P O Box 6002
Halfway House
1685
Tel: (011) 207 2060
Fax: (086) 674 6121

ZITHOLELE CONSORTIUM

NEW WASTEWATER TREATMENT WORKS AT LANSERIA

Johannesburg Water Contract No.: JW13045R

PRELIMINARY DESIGN REPORT

Report No : 13082-45-Rep-012 Rev 4

Submitted to:

Johannesburg Water

Johannesburg Water (SOC) Ltd.
PO Box 61542
Marshalltown
2107

13082 August 2017

DOCUMENT CONTROL SHEET

Project Title: **NEW WASTEWATER TREATMENT WORKS AT LANSERIA**

JW Project No: **BWW1000**

ZC Project No: **13082**

Document Ref. No: **13082-45-Rep-012-Preliminary Design Report**

DOCUMENT APPROVAL

ACTION	FUNCTION	NAME	DATE	SIGNATURE
Prepared	ZC Lead Engineers	Dr. S. Sotemann PrEng Mr. J. Swart PrEng	15.08.2017	
Reviewed	ZC Project Reviewers	Mr. S. Pillay PrEng	15.08.2017	
Approved	JW Project Manager	Mr. R. Dodding	2017/08/15	R Dodding.
Approved	JW Environmental Specialist	Ms. J. Ngobele	15.08.2017	

RECORD OF REVISIONS

Date	Revision	Author	Comments
02.09.2016	0	Nevin Rajasakran	Issued to JW for comments
28.10.2016	1	Nevin Rajasakran	Addressed comments per "Comments and Responses Sheet"
17.03.2017	2	Sven Sotemann Jan Swart	Process Engineering Design changed and is now based on 'raw wastewater'. All relevant sections updated.
21.04.2017	3	Sven Sotemann Jan Swart	Addressed comments per "Comments and Responses Sheet"
15.08.2017	4	Sven Sotemann Jan Swart	Issued as Final

EXECUTIVE SUMMARY

Johannesburg Water SOC Ltd. (JW) appointed the Zitholele Consortium in December 2014 for the provision of a full suite of Professional Services for the implementation of “a New Waste Water Treatment Works (WwTW) at Lanseria”. The Consortium comprises seven specialist professional service providers, with expertise in project management, engineering, architecture, quantity surveying, health and safety and construction management. The scope of the assignment includes the planning and concept design of the ultimate treatment capacity of the works of 150 Mℓ/d, but the full implementation and commissioning of the first 50 Mℓ/d module.

The environmental authorisation process is being undertaken by an independent Environment Assessment Practitioner (EAP), with the Consortium providing technical specialist input to the process. The environmental authorisation process commenced in October 2015 when the EAP was appointed by JW. The Competent Authority is the Gauteng Department of Agriculture and Rural Development (GDARD). A Water Use License Application (WULA) is also being prepared, and will be submitted to the Department of Water and Sanitation (DWS) for approval.

The implementation of the bulk outfall sewer that will discharge to the Lanseria Works is being undertaken as a separate project, but a co-ordination forum has been established between the two project teams to ensure co-ordination between the projects.

This Preliminary Design Report documents the Concept and Viability (Preliminary) Design that has been undertaken by the Consortium.

Feasibility Study and Investigation

A detailed Feasibility Study and Investigation was undertaken prior to embarking on the Concept and Viability phase of the project. The following aspects were developed and documented in a set of reports:

- Basis of Design
- Preliminary process model and process design (base case)
- Treatment technology options identification, evaluation and recommendations for
- selection
- Plant layout options and selection of preferred option
- Bulk services aspects specifically related to an access road, potable water supply and bulk electrical power supply
- Value addition aspects including energy neutrality, nutrient recovery and water reclamation and reuse.

Basis of Design

The Basis of Design report confirmed the ultimate expected wastewater flows to the works as 150 Mℓ/d, to be implemented in three modules of 50 Mℓ/d each, as well as the peak factors to be used to determine Peak Dry Weather Flows and Peak Wet Weather Flows. These flows were used in the design of the individual process units.

The Basis of Design was also informed by a characterisation of the anticipated wastewater flow to the works, which was based on sampling undertaken at the existing Northern WwTW, and at relevant pump stations within the drainage basin.

The Basis of Design report further documents the effluent discharge standard that has been determined for the catchment by the DWS. This new standard is very stringent relative to the standard that was previously applicable to Northern WwTW. Negotiations have commenced with DWS to better understand the rationale behind the stringent standard; and to motivate the standard that may be achievable by using JW's process design approach, whilst still maintaining an acceptable effluent discharge quality.

The process engineering design has been based on JW's process design guidelines, "Guidelines for the Design of Wastewater Treatment Unit Processes, August 2015", and the requirements of the relaxed Northern WwTW effluent discharge standard.

The quