155.69	0.00
n58	0.00	1939.80	154.84	0.00
n59	0.00	1939.80	154.68	0.00
n60	0.00	1939.80	153.94	0.00
n61	0.00	1939.80	153.44	0.00
n62	0.00	1939.80	153.06	0.00
n65	0.00	1918.87	152.92	0.00
n66	0.00	1918.67	152.35	0.00
n67	0.00	1918.52	147.89	0.00

n68	0.00	1919.19	151.02	0.00
n69	0.00	1925.55	151.81	0.00
n70	0.00	1927.01	151.48	0.00
n72	0.00	1919.05	151.58	0.00
n73	0.00	1919.05	151.48	0.00
n74	0.00	1919.04	150.84	0.00
n76	0.00	1918.87	155.91	0.00
n77	0.00	1918.87	154.43	0.00
n78	0.00	1918.87	153.85	0.00
n79	0.00	1918.90	152.56	0.00

Page 5 prueba

Node Results: (continued)

Node ID	Demand LPS	Head m	Pressure m	Quality
n80	0.00	1919.04	151.69	0.00
n81	0.00	1919.13	151.14	0.00
2	0.00	1787.99	4.26	0.00
3	125.00	1918.00	148.37	0.00
4	0.00	1919.02	150.39	0.00
5	0.00	1919.04	150.91	0.00
6	0.00	1919.05	151.46	0.00
7	0.00	1919.13	151.00	0.00
8	0.00	1919.02	150.14	0.00
9	0.00	1919.03	150.40	0.00
10	0.00	1918.80	152.68	0.00
11	0.00	1918.77	152.44	0.00
12	0.00	1918.73	152.48	0.00
13	0.00	1918.87	153.88	0.00
14	0.00	1930.52	153.84	0.00
15	0.00	1930.56	154.48	0.00
16	0.00	1930.74	153.70	0.00
17	0.00	1930.71	154.22	0.00
18	0.00	1934.37	157.73	0.00
19	0.00	1934.37	158.14	0.00
20	0.00	1934.37	159.38	0.00
21	0.00	1934.37	159.31	0.00
22	0.00	1938.96	155.49	0.00
23	0.00	1938.95	156.03	0.00
24	0.00	1939.05	155.05	0.00
25	0.00	1939.21	156.76	0.00
26	0.00	1938.82	157.69	0.00
27	0.00	1939.80	154.26	0.00
28	0.00	1939.80	152.82	0.00
29	0.00	1936.18	155.10	0.00
30	0.00	1935.77	154.83	0.00
31	0.00	1935.25	154.90	0.00
32	0.00	1927.99	151.14	0.00
33	0.00	1930.61	155.19	0.00
37	0.00	1930.61	155.11	0.00

39	0.00	1930.66	154.84	0.00	
40	0.00	1930.66	155.02	0.00	
1	-125.01	1788.00	0.00	0.00	Reservoir

Page 6 prueba

Link Results:

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
p1	0.19	0.00	0.00	Open
p2	0.19	0.00	0.00	Open
p3	0.19	0.00	0.00	Open
p4	0.19	0.00	0.00	Open
p5	0.19	0.00	0.00	Open
p6	0.19	0.00	0.00	Open
p7	0.19	0.00	0.00	Open
p9	-40.24	0.63	1.31	Open
p10	-40.24	0.63	1.31	Open
p11	-40.24	0.63	1.30	Open
p12	0.00	0.00	0.00	Open
p17	32.18	0.50	0.87	Open
p18	32.18	0.50	0.87	Open
p23	-19.57	0.30	0.35	Open
p24	-19.57	0.30	0.34	Open
p25	-19.58	0.30	0.34	Open
p30	-125.01	1.95	10.70	Open
p31	40.24	0.63	1.31	Open
p32	40.24	0.63	1.31	Open
p33	-40.24	0.63	1.31	Open
p34	-40.24	0.63	1.31	Open
p36	-32.18	0.50	0.87	Open
p37	-32.18	0.50	0.86	Open
p39	32.18	0.50	0.87	Open
p42	-125.01	1.95	10.69	Open
p43	-125.01	1.95	10.69	Open
p44	-125.01	1.95	10.69	Open
p45	-125.01	1.95	10.69	Open
p46	-84.77	1.32	5.20	Open
p47	-125.01	1.95	10.69	Open
p48	0.00	0.00	0.00	Open
p49	0.00	0.00	0.00	Open
p50	0.00	0.00	0.00	Open
p51	0.00	0.00	0.00	Open
p52	0.00	0.00	0.00	Open
p53	0.00	0.00	0.00	Open
p54	0.00	0.00	0.00	Open
p57	32.82	0.51	0.90	Open
p58	32.82	0.51	0.90	Open
p59	32.82	0.51	0.90	Open
p60	32.82	0.51	0.90	Open
p61	32.82	0.51	0.90	Open
p62	32.82	0.51	0.90	Open

p63	-92.18	1.43	6.08	Open
p64	-72.61	1.13	3.91	Open
p65	-125.00	1.95	10.69	Open
p66	-125.00	1.95	10.69	Open

Page 7 prueba

Link Results: (continued)

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
p67	-125.00	1.95	10.69	Open
p68	-125.00	1.95	10.69	Open
p69	-92.82	1.44	6.16	Open
p70	-125.00	1.95	10.69	Open
p71	0.00	0.00	0.00	Open
p72	0.19	0.00	0.00	Open
p74	19.58	0.30	0.37	Open
p75	19.58	0.30	0.34	Open
p76	19.58	0.30	0.35	Open
p78	0.00	0.00	0.00	Open
p79	0.00	0.00	0.00	Open
p80	0.00	0.00	0.00	Open
p81	-32.82	0.51	0.90	Open
p82	-32.82	0.51	0.90	Open
p83	-32.82	0.51	0.90	Open
p84	-52.39	0.82	2.13	Open
p85	-52.40	0.82	2.14	Open
1	125.01	1.95	10.72	Open
4	125.00	1.95	10.69	Open
6	0.00	0.00	0.00	Open
7	0.00	0.00	0.00	Open
9	0.00	0.00	0.00	Open
11	0.00	0.00	0.00	Open
13	0.00	0.00	0.00	Open
15	0.00	0.00	0.00	Open
17	0.00	0.00	0.00	Open
19	0.00	0.00	0.00	Open
21	0.00	0.00	0.00	Open
23	0.00	0.00	0.00	Open
25	0.00	0.00	0.00	Open
27	0.00	0.00	0.00	Open
29	0.00	0.00	0.00	Open
31	0.00	0.00	0.00	Open
33	0.00	0.00	0.00	Open
35	0.00	0.00	0.00	Open
37	0.00	0.00	0.00	Open
39	0.00	0.00	0.00	Open
41	0.00	0.00	0.00	Open
43	0.00	0.00	0.00	Open
45	0.00	0.00	0.00	Open
47	0.00	0.00	0.00	Open

49	0.00	0.00	0.00	Open
51	0.00	0.00	0.00	Open
53	0.00	0.00	0.00	Open
55	0.00	0.00	0.00	Open
57	0.00	0.00	0.00	Open
59	0.00	0.00	0.00	Open

Page 8 prueba

Link Results: (continued)

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
61	0.00	0.00	0.00	Open
63	-32.18	0.50	0.87	Open
64	-32.18	0.50	0.87	Open
65	0.00	0.00	0.00	Open
66	32.18	0.50	0.87	Open
67	32.18	0.50	0.87	Open
68	0.00	0.00	0.00	Open
2	125.01	0.00	-151.99	Open Pump

C4 Farm Dam Water

C4.1 EPANET results

Page 1 11/20/2013 5:54:55 PM

```
******************************************************************
*                    E P A N E T                    *
*              Hydraulic and Water Quality          *
*              Analysis for Pipe Networks           *
*                   Version 2.0                     *
******************************************************************
```

Input File: FDW_Scen1 - D1 to D3_HB.net

Farm Dam Water
Pumped from
Farm Dam D1
to
PW Dam D3

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
p3	n4	n5	2.765	113.4
p4	n5	n6	117.4	113.4
p5	n6	n7	88.44	113.4
p6	n7	n8	155.4	113.4
p7	n8	n9	594.1	113.4
p8	n9	n10	136.4	113.4
p9	n10	n11	638.4	113.4
p12	n11	n14	69.23	113.4
p13	n14	n15	26.18	113.4
p18	n3	n4	627.4	113.4
p20	n15	n21	7.664	113.4
p21	n14	n22	414.3	113.4
p22	n22	n23	185.3	113.4
p23	n23	n24	22.88	113.4
p25	n3	n27	178.7	113.4
p27	n27	n29	152.6	113.4
p28	n30	n29	1445	113.4
p29	n30	n31	1059	113.4
p30	n31	n32	13.7	113.4
p31	n32	n33	160	113.4
1	1	2	1	113.4
2	2	n33	#N/A	#N/A Pump

Page 2 Farm Dam Water
Energy Usage:

Pump	Usage Factor	Avg. Effic.	Kw-hr /m3	Avg. Kw	Peak Kw	Cost /day
2	100.00	75.00	0.08	1.50	1.50	0.00

Demand Charge: 0.00
Total Cost: 0.00

Node Results:

Node ID	Demand LPS	Head m	Pressure m	Quality
n3	0.00	1798.49	36.38	0.00
n4	0.00	1796.93	32.71	0.00
n5	0.00	1796.92	32.60	0.00
n6	0.00	1796.63	30.28	0.00
n7	0.00	1796.41	29.81	0.00
n8	0.00	1796.02	28.00	0.00
n9	0.00	1794.54	20.72	0.00
n10	0.00	1794.20	18.68	0.00
n11	0.00	1792.61	13.61	0.00
n14	0.00	1792.43	13.46	0.00
n15	0.00	1792.43	13.38	0.00
n21	0.00	1792.43	13.49	0.00
n22	0.00	1791.40	10.40	0.00
n23	0.00	1790.94	7.44	0.00
n24	5.00	1790.88	7.79	0.00
n27	0.00	1798.94	30.41	0.00
n29	0.00	1799.32	31.64	0.00
n30	0.00	1802.92	31.16	0.00
n31	0.00	1805.56	27.04	0.00
n32	0.00	1805.60	27.11	0.00
n33	0.00	1806.00	27.16	0.00
2	0.00	1783.00	4.16	0.00
1	-5.00	1783.00	0.00	0.00 Reservoir

Link Results:

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
p3	5.00	0.50	2.48	Open
p4	5.00	0.50	2.49	Open
p5	5.00	0.50	2.49	Open
p6	5.00	0.50	2.49	Open
p7	5.00	0.50	2.49	Open
p8	5.00	0.50	2.49	Open
p9	5.00	0.50	2.49	Open
p12	5.00	0.50	2.50	Open

Page 3 Farm Dam Water

Link Results: (continued)

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
p13	0.00	0.00	0.00	Open
p18	5.00	0.50	2.49	Open
p20	0.00	0.00	0.00	Open
p21	5.00	0.50	2.49	Open
p22	5.00	0.50	2.49	Open
p23	5.00	0.50	2.49	Open
p25	-5.00	0.50	2.49	Open
p27	-5.00	0.50	2.49	Open
p28	5.00	0.50	2.49	Open
p29	-5.00	0.50	2.49	Open
p30	-5.00	0.50	2.49	Open
p31	-5.00	0.50	2.49	Open
1	5.00	0.50	2.38	Open
2	5.00	0.00	-23.00	Open Pump

Page 1 11/20/2013 5:54:42 PM

```
**************************************************************************
*                    E P A N E T                                         *
*                Hydraulic and Water Quality                             *
*                Analysis for Pipe Networks                              *
*                    Version 2.0                                         *
**************************************************************************
```

Input File: FDW_Scen2 - D1 to D5_HB.net

Farm Dam Water
Pumped from
Farm Dam D1
to
RW Dam D5

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
p3	n4	n5	2.765	113.4
p4	n5	n6	117.4	113.4
p5	n6	n7	88.44	113.4
p6	n7	n8	155.4	113.4
p7	n8	n9	594.1	113.4
p8	n9	n10	136.4	113.4
p9	n10	n11	638.4	113.4
p12	n11	n14	69.23	113.4
p13	n14	n15	26.18	113.4
p18	n3	n4	627.4	113.4
p20	n15	n21	7.664	113.4

p21	n14	n22	414.3	113.4
p22	n22	n23	185.3	113.4
p23	n23	n24	22.88	113.4
p25	n3	n27	178.7	113.4
p27	n27	n29	152.6	113.4
p28	n30	n29	1445	113.4
p29	n30	n31	1059	113.4
p30	n31	n32	13.7	113.4
p31	n32	n33	160	113.4
1	1	2	1	113.4
2	2	n33	#N/A	#N/A Pump

Page 2 Farm Dam Water

Energy Usage:

Pump	Usage Factor	Avg. Effic.	Kw-hr /m3	Avg. Kw	Peak Kw	Cost /day
2	100.00	75.00	0.07	1.24	1.24	0.00

Demand Charge: 0.00
Total Cost: 0.00

Node Results:

Node ID	Demand LPS	Head m	Pressure m	Quality
n3	0.00	1794.49	32.38	0.00
n4	0.00	1792.93	28.71	0.00
n5	0.00	1792.92	28.61	0.00
n6	0.00	1792.63	26.28	0.00
n7	0.00	1792.41	25.81	0.00
n8	0.00	1792.02	24.00	0.00
n9	0.00	1790.54	16.72	0.00
n10	0.00	1790.20	14.68	0.00
n11	0.00	1788.61	9.61	0.00
n14	0.00	1788.43	9.46	0.00
n15	0.00	1788.37	9.31	0.00
n21	5.00	1788.35	9.41	0.00
n22	0.00	1788.43	7.43	0.00
n23	0.00	1788.43	4.93	0.00
n24	0.00	1788.43	5.34	0.00
n27	0.00	1794.94	26.41	0.00
n29	0.00	1795.32	27.64	0.00
n30	0.00	1798.92	27.16	0.00
n31	0.00	1801.56	23.04	0.00
n32	0.00	1801.60	23.11	0.00
n33	0.00	1802.00	23.16	0.00
2	0.00	1783.00	4.16	0.00
1	-5.00	1783.00	0.00	0.00 Reservoir

Link Results:

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
p3	5.00	0.50	2.48	Open
p4	5.00	0.50	2.49	Open
p5	5.00	0.50	2.49	Open
p6	5.00	0.50	2.49	Open
p7	5.00	0.50	2.49	Open
p8	5.00	0.50	2.49	Open
p9	5.00	0.50	2.49	Open
p12	5.00	0.50	2.49	Open

Page 3 Farm Dam Water

Link Results: (continued)

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
p13	5.00	0.50	2.50	Open
p18	5.00	0.50	2.49	Open
p20	5.00	0.50	2.49	Open
p21	0.00	0.00	0.00	Open
p22	0.00	0.00	0.00	Open
p23	0.00	0.00	0.00	Open
p25	-5.00	0.50	2.49	Open
p27	-5.00	0.50	2.49	Open
p28	5.00	0.50	2.49	Open
p29	-5.00	0.50	2.49	Open
p30	-5.00	0.50	2.49	Open
p31	-5.00	0.50	2.49	Open
1	5.00	0.50	2.38	Open
2	5.00	0.00	-19.00	Open Pump

Page 1 11/20/2013 5:54:24 PM

```
******************************************************************
*                    E P A N E T                                 *
*                Hydraulic and Water Quality                     *
*                Analysis for Pipe Networks                      *
*                    Version 2.0                                 *
******************************************************************
```

Input File: FDW_Scen3 - D5 to D3_HB.net

Farm Dam Water
Pumped from
RW Dam D5
to
RW Dam D3

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
p3	n4	n5	2.765	113.4
p4	n5	n6	117.4	113.4
p5	n6	n7	88.44	113.4
p6	n7	n8	155.4	113.4
p7	n8	n9	594.1	113.4
p8	n9	n10	136.4	113.4
p9	n10	n11	638.4	113.4
p12	n11	n14	69.23	113.4
p13	n14	n15	481	113.4
p18	n3	n4	627.4	113.4
p20	n15	n21	296	113.4
p21	n14	n22	414.3	113.4
p22	n22	n23	185.3	113.4
p23	n23	n24	22.88	113.4
p25	n3	n27	178.7	113.4
p27	n27	n29	152.6	113.4
p28	n30	n29	1445	113.4
p29	n30	n31	1059	113.4
p30	n31	n32	13.7	113.4
p31	n32	n33	160	113.4
1	1	2	1	113.4
3	3	4	20	55.8
2	2	n33	#N/A	#N/A Pump
4	4	n21	#N/A	#N/A Pump

Page 2 Farm Dam Water

Energy Usage:

Pump	Usage Factor	Avg. Effic.	Kw-hr /m3	Avg. Kw	Peak Kw	Cost /day
2	0.00	0.00	0.00	0.00	0.00	0.00
4	100.00	75.00	0.20	12.64	12.64	0.00

Demand Charge: 0.00
Total Cost: 0.00

Node Results:

Node ID	Demand LPS	Head m	Pressure m	Quality
n3	0.00	1787.65	25.53	0.00
n4	0.00	1788.23	24.01	0.00
n5	0.00	1788.81	24.49	0.00

n6	0.00	1789.39	23.05	0.00
n7	0.00	1789.97	23.38	0.00
n8	0.00	1790.55	22.54	0.00
n9	0.00	1791.13	17.31	0.00
n10	0.00	1791.71	16.20	0.00
n11	0.00	1792.29	13.30	0.00
n14	0.00	1792.87	13.90	0.00
n15	0.00	1799.91	23.45	0.00
n21	5.00	1804.25	24.82	0.00
n22	0.00	1786.81	5.81	0.00
n23	0.00	1784.10	0.60	0.00
n24	13.00	1783.76	0.67	0.00
n27	0.00	1787.07	18.53	0.00
n29	0.00	1786.49	18.81	0.00
n30	0.00	1785.90	14.14	0.00
n31	0.00	1785.32	6.80	0.00
n32	0.00	1784.74	6.25	0.00
n33	0.00	1784.16	5.32	0.00
2	0.00	1783.58	4.74	0.00
4	0.00	1750.51	-16.92	0.00
1	0.00	1783.00	0.00	0.00 Reservoir
3	-18.00	1767.43	0.00	0.00 Reservoir

Page 3 Farm Dam Water

Link Results:

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
p3	0.00	0.00	0.00	Closed
p4	0.00	0.00	0.00	Closed
p5	0.00	0.00	0.00	Closed
p6	0.00	0.00	0.00	Closed
p7	0.00	0.00	0.00	Closed
p8	0.00	0.00	0.00	Closed
p9	0.00	0.00	0.00	Closed
p12	0.00	0.00	0.00	Closed
p13	-13.00	1.29	14.64	Open
p18	0.00	0.00	0.00	Closed
p20	-13.00	1.29	14.64	Open
p21	13.00	1.29	14.64	Open
p22	13.00	1.29	14.64	Open
p23	13.00	1.29	14.64	Open
p25	0.00	0.00	0.00	Closed
p27	0.00	0.00	0.00	Closed
p28	0.00	0.00	0.00	Closed
p29	0.00	0.00	0.00	Closed
p30	0.00	0.00	0.00	Closed
p31	0.00	0.00	0.00	Closed
1	0.00	0.00	0.00	Closed
3	18.00	7.36	845.89	Open
2	0.00	0.00	0.00	Closed Pump

4	18.00	0.00	-53.74	Open Pump

C5 Inpit Stormwater Pipeline

C5.1 EPANET results

Page 1 12/6/2013 12:14:05 PM

```
**************************************************************
*                    E P A N E T                             *
*              Hydraulic and Water Quality                   *
*              Analysis for Pipe Networks                    *
*                   Version 2.0                              *
**************************************************************
```

Input File: INPIT_SW_NGD - 04.12.13.net

Scenario 1
Reservoir/Pump points:

Western Lymph Pit 1 (Inpit Stormwater); Eastern Pit Lymph Pit 2 (Inpit Stormwater) pumped to
SW Dam D2-1/D2-2/D2-3

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
p2	n2	n3	230.9	255.8
p18	n3	n4	627.4	288.3
p25	n3	n27	178.7	255.8
p27	n27	n29	152.6	255.8
p28	n30	n29	1445	255.8
p29	n30	n31	1059	255.8
p30	n31	n32	13.7	255.8
1	1	n32	160	255.8
3	2	n2	38	255.8
9	6	5	1	408.6
10	8	7	1	255.8
8	5	2	#N/A	#N/A Pump
11	7	1	#N/A	#N/A Pump

Energy Usage:

Pump	Usage Factor	Avg. Effic.	Kw-hr /m3	Avg. Kw	Peak Kw	Cost /day
8	100.00	75.00	0.07	20.48	20.48	0.00
11	100.00	75.00	0.09	18.28	18.28	0.00

Demand Charge: 0.00

Total Cost: 0.00

Page 2 Scenario 1

Node Results:

Node ID	Demand LPS	Head m	Pressure m	Quality	
n2	0.00	1795.98	24.01	0.00	
n3	0.00	1794.07	31.96	0.00	
n4	138.80	1786.24	22.02	0.00	
n27	0.00	1794.86	26.33	0.00	
n29	0.00	1795.53	27.85	0.00	
n30	0.00	1801.87	30.10	0.00	
n31	0.00	1806.51	27.98	0.00	
n32	0.00	1806.57	28.08	0.00	
1	0.00	1807.27	28.43	0.00	
2	0.00	1796.30	23.14	0.00	
5	0.00	1777.00	3.84	0.00	
7	0.00	1783.00	4.16	0.00	
6	-81.18	1777.00	0.00	0.00	Reservoir
8	-57.62	1783.00	0.00	0.00	Reservoir

Link Results:

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status	
p2	81.18	1.58	8.28	Open	
p18	138.80	2.13	12.48	Open	
p25	-57.62	1.12	4.39	Open	
p27	-57.62	1.12	4.39	Open	
p28	57.62	1.12	4.39	Open	
p29	-57.62	1.12	4.39	Open	
p30	-57.62	1.12	4.39	Open	
1	57.62	1.12	4.39	Open	
3	81.18	1.58	8.28	Open	
9	81.18	0.62	0.89	Open	
10	57.62	1.12	4.32	Open	
8	81.18	0.00	-19.30	Open	Pump
11	57.62	0.00	-24.28	Open	Pump

Page 1 11/20/2013 5:51:36 PM

```
**************************************************************
*                    E P A N E T                             *
*                Hydraulic and Water Quality                 *
*                Analysis for Pipe Networks                  *
*                    Version 2.0                             *
**************************************************************
```

Input File: DMW_HB - 21.10.13.net

Scenario 2

Reservoir/Pump points:

SW Dam D2-1/D2-2/D2-3
to
RW Dam D5

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
p3	n4	n5	2.765	454.2
p4	n5	n6	117.4	551
p5	n6	n7	88.44	551
p6	n7	n8	155.4	551
p7	n8	n9	594.1	551
p8	n9	n10	136.4	551
p9	n10	n11	638.4	551
p10	n11	n12	114.3	322.4
p11	n12	n13	10.02	322.4
p12	n11	n14	69.23	551
p13	n14	n15	26.18	551
p14	n15	n16	13.59	551
p15	n16	n17	7.576	551
p16	n16	n18	440.9	551
p17	n18	n19	61.91	551
p20	n15	n21	7.664	551
p21	n14	n22	414.3	181.6
p22	n22	n23	185.3	181.6
p23	n23	n24	22.88	181.6
p33	n5	n35	18.84	551
5	3	n35	22.57	551
7	4	n36	1	551

Link - Node Table: (continued)

Link ID	Start Node	End Node	Length m	Diameter mm
2	9	10	1	322.4
12	11	12	1	454.2
6	n36	3	#N/A	#N/A Pump
4	10	n13	#N/A	#N/A Pump
13	12	n4	#N/A	#N/A Pump

Energy Usage:

Pump	Usage Factor	Avg. Effic.	Kw-hr /m3	Avg. Kw	Peak Kw	Cost /day
6	100.00	75.00	0.15	130.83	130.83	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00
13	100.00	75.00	0.15	214.14	214.14	0.00

Demand Charge: 0.00
Total Cost: 0.00

Node Results:

Node ID	Demand LPS	Head m	Pressure m	Quality
n5	0.00	1809.72	45.40	0.00
n6	0.00	1808.68	42.34	0.00
n7	0.00	1807.90	41.31	0.00
n8	0.00	1806.53	38.52	0.00
n9	0.00	1801.30	27.48	0.00
n10	0.00	1800.10	24.58	0.00
n11	0.00	1794.47	15.47	0.00
n12	0.00	1791.35	13.78	0.00
n13	0.00	1788.23	10.73	0.00
n14	0.00	1793.86	14.88	0.00
n15	0.00	1793.64	14.58	0.00
n16	0.00	1793.52	14.46	0.00
n17	0.00	1793.52	14.52	0.00
n18	0.00	1789.78	13.25	0.00
n19	619.00	1789.26	12.12	0.00
n21	0.00	1793.64	14.70	0.00
n22	0.00	1793.25	12.25	0.00

Page 3 Scenario 1

Node Results: (continued)

Node ID	Demand LPS	Head m	Pressure m	Quality	
n23	0.00	1792.97	9.47	0.00	
n24	13.00	1792.94	9.85	0.00	
n35	0.00	1809.75	45.49	0.00	
n36	0.00	1768.00	4.28	0.00	
3	0.00	1809.78	46.07	0.00	
10	0.00	1785.12	7.62	0.00	
12	0.00	1767.99	3.77	0.00	
4	-239.59	1768.00	0.00	0.00	Reservoir
9	0.00	1782.00	0.00	0.00	Reservoir
11	-392.41	1768.00	0.00	0.00	Reservoir

Link Results:

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
p3	392.41	2.42	9.31	Open
p4	632.00	2.65	8.81	Open
p5	632.00	2.65	8.81	Open
p6	632.00	2.65	8.81	Open

p7	632.00	2.65	8.81	Open
p8	632.00	2.65	8.81	Open
p9	632.00	2.65	8.81	Open
p10	0.00	0.00	0.00	Closed
p11	0.00	0.00	0.00	Closed
p12	632.00	2.65	8.81	Open
p13	619.00	2.60	8.48	Open
p14	619.00	2.60	8.48	Open
p15	0.00	0.00	0.00	Closed
p16	619.00	2.60	8.48	Open
p17	619.00	2.60	8.48	Open
p20	0.00	0.00	0.00	Closed
p21	13.00	0.50	1.48	Open
p22	13.00	0.50	1.48	Open

Page 4 Scenario 1

Link Results: (continued)

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
p23	13.00	0.50	1.48	Open
p33	-239.59	1.00	1.46	Open
5	239.59	1.00	1.46	Open
7	239.59	1.00	1.49	Open
2	0.00	0.00	0.00	Closed
12	392.41	2.42	9.38	Open
6	239.59	0.00	-41.78	Open Pump
4	0.00	0.00	0.00	Closed Pump
13	392.41	0.00	-41.75	Open Pump

C6 Raw Water

C6.1 EPANET results

Page 1 11/20/2013 5:56:31 PM
****
* E P A N E T *
* Hydraulic and Water Quality *
* Analysis for Pipe Networks *
* Version 2.0 *
****

Input File: RW_Raw Water_HB.net

Raw Water

Pumping from
SW Dam D2-1/D2-2/D2-3

to

-Dust suppression draw-off point
-Wash bay
-Mobile equipment workshop
-Dust suppression primary crushing
-Diesel depot

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter mm
p1	n1	n2	14.42	145.2
p2	n2	n3	128.1	145.2
p3	n3	n4	14.18	145.2
p4	n3	n5	124.2	55.8
p5	n5	n6	86.58	55.8
p6	n6	n7	56.03	35.4
p7	n7	n8	4.849	35.4
p8	n7	n9	71.84	35.4
p9	n9	n10	4.947	35.4
p10	n6	n11	155.7	55.8
p11	n11	n12	90.14	55.8
p12	n12	n13	34.73	55.8
p13	n11	n14	21.05	55.8
p14	n14	n15	84.39	55.8
1	1	2	1	145.2
2	2	n1	#N/A	#N/A Pump

Energy Usage:

Pump	Usage Factor	Avg. Effic.	Kw-hr /m3	Avg. Kw	Peak Kw	Cost /day
2	100.00	75.00	0.15	18.77	18.77	0.00

Demand Charge: 0.00
Total Cost: 0.00

Node Results:

Node ID	Demand LPS	Head m	Pressure m	Quality	
n1	0.00	1808.89	45.28	0.00	
n2	0.00	1808.50	44.48	0.00	
n3	0.00	1804.96	40.68	0.00	
n4	32.00	1804.63	40.03	0.00	
n5	0.00	1800.91	37.68	0.00	
n6	0.00	1798.09	31.87	0.00	
n7	0.00	1797.72	31.50	0.00	
n8	0.20	1797.71	31.21	0.00	
n9	0.00	1797.58	31.21	0.00	
n10	0.20	1797.57	31.04	0.00	
n11	0.00	1794.17	23.86	0.00	
n12	0.00	1794.17	23.80	0.00	
n13	0.00	1794.17	24.54	0.00	
n14	0.00	1793.64	23.19	0.00	
n15	2.70	1791.51	20.93	0.00	
2	0.00	1767.97	4.36	0.00	
1	-35.10	1768.00	0.00	0.00	Reservoir

Link Results:

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
p1	35.10	2.12	27.63	Open
p2	35.10	2.12	27.63	Open
p3	32.00	1.93	23.28	Open
p4	3.10	1.27	32.55	Open
p5	3.10	1.27	32.56	Open
p6	0.40	0.41	6.73	Open
p7	0.20	0.20	1.87	Open
p8	0.20	0.20	1.87	Open
p9	0.20	0.20	1.87	Open
p10	2.70	1.10	25.21	Open
p11	0.00	0.00	0.00	Open
p12	0.00	0.00	0.00	Open
p13	2.70	1.10	25.21	Open
p14	2.70	1.10	25.20	Open

Page 3 Raw Water

Link Results: (continued)

Link ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
1	35.10	2.12	27.68	Open
2	35.10	0.00	-40.92	Open Pump

C7 Selected Pump Specifications

Appendix D

Sewer Network

D1 Hydraulic Results

HYDRAULIC RESULTS FOR : O:\in_projects\projects\22474800_00 belfast mine\drawings\arup\technocad\pipemate\belfast sewer --- 20-07-2012
Job Description : Belfast Sewer Network Layout 2

Design Parameters
==========
Ground level data source : SurfMate TIN Surface = PLANT_CONTOURS
Pipe Schedule File : C:\Technocad\PipeMate2012\PVC-Class 51 Solid normal duty.Sch
Manning Coefficient : 0.0120
Minimum Nominal Diameter : 110mm uPVC Class 51
Minimum Internal Diameter : 108 mm
Starting Grade : 1: 80
Minimum Cover : 800 mm
Design Pipe Full fraction : 0.80 x Diameter for calculation of Qmax and Vmax.
Minimum Manhole Drop : 0.000 m
Lower velocity flag : 0.70 m/s
Upper velocity flag : 2.50 m/s

Sewage Hydraulic Parameters Used:
==========
Inflows have been specified in l/s
Constant peak factor : 1.000
Infiltration by pipelength : 2.700 l/s/km

Pipe No	U/S MH	D/S MH	Grade 1:	Length (m)	ID (mm)	Peak factor	Qdes (l/s)	Vdes (m/s)	Qmax (l/s)	Vmax (m/s)	Cap. %
BRANCH No1											
1	"MH1"	"MH2"	80.0	14.55	108	1.000	0.05	0.2*	7.51	0.96	0.7
2	"MH2"	"MH3"	72.8	72.32	108	1.000	1.71	0.7*	7.87	1.00	21.8
3	"MH3"	"MH4"	77.7	80.00	108	1.000	1.93	0.7	7.62	0.97	25.3
4	"MH4"	"MH5"	120.0	80.00	108	1.000	2.15	0.6*	6.13	0.78	35.0
5	"MH5"	"MH6"	120.0	80.00	108	1.000	2.36	0.6*	6.13	0.78	38.5
6	"MH6"	"MH7"	120.0	80.00	108	1.000	2.58	0.7*	6.13	0.78	42.1
7	"MH7"	"MH8"	120.0	80.00	108	1.000	2.79	0.7*	6.13	0.78	45.6
8	"MH8"	"MH9"	120.0	39.83	108	1.000	2.90	0.7*	6.13	0.78	47.3
9	"MH9"	"MH10"	120.0	40.17	108	1.000	3.59	0.7	6.13	0.78	58.5
10	"MH10"	"MH11"	120.0	80.00	108	1.000	3.80	0.7	6.13	0.78	62.0
11	"MH11"	"MH12"	89.8	41.13	154	1.000	16.58	1.1	18.26	1.14	90.8
BRANCH No2											
12	"MH13"	"MH14"	80.0	27.35	108	1.000	5.82	0.9	7.51	0.96	77.6
13	"MH14"	"MH15"	63.1	48.49	108	1.000	5.95	1.0	8.45	1.08	70.4
14	"MH15"	"MH16"	102.7	52.70	108	1.000	6.50	0.8	6.63	0.84	98.1
15	"MH16"	"MH17"	120.0	59.92	154	1.000	6.66	0.8	15.79	0.99	42.2

16	"MH17"	"MH18"	200.1	20.46	154	1.000	7.98	0.7	12.23	0.77	65.2
17	"MH18"	"MH19"	179.3	80.00	154	1.000	8.19	0.7	12.92	0.81	63.4
18	"MH19"	"MH20"	100.3	25.67	154	1.000	8.26	0.9	17.28	1.08	47.8
19	"MH20"	"MH21"	153.0	54.33	154	1.000	8.51	0.8	13.99	0.88	60.8
20	"MH21"	"MH22"	200.1	20.45	154	1.000	8.56	0.7	12.23	0.77	70.0
21	"MH22"	"MH11"	145.0	86.95	154	1.000	12.66	0.9	14.37	0.90	88.2

BRANCH No3

22	"MH23"	"MH24"	80.0	24.33	108	1.000	0.10	0.3*	7.51	0.96	1.3
23	"MH24"	"MH25"	120.0	54.57	108	1.000	0.24	0.3*	6.13	0.78	4.0
24	"MH25"	"MH26"	78.9	62.13	108	1.000	0.41	0.4*	7.56	0.96	5.4
25	"MH26"	"MH27"	56.4	43.24	108	1.000	0.94	0.6*	8.95	1.14	10.5
26	"MH27"	"MH28"	46.7	21.09	108	1.000	1.00	0.7	9.83	1.25	10.2
27	"MH28"	"MH29"	99.4	62.45	108	1.000	1.38	0.6*	6.74	0.86	20.5
28	"MH29"	"MH2"	50.9	33.16	108	1.000	1.47	0.8	9.42	1.20	15.6

BRANCH No4

29	"MH30"	"MH26"	80.0	42.06	108	1.000	0.41	0.4*	7.51	0.96	5.5

BRANCH No5

30	"MH31"	"MH28"	80.0	49.67	108	1.000	0.21	0.4*	7.51	0.96	2.9

BRANCH No6

31	"MH32"	"MH33"	80.0	36.37	108	1.000	0.13	0.3*	7.51	0.96	1.7
32	"MH33"	"MH34"	111.5	37.06	108	1.000	0.23	0.3*	6.36	0.81	3.6
33	"MH34"	"MH35"	30.8	80.00	108	1.000	0.44	0.6*	12.10	1.54	3.7
34	"MH35"	"MH9"	27.2	48.83	108	1.000	0.58	0.7	12.89	1.64	4.5

BRANCH No7

35	"MH36"	"MH37"	70.5	84.30	108	1.000	0.31	0.4*	8.00	1.02	3.8
36	"MH37"	"MH38"	66.0	44.26	108	1.000	0.43	0.5*	8.27	1.05	5.2
37	"MH38"	"MH39"	45.7	27.99	108	1.000	0.50	0.6*	9.93	1.26	5.1
38	"MH39"	"MH40"	87.6	60.24	108	1.000	0.67	0.5*	7.18	0.91	9.3
39	"MH40"	"MH41"	120.0	36.70	108	1.000	0.81	0.5*	6.13	0.78	13.2
40	"MH41"	"MH42"	120.0	68.77	108	1.000	0.99	0.5*	6.13	0.78	16.2
41	"MH42"	"MH43"	120.0	25.21	108	1.000	1.06	0.5*	6.13	0.78	17.3
42	"MH43"	"MH44"	120.0	61.40	108	1.000	1.23	0.5*	6.13	0.78	20.0
43	"MH44"	"MH45"	120.0	80.00	108	1.000	1.44	0.6*	6.13	0.78	23.5
44	"MH45"	"MH46"	120.0	74.26	108	1.000	1.64	0.6*	6.13	0.78	26.8
45	"MH46"	"MH47"	100.5	80.00	108	1.000	1.86	0.6*	6.70	0.85	27.8
46	"MH47"	"MH48"	120.0	12.52	108	1.000	1.92	0.6*	6.13	0.78	31.4
47	"MH48"	"MH49"	109.2	79.92	108	1.000	2.18	0.6*	6.43	0.82	33.9
48	"MH49"	"MH50"	71.2	80.00	108	1.000	2.40	0.8	7.96	1.01	30.1
49	"MH50"	"MH51"	120.0	47.71	108	1.000	2.52	0.6*	6.13	0.78	41.2
50	"MH51"	"MH52"	120.0	80.00	108	1.000	2.74	0.7*	6.13	0.78	44.7
51	"MH52"	"MH53"	120.0	77.47	108	1.000	2.95	0.7*	6.13	0.78	48.1
52	"MH53"	"MH54"	50.8	80.00	108	1.000	3.17	0.9	9.42	1.20	33.6
53	"MH54"	"MH55"	49.1	80.00	108	1.000	3.38	1.0	9.58	1.22	35.3
54	"MH55"	"MH56"	43.6	23.43	108	1.000	3.44	1.0	10.17	1.29	33.9
55	"MH56"	"MH22"	30.8	97.71	108	1.000	3.87	1.2	12.11	1.54	31.9

BRANCH No8

56	"MH57"	"MH20"	30.6	35.64	108	1.000	0.10	0.4*	12.14	1.54	0.8

BRANCH No9

57	"MH58"	"MH59"	80.0	68.13	108	1.000	0.69	0.5*	7.51	0.96	9.2
58	"MH59"	"MH60"	120.0	28.63	108	1.000	0.77	0.5*	6.13	0.78	12.6
59	"MH60"	"MH61"	120.0	14.49	108	1.000	0.81	0.5*	6.13	0.78	13.2
60	"MH61"	"MH62"	69.1	25.79	108	1.000	1.10	0.6*	8.08	1.03	13.6
61	"MH62"	"MH17"	59.1	59.85	108	1.000	1.26	0.7*	8.74	1.11	14.4

BRANCH No10

62	"MH63"	"MH15"	80.0	15.67	108	1.000	0.11	0.3*	7.51	0.96	1.5

BRANCH No11

63	"MH64"	"MH40"	60.2	8.56	108	1.000	0.04	0.2*	8.65	1.10	0.5

Appendix E

Architectural – Finishing Schedule

E1 Supply Chain Management Store

1.	**OUTSIDE**	
	WALLS	- IBR Roofsheeting with chromodec finish
		- Facebrick plinth (Rosa Verona Corobrick)
		- Facebrick walls at offices
		- See elevations for type op bricks A – Country Classic B – Protea Travertine
	WINDOW	- Wispeco steelframe windows with galvanized finish. Glazing as per SABS regulations
	ROOF	- IBR Roofsheeting with chromodec finish
		- Aluminium powdercoated gutters & downpipes (size as per drawings)
	APRIN	- 1000m wide paving apron. 100x200x50mm concrete paving bricks on 25 micron usb green on compation as per engineer.
2.	**INSIDE**	
	Office Block **Offices / Conference Room / Tea Room / Passages**	
	FLOOR	- 30 mm Screed on 100mm surfacebed
		- Allow R110/m2 for 300x300 ceramic floortiles
	SKIRTING	- 100 mm floor tile strip against wall
		- All outside walls to have 3 panel PVC powerskirting
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- 50 x 50 mm Shadow line
	CEILING	- 1200x600 suspended ceiling grid with vinyl cladded panels
		-
	Store Rooms	
	FLOOR	- 30 mm Screed with grano finish
		-
	SKIRTING	- No
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints

		- Paint with primer & two coats PVA
	Toilets & Kitchen	
	FLOOR	- 30 mm Screed on 100mm surface bed. - Allow R110/m2 for floor tiles
	SKIRTING	- No
	WALLS	- 12 mm Plaster with wood floated finish
		- Allow R80/m2 for ceramic wall tiles floor to ceiling
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA
	SANITARY FITTINGS	- WC – Vaal Hibiscus close couple toilet suite - Code: 772654
		- Basin – Vaal Concorde slimline freestanding basin with pedestal
		- Urinal – Vaal Trento urinal with sensor movement mechanism
		- Basin Tap - Cobra basin mixer (chrome) Carina - Code: 293CA
		- Kitchen Zink – Franci Single stella Zink - Code: 3396ST
		- Zink Mixer – Cobra sink mixer (chrome) - Code:
	KITCHEN CUPBOARDS	- Allow R15000 for Cupboards - Allow R3500 for freestanding stove.
	General	
	DOORS	- 1.2mm Steel door frames
		- Semi solid doors
		- Paint frames with primer & two coats Velvaglo
		- Paint doors with primer & two coats Velvaglo
		- Allow R500/door for ironmongery
	GEYSERS	- Heat Pumps
3.	**MAIN AREA**	
	FLOOR	- 150mm Power floated surface bed with hardener. See engineer's specification.
		- Expansion joints with jointex as per engineers specifications
	SKIRTING	- No
	WALLS	- Facebrick plinth (Rosa Verona Corobrick)
		- IBR cladding with chromadek finish
		- Steelstructure framework with galvanized finish

	ROOF	- IBR Roofsheeting
		-
		- Steeltrusses with galvanished finish
	ROLLUP DOORS	- See drawings for size of rollup doors, manual operated Serranda dipped galvanized doors
	FIREDOORS	- 1.2mm steelframe
		- Paint with primer & 2 coats Velvaglo
		- Tong and Groove Meranti door
		- Paint with primer & two coats Velvaglo.
		- Allow R500/door for ironmongary
4.	**GENERAL**	
		- Whirly roof extractors as per roof plan
		- Floor outlets as per drawings
		- Fire hose reels as per drawings
		- Fire signage as per regulations

E2 Security Building at Office

1.	**OUTSIDE**	
	WALLS	- Facebrick walls
		- See elevations for type op bricks A – Country Classic B – Protea Travertine
		- See elevations for plastered areas to be painted with primer & two coats Wall & All
	WINDOW	- Wispeco steelfram windows with galvanized finish. Glazing as per SABS regulations
	ROOF	- IBR Roofsheeting with chromodec finish
		- Aluminium powdercoated gutters & downpipes (size as per drawings)
	APR0N	- 1000m wide paving apron. 100x200x50mm concrete pavingbricks on 25 micron usb green on compation as per engineer.
2.	**INSIDE**	
	Office Block **Offices / Reception Area / Waiting Area / Lecture Rooms**	
	FLOOR	- 30 mm Screed on 100mm surfacebed
		- Allow R110/m2 for 300x300 ceramic floortiles
	SKIRTING	- 100 mm floor tile strip against wall
		- See drawings for 3 panel PVC powerskirting
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- 50 x 50 mm Shadow line
	CEILING	- 1200x600 suspended ceiling grid with vinyl cladded panels
		-
	Store Rooms	
	FLOOR	- 30 mm Screed with grano finish
		-
	SKIRTING	- No
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA

	Toilets & Kitchen	
	FLOOR	- 30 mm Screed on 100mm surface bed.
	SKIRTING	- No
	WALLS	- 12 mm Plaster with wood floated finish
		- Allow R80/m2 for ceramic wall tiles floor to ceiling
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA
	SANITARY FITTINGS	- WC – Vaal Hibiscus close couple toilet suite - Code: 772654
		- Basin – Vaal Concorde slimline freestanding basin with pedestal
		- Urinal – Vaal Trento urinal with sensor movement mechanism
		- Basin Tap - Cobra basin mixer (chrome) Carina - Code: 293CA
		- Kitchen Zink – Franci Single stella Zink - Code: 3396ST
		- Zink Mixer – Cobra sink mixer (chrome) - Code:
	KITCHEN CUPBOARDS	- Allow R15000 for Cupboards - Allow R3500 for freestanding stove.
	General	
	DOORS	- 1.2mm Steel door frames
		- Semi solid doors
		- Paint frames with primer & two coats Velvaglo
		- Paint doors with primer & two coats Velvaglo
		- Allow R500/door for ironmongery
	GEYSERS	- Heat Pumps

E3 Change House

1.	**OUTSIDE**	
	WALLS	- Plaster panels as per elevation to be painted with pimer & two coats Wall & All
		- Facebrick walls
		- See elevations for type op bricks A – Country Classic B – Protea Travertine
	WINDOW	- Wispeco steelframe windows with galvanized finish. Glazing as per SABS regulations
	ROOF	- IBR Roofsheeting with chromodec finish
		- Aluminium powdercoated gutters & downpipes (size as per drawings)
	APRIN	- 1000m wide paving aprin. 100x200x50mm concrete pavingbricks on 25 micron usb green on compation as per engineer.
2.	**INSIDE**	
	Store Rooms & Heat Pump Room	
	FLOOR	- 30 mm Screed with grano finish
		-
	SKIRTING	- No
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA
	Toilets & Laundry	
	FLOOR	- 30 mm Screed on 100mm surface bed. - Allow R110/m2 for floor tiles
	SKIRTING	- No
	WALLS	- 12 mm Plaster with wood floated finish
		- Allow R80/m2 for ceramic wall tiles floor to ceiling
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats Enamel
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats Enamel

	SANITARY FITTINGS	- WC – Vaal Hibiscus close couple toilet suite - Code: 772654
		- Basin – Vaal Concorde slimline freestanding basin with pedestal
		- Urinal – Vaal Trento urinal with sensor movement mechanism
		- Basin Tap - Cobra basin mixer (chrome) Carina - Code: 293CA
		- Shower Mixer - Code:
		- Cobra shower mixer - Code:
3.	**GENERAL**	
	DOORS	- 1.2mm Steel door frames
		- Semi solid doors
		- Paint frames with primer & two coats Velvaglo
		- Paint doors with primer & two coats Velvaglo
		- Allow R500/door for ironmongery
		- Heat pump room door to be provided with 300x600 aluminium louver
	GEYSERS	- Heat pump by engineer
	WINDOWS	- Wispeco steel window frames galvanized finish. Glazing SABS

E4 Main Office Building

1.	**OUTSIDE**	
	WALLS	- IBR Roofsheeting with chromodec finish
		- Facebrick plinth (Rosa Verona Corobrick)
		- Facebrick walls at offices
		- See elevations for type op bricks A – Country Classic B – Protea Travertine
	WINDOW	- Wispeco steelframe windows with galvanized finish. Glazing as per SABS regulations
	ROOF	- IBR Roofsheeting with chromodec finish
		- Aluminium powdercoated gutters & downpipes (size as per drawings)
	APRIN	- 1000m wide paving aprin. 100x200x50mm concrete pavingbricks on 25 micron usb green on compation as per engineer.
2.	**INSIDE**	
	Office Block **Offices / Conference Room / Tea Room / Passages**	
	FLOOR	- 30 mm Screed on 100mm surfacebed
		- Allow R110/m2 for 300x300 ceramic floortiles
	SKIRTING	- 100 mm floor tile strip against wall
		- All outside walls to have 3 panel PVC powerskirting
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- 50 x 50 mm Shadow line
	CEILING	- 1200x600 suspended ceiling grid with vinyl cladded panels
		-
	Store Rooms	
	FLOOR	- 30 mm Screed with grano finish
		-
	SKIRTING	- No
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA

	Toilets & Kitchen	
	FLOOR	- 30 mm Screed on 100mm surface bed. - Allow R110/m2 for floor tiles
	SKIRTING	- No
	WALLS	- 12 mm Plaster with wood floated finish
		- Allow R80/m2 for ceramic wall tiles floor to ceiling
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA
	SANITARY FITTINGS	- WC – Vaal Hibiscus close couple toilet suite - Code: 772654
		- Basin – Vaal Concorde slimline freestanding basin with pedestal
		- Urinal – Vaal Trento urinal with sensor movement mechanism
		- Basin Tap - Cobra basin mixer (chrome) Carina - Code: 293CA
		- Kitchen Zink – Franci Single stella Zink - Code: 3396ST
		- Zink Mixer – Cobra sink mixer (chrome) - Code:
	KITCHEN CUPBOARDS	- Allow R15000 for Cupboards - Allow R3500 for freestanding stove.
	General	
	DOORS	- 1.2mm Steel door frames
		- Semi solid doors
		- Paint frames with primer & two coats Velvaglo
		- Paint doors with primer & two coats Velvaglo
		- Allow R500/door for ironmongery
	GEYSERS	- Heat Pump
3.	**MAIN AREA**	
	FLOOR	- 150mm Power floated surface bed with hardener. See engineer's specification.
		- Expansion joints with jointex as per engineers specifications
	SKIRTING	- No
	WALLS	- Facebrick plinth (Rosa Verona Corobrick)
		- IBR cladding with chromadek finish
		- Steelstructure framework with galvanized finish
	ROOF	- IBR Roofsheeting

		-
		- Steeltrusses with galvanished finish
	ROLLUP DOORS	- See drawings for size of rollup doors, manual operated Serranda dipped galvanized doors
	FIREDOORS	- 1.2mm steelframe
		- Paint with primer & 2 coats Velvaglo
		- Tong and Groove Meranti door
		- Paint with primer & two coats Velvaglo.
		- Allow R500/door for ironmongary
4.	**GENERAL**	
		- Whirly roof extractors as per roof plan
		- Floor outlets as per drawings
		- Fire hose reels as per drawings
		- Fire signage as per regulations

E5 Canteen

E6 Plant Workshop and Offices

1.	**OUTSIDE**	
	WALLS	- IBR Roofsheeting with chromodec finish
		- Facebrick plinth (Rosa Verona Corobrick)
		- Facebrick walls at offices
		- See elevations for type op bricks A – Country Classic B – Protea Travertine
	WINDOW	- Wispeco steelframe windows with galvanized finish. Glazing as per SABS regulations
	ROOF	- IBR Roofsheeting with chromodec finish
		- Aluminium powdercoated gutters & downpipes (size as per drawings)
	APRIN	- 1000m wide paving aprin. 100x200x50mm concrete pavingbricks on 25 micron usb green on compation as per engineer.
2.	**INSIDE**	
	Office Block **Offices / Conference Room / Tea Room / Passages**	
	FLOOR	- 30 mm Screed on 100mm surfacebed
		- Allow R110/m2 for 300x300 ceramic floortiles
	SKIRTING	- 100 mm floor tile strip against wall
		- All outside walls to have 3 panel PVC powerskirting
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- 50 x 50 mm Shadow line
	CEILING	- 1200x600 suspended ceiling grid with vinyl cladded panels
		-
	Store Rooms	
	FLOOR	- 30 mm Screed with grano finish
		-
	SKIRTING	- No
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA

	Toilets & Kitchen	
	FLOOR	- 30 mm Screed on 100mm surface bed. - Allow R110/m2 for floor tiles
	SKIRTING	- No
	WALLS	- 12 mm Plaster with wood floated finish
		- Allow R80/m2 for ceramic wall tiles floor to ceiling
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA
	SANITARY FITTINGS	- WC – Vaal Hibiscus close couple toilet suite - Code: 772654
		- Basin – Vaal Concorde slimline freestanding basin with pedestal
		- Urinal – Vaal Trento urinal with sensor movement mechanism
		- Basin Tap - Cobra basin mixer (chrome) Carina - Code: 293CA
		- Kitchen Zink – Franci Single stella Zink - Code: 3396ST
		- Zink Mixer – Cobra sink mixer (chrome) - Code:
	KITCHEN CUPBOARDS	- Allow R15000 for Cupboards - Allow R3500 for freestanding stove.
	General	
	DOORS	- 1.2mm Steel door frames
		- Semi solid doors
		- Paint frames with primer & two coats Velvaglo
		- Paint doors with primer & two coats Velvaglo
		- Allow R500/door for ironmongery
	GEYSERS	- 150L Kwiket geyser
3.	**MAIN AREA**	
	FLOOR	- 150mm Power floated surface bed with hardener. See engineer's specification.
		- Expansion joints with jointex as per engineers specifications
	SKIRTING	- No
	WALLS	- Facebrick plinth (Rosa Verona Corobrick)
		- IBR cladding with chromadek finish
		- Steelstructure framework with galvanized finish
	ROOF	- IBR Roofsheeting

		-
		- Steeltrusses with galvanished finish
	ROLLUP DOORS	- See drawings for size of rollup doors, manual operated Serranda dipped galvanized doors
	FIREDOORS	- 1.2mm steelframe
		- Paint with primer & 2 coats Velvaglo
		- Tong and Groove Meranti door
		- Paint with primer & two coats Velvaglo.
		- Allow R500/door for ironmongary
4.	**GENERAL**	
		- Whirly roof extractors as per roof plan
		- Floor outlets as per drawings
		- Fire hose reels as per drawings
		- Fire signage as per regulations

E7 Motor Control Centre and Master Control Room

1.	**OUTSIDE**	
	WALLS	- See elevations for plastered areas to be painted with primer & two coats Wall & All
		- Facebrick walls at offices
		- See elevations for type op bricks A – Country Classic B – Protea Travertine
	WINDOW	- Wispeco steelframe windows with galvanized finish. Glazing as per SABS regulations
	ROOF	- IBR Roofsheeting with chromodec finish
		- Aluminium powdercoated gutters & downpipes (size as per drawings)
	APRIN	- 1000m wide paving aprin. 100x200x50mm concrete pavingbricks on 25 micron usb green on compation as per engineer.
2.	**INSIDE**	
	Office Block **Offices / Conference Room / Tea Room / Passages**	
	FLOOR	- 30 mm Screed on 100mm surfacebed
		- Allow R110/m2 for 300x300 ceramic floortiles
	SKIRTING	- 100 mm floor tile strip against wall
		- All outside walls to have 3 panel PVC powerskirting
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- 50 x 50 mm Shadow line
	CEILING	- 1200x600 suspended ceiling grid with vinyl cladded panels
		-
	Store Rooms	
	FLOOR	- 30 mm Screed with grano finish
		-
	SKIRTING	- No
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA

	Toilets & Kitchen	
	FLOOR	- 30 mm Screed on 100mm surface bed. - Allow R110/m2 for floor tiles
	SKIRTING	- No
	WALLS	- 12 mm Plaster with wood floated finish
		- Allow R80/m2 for ceramic wall tiles floor to ceiling
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA
	SANITARY FITTINGS	- WC – Vaal Hibiscus close couple toilet suite - Code: 772654
		- Basin – Vaal Concorde slimline freestanding basin with pedestal
		- Urinal – Vaal Trento urinal with sensor movement mechanism
		- Basin Tap - Cobra basin mixer (chrome) Carina - Code: 293CA
		- Kitchen Zink – Franci Single stella Zink - Code: 3396ST
		- Zink Mixer – Cobra sink mixer (chrome) - Code:
	KITCHEN CUPBOARDS	- Allow R15000 for Cupboards - Allow R3500 for freestanding stove.
	General	
	DOORS	- 1.2mm Steel door frames
		- Semi solid doors
		- Paint frames with primer & two coats Velvaglo
		- Paint doors with primer & two coats Velvaglo
		- Allow R500/door for ironmongery
	GEYSERS	- 150L Kwiket geyser
	OPEN PATIO	- Derbigum torch on waterproofing on 30mm screed with fall to outlets
		- Allow R80/m2 for floortiles
		- See drawings for galvanized balustrades
3.	**GROUND FLOOR**	
	FLOOR	- 150mm Power floated surface bed with hardener. See engineer's specification.
		- Expansion joints with jointex as per engineers specifications
	SKIRTING	- No
	WALLS	- 12mm plaster with wood floated finish

		- Painted with primer 7 two coats Double Velvet
	ROOF	- Exposed concrete slab with no paint
		-
	DOORS	- Steel frame painted with primer & two coats Velvaglo
		- Tong & grouve Meranti doors painted with primer & two coats Velvaglo
		- Steel gates with galvanized finish
		- Steel frame & door painted with primer & two coats Velvaglo
4.	**GENERAL**	
	RAMPS	- Concrete surface with wood floated finish
		- Balustrades as per drawings – galvanized finish

E8 Laboratory

1.	**OUTSIDE**	
	WALLS	- IBR Roofsheeting with chromodec finish
		- Facebrick plinth (Rosa Verona Corobrick)
		- Facebrick walls at offices
		- See elevations for type op bricks A – Country Classic B – Protea Travertine
	WINDOW	- Wispeco steelframe windows with galvanized finish. Glazing as per SABS regulations
	ROOF	- IBR Roofsheeting with chromodec finish
		- Aluminium powdercoated gutters & downpipes (size as per drawings)
	APRIN	- 1000m wide paving aprin. 100x200x50mm concrete pavingbricks on 25 micron usb green on compation as per engineer.
2.	**INSIDE**	
	Office Block **Offices / Conference Room / Tea Room / Passages**	
	FLOOR	- 30 mm Screed on 100mm surfacebed
		- Allow R110/m2 for 300x300 ceramic floortiles
	SKIRTING	- 100 mm floor tile strip against wall
		- All outside walls to have 3 panel PVC powerskirting
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- 50 x 50 mm Shadow line
	CEILING	- 1200x600 suspended ceiling grid with vinyl cladded panels
		-
	Store Rooms	
	FLOOR	- 30 mm Screed with grano finish
		-
	SKIRTING	- No
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA

	Toilets & Kitchen	
	FLOOR	- 30 mm Screed on 100mm surface bed. - Allow R110/m2 for floor tiles
	SKIRTING	- No
	WALLS	- 12 mm Plaster with wood floated finish
		- Allow R80/m2 for ceramic wall tiles floor to ceiling
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA
	SANITARY FITTINGS	- WC – Vaal Hibiscus close couple toilet suite - Code: 772654
		- Basin – Vaal Concorde slimline freestanding basin with pedestal
		- Urinal – Vaal Trento urinal with sensor movement mechanism
		- Basin Tap - Cobra basin mixer (chrome) Carina - Code: 293CA
		- Kitchen Zink – Franci Single stella Zink - Code: 3396ST
		- Zink Mixer – Cobra sink mixer (chrome) - Code:
	KITCHEN CUPBOARDS	- Allow R15000 for Cupboards - Allow R3500 for freestanding stove.
	General	
	DOORS	- 1.2mm Steel door frames
		- Semi solid doors
		- Paint frames with primer & two coats Velvaglo
		- Paint doors with primer & two coats Velvaglo
		- Allow R500/door for ironmongery
	GEYSERS	- 150L Kwiket geyser
3.	**MAIN AREA**	
	FLOOR	- 150mm Power floated surface bed with hardener. See engineer's specification.
		- Expansion joints with jointex as per engineers specifications
	SKIRTING	- No
	WALLS	- Facebrick plinth (Rosa Verona Corobrick)
		- IBR cladding with chromadek finish
		- Steelstructure framework with galvanized finish
	ROOF	- IBR Roofsheeting

		-
		- Steeltrusses with galvanished finish
	ROLLUP DOORS	- See drawings for size of rollup doors, manual operated Serranda dipped galvanized doors
	FIREDOORS	- 1.2mm steelframe
		- Paint with primer & 2 coats Velvaglo
		- Tong and Groove Meranti door
		- Paint with primer & two coats Velvaglo.
		- Allow R500/door for ironmongary
4.	**GENERAL**	
		- Whirly roof extractors as per roof plan
		- Floor outlets as per drawings
		- Fire hose reels as per drawings
		- Fire signage as per regulations

E9 Mobile Equipment Workshop

1.	**OUTSIDE**	
	WALLS	- IBR Roofsheeting with chromodec finish
		- Facebrick plinth (Rosa Verona Corobrick)
		- Facebrick walls at offices
		- See elevations for type op bricks A – Country Classic B – Protea Travertine
	WINDOW	- Wispeco steelframe windows with galvanized finish. Glazing as per SABS regulations
	ROOF	- IBR Roofsheeting with chromodec finish
		- Aluminium powdercoated gutters & downpipes (size as per drawings)
	APRIN	- 1000m wide paving aprin. 100x200x50mm concrete pavingbricks on 25 micron usb green on compation as per engineer.
2.	**INSIDE**	
	Office Block **Offices / Conference Room / Tea Room / Passages**	
	FLOOR	- 30 mm Screed on 100mm surfacebed
		- Allow R110/m2 for 300x300 ceramic floortiles
	SKIRTING	- 100 mm floor tile strip against wall
		- All outside walls to have 3 panel PVC powerskirting
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- 50 x 50 mm Shadow line
	CEILING	- 1200x600 suspended ceiling grid with vinyl cladded panels
		-
	Store Rooms	
	FLOOR	- 30 mm Screed with grano finish
		-
	SKIRTING	- No
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA

	Toilets & Kitchen	
	FLOOR	- 30 mm Screed on 100mm surface bed. - Allow R110/m2 for floor tiles
	SKIRTING	- No
	WALLS	- 12 mm Plaster with wood floated finish
		- Allow R80/m2 for ceramic wall tiles floor to ceiling
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA
	SANITARY FITTINGS	- WC – Vaal Hibiscus close couple toilet suite - Code: 772654
		- Basin – Vaal Concorde slimline freestanding basin with pedestal
		- Urinal – Vaal Trento urinal with sensor movement mechanism
		- Basin Tap - Cobra basin mixer (chrome) Carina - Code: 293CA
		- Kitchen Zink – Franci Single stella Zink - Code: 3396ST
		- Zink Mixer – Cobra sink mixer (chrome) - Code:
	KITCHEN CUPBOARDS	- Allow R15000 for Cupboards - Allow R3500 for freestanding stove.
	General	
	DOORS	- 1.2mm Steel door frames
		- Semi solid doors
		- Paint frames with primer & two coats Velvaglo
		- Paint doors with primer & two coats Velvaglo
		- Allow R500/door for ironmongery
	GEYSERS	- 150L Kwiket geyser
3.	**MAIN AREA**	
	FLOOR	- 150mm Power floated surface bed with hardener. See engineer's specification.
		- Expansion joints with jointex as per engineers specifications
	SKIRTING	- No
	WALLS	- Facebrick plinth (Rosa Verona Corobrick)
		- IBR cladding with chromadek finish
		- Steelstructure framework with galvanized finish
	ROOF	- IBR Roofsheeting

		-
		- Steeltrusses with galvanished finish
	ROLLUP DOORS	- See drawings for size of rollup doors, manual operated Serranda dipped galvanized doors
	FIREDOORS	- 1.2mm steelframe
		- Paint with primer & 2 coats Velvaglo
		- Tong and Groove Meranti door
		- Paint with primer & two coats Velvaglo.
		- Allow R500/door for ironmongary
4.	**GENERAL**	
		- Whirly roof extractors as per roof plan
		- Floor outlets as per drawings
		- Fire hose reels as per drawings
		- Fire signage as per regulations

E10 Tyre Store and Pump

1.	**OUTSIDE**	
	WALLS	- IBR Roofsheeting with chromodec finish
		- Facebrick plinth (Rosa Verona Corobrick)
		- Facebrick walls at offices
		- See elevations for type op bricks A – Country Classic B – Protea Travertine
	WINDOW	- Wispeco steelframe windows with galvanized finish. Glazing as per SABS regulations
	ROOF	- IBR Roofsheeting with chromodec finish
		- Aluminium powdercoated gutters & downpipes (size as per drawings)
	APRIN	- 1000m wide paving aprin. 100x200x50mm concrete pavingbricks on 25 micron usb green on compation as per engineer.
2.	**INSIDE**	
	Offices / Passages	
	FLOOR	- 30 mm Screed on 100mm surfacebed
		- Allow R110/m2 for 300x300 ceramic floortiles
	SKIRTING	- 100 mm floor tile strip against wall
		- All outside walls to have 3 panel PVC powerskirting
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- 50 x 50 mm Shadow line
	CEILING	- 1200x600 suspended ceiling grid with vinyl cladded panels
		-
	Store Rooms	
	FLOOR	- 30 mm Screed with grano finish
		-
	SKIRTING	- No
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA

	Toilets	
	FLOOR	- 30 mm Screed on 100mm surface bed. - Allow R110/m2 for floor tiles
	SKIRTING	- No
	WALLS	- 12 mm Plaster with wood floated finish
		- Allow R80/m2 for ceramic wall tiles floor to ceiling
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA
	SANITARY FITTINGS	- WC – Vaal Hibiscus close couple toilet suite - Code: 772654
		- Basin – Vaal Concorde slimline freestanding basin with pedestal
		- Urinal – Vaal Trento urinal with sensor movement mechanism
		- Basin Tap - Cobra basin mixer (chrome) Carina - Code: 293CA
	General	
	DOORS	- 1.2mm Steel door frames
		- Semi solid doors
		- Paint frames with primer & two coats Velvaglo
		- Paint doors with primer & two coats Velvaglo
		- Allow R500/door for ironmongery
	GEYSERS	- 150L Kwiket geyser
3.	**MAIN AREA**	
	FLOOR	- 150mm Power floated surface bed with hardener. See engineer's specification.
		- Expansion joints with jointex as per engineers specifications
	SKIRTING	- No
	WALLS	- Facebrick plinth (Rosa Verona Corobrick)
		- IBR cladding with chromadek finish
		- Steelstructure framework with galvanized finish
	ROOF	- IBR Roofsheeting
		-
		- Steeltrusses with galvanished finish
	ROLLUP DOORS	- See drawings for size of rollup doors, manual operated Serranda dipped galvanized doors
	FIREDOORS	- 1.2mm steelframe

		- Paint with primer & 2 coats Velvaglo
		- Tong and Groove Meranti door
		- Paint with primer & two coats Velvaglo.
		- Allow R500/door for ironmongary
4.	**GENERAL**	
		- Vent roof extractors as per roof plan
		- Floor outlets as per drawings
		- Fire hose reels as per drawings
		- Fire signage as per regulations

E11 Shovel Laydown Building and Yard

1.	**OUTSIDE**	
	WALLS	- IBR Roofsheeting with chromodec finish
		- Facebrick plinth (Rosa Verona Corobrick)
		- Facebrick walls at offices
		- See elevations for type op bricks A – Country Classic B – Protea Travertine
	WINDOW	- Wispeco steelframe windows with galvanized finish. Glazing as per SABS regulations
	ROOF	- IBR Roofsheeting with chromodec finish
		- Aluminium powdercoated gutters & downpipes (size as per drawings)
	APRIN	- 1000m wide paving aprin. 100x200x50mm concrete pavingbricks on 25 micron usb green on compation as per engineer.
2.	**INSIDE**	
	Office Block **Offices / Conference Room / Tea Room / Passages**	
	FLOOR	- 30 mm Screed on 100mm surfacebed
		- Allow R110/m2 for 300x300 ceramic floortiles
	SKIRTING	- 100 mm floor tile strip against wall
		- All outside walls to have 3 panel PVC powerskirting
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- 50 x 50 mm Shadow line
	CEILING	- 1200x600 suspended ceiling grid with vinyl cladded panels
		-
	Store Rooms	
	FLOOR	- 30 mm Screed with grano finish
		-
	SKIRTING	- No
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA

	Toilets & Kitchen	
	FLOOR	- 30 mm Screed on 100mm surface bed. - Allow R110/m2 for floor tiles
	SKIRTING	- No
	WALLS	- 12 mm Plaster with wood floated finish
		- Allow R80/m2 for ceramic wall tiles floor to ceiling
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA
	SANITARY FITTINGS	- WC – Vaal Hibiscus close couple toilet suite - Code: 772654
		- Basin – Vaal Concorde slimline freestanding basin with pedestal
		- Urinal – Vaal Trento urinal with sensor movement mechanism
		- Basin Tap - Cobra basin mixer (chrome) Carina - Code: 293CA
		- Kitchen Zink – Franci Single stella Zink - Code: 3396ST
		- Zink Mixer – Cobra sink mixer (chrome) - Code:
	KITCHEN CUPBOARDS	- Allow R15000 for Cupboards - Allow R3500 for freestanding stove.
	General	
	DOORS	- 1.2mm Steel door frames
		- Semi solid doors
		- Paint frames with primer & two coats Velvaglo
		- Paint doors with primer & two coats Velvaglo
		- Allow R500/door for ironmongery
	GEYSERS	- 150L Kwiket geyser
3.	**MAIN AREA**	
	FLOOR	- 150mm Power floated surface bed with hardener. See engineer's specification.
		- Expansion joints with jointex as per engineers specifications
	SKIRTING	- No
	WALLS	- Facebrick plinth (Rosa Verona Corobrick)
		- IBR cladding with chromadek finish
		- Steelstructure framework with galvanized finish
	ROOF	- IBR Roofsheeting

		-
		- Steeltrusses with galvanished finish
	ROLLUP DOORS	- See drawings for size of rollup doors, manual operated Serranda dipped galvanized doors
	FIREDOORS	- 1.2mm steelframe
		- Paint with primer & 2 coats Velvaglo
		- Tong and Groove Meranti door
		- Paint with primer & two coats Velvaglo.
		- Allow R500/door for ironmongary
4.	**GENERAL**	
		- Whirly roof extractors as per roof plan
		- Floor outlets as per drawings
		- Fire hose reels as per drawings
		- Fire signage as per regulations

E12 Mining Offices

E13 Plant Security Office

1.	**OUTSIDE**	
	WALLS	- Facebrick walls
		- See elevations for type op bricks A – Country Classic B – Protea Travertine
		- See elevations for plastered areas to be painted with primer & two coats Wall & All
	WINDOW	- Wispeco steelfram windows with galvanized finish. Glazing as per SABS regulations
	ROOF	- IBR Roofsheeting with chromodec finish
		- Aluminium powdercoated gutters & downpipes (size as per drawings)
	APRIN	- 1000m wide paving aprin. 100x200x50mm concrete pavingbricks on 25 micron usb green on compation as per engineer.
2.	**INSIDE**	
	Office Block **Offices / Reception Area / Waiting Area / Lecture Rooms**	
	FLOOR	- 30 mm Screed on 100mm surfacebed
		- Allow R110/m2 for 300x300 ceramic floortiles
	SKIRTING	- 100 mm floor tile strip against wall
		- See drawings for 3 panel PVC powerskirting
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- 50 x 50 mm Shadow line
	CEILING	- 1200x600 suspended ceiling grid with vinyl cladded panels
		-
	Store Rooms	
	FLOOR	- 30 mm Screed with grano finish
		-
	SKIRTING	- No
	WALLS	- 12 mm Plaster with steel floated finish
		- Paint with primer and two coats double Velvet
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA

	Toilets & Kitchen	
	FLOOR	- 30 mm Screed on 100mm surface bed.
	SKIRTING	- No
	WALLS	- 12 mm Plaster with wood floated finish
		- Allow R80/m2 for ceramic wall tiles floor to ceiling
	CORNICE	- Gypsum cornice
		- Paint with primer & two coats PVA
	CEILINGS	- 6.4mm Gypsum ceiling board with T strip joints
		- Paint with primer & two coats PVA
	SANITARY FITTINGS	- WC – Vaal Hibiscus close couple toilet suite - Code: 772654
		- Basin – Vaal Concorde slimline freestanding basin with pedestal
		- Urinal – Vaal Trento urinal with sensor movement mechanism
		- Basin Tap - Cobra basin mixer (chrome) Carina - Code: 293CA
		- Kitchen Zink – Franci Single stella Zink - Code: 3396ST
		- Zink Mixer – Cobra sink mixer (chrome) - Code:
	KITCHEN CUPBOARDS	- Allow R15000 for Cupboards - Allow R3500 for freestanding stove.
	General	
	DOORS	- 1.2mm Steel door frames
		- Semi solid doors
		- Paint frames with primer & two coats Velvaglo
		- Paint doors with primer & two coats Velvaglo
		- Allow R500/door for ironmongery
	GEYSERS	- 150L Kwiket geyser

E14 Truck Parking Ablution

Appendix F

Pollution Control Dams

F1 Dry Freeboard Calculations

Dry Freeboard Calculations

D2-1

				U/S Slope	Run up Factor
Wind Speed (km/hr)	80	km/hr		1.5	1.2
Wind Fetch (km) =	0.065	km		2	1.25
				2.5	1.24
Upstream Slope =	3	:1		3	1.19
				4	0.9
Wave Ht		0.15	m		
Run Up Factor =		1.19			
Dry Feeboard =		**0.180**	**m**		

Design Flood	1.2	m^3/s	Flood Rise	0.59	m
Spillway Length	1.5	m	Wave Height	0.18	m
			Total		
Coefficient	1.76		Freeboard	**0.77**	**m**

D2-2

				U/S Slope	Run up Factor
Wind Speed (km/hr)	80	km/hr		1.5	1.2
Wind Fetch (km) =	0.08	km		2	1.25
				2.5	1.24
Upstream Slope =	3	:1		3	1.19
				4	0.9
Wave Ht		0.16	m		
Run Up Factor =		1.19			
Dry Feeboard =		**0.200**	**m**		

Design Flood	4.3	m^3/s	Flood Rise	0.55	m
Spillway Length	6.0	m	Wave Height	0.20	m
			Total		
Coefficient	1.76		Freeboard	**0.75**	**m**

D2-3

Wind Speed (km/hr)	80	km/hr	U/S Slope	Run up Factor	
			1.5	1.2	
Wind Fetch (km) =	0.17	km	2	1.25	
			2.5	1.24	
Upstream Slope =	3	:1	3	1.19	
			4	0.9	
Wave Ht		0.23	m		
Run Up Factor =		1.19			
Dry Feeboard =		**0.280**	**m**		
Design Flood	9.0	m^3/s	Flood Rise	0.51	m
Spillway Length	14.0	m	Wave Height	0.28	m
Coefficient	1.76		Total Freeboard	**0.79**	**m**

D5

Wind Speed (km/hr)	80	km/hr	U/S Slope	Run up Factor	
			1.5	1.2	
Wind Fetch (km) =	0.53	km	2	1.25	
			2.5	1.24	
Upstream Slope =	3	:1	3	1.19	
			4	0.9	
Wave Ht		0.40	m		
Run Up Factor =		1.19			
Dry Feeboard =		**0.480**	**m**		
Design Flood	5.9	m^3/s	Flood Rise	0.30	m
Spillway Length	20.0	m	Wave Height	0.48	m
Coefficient	1.76		Total Freeboard	**0.78**	**m**

Appendix G

Structures

G1 Structural Calculations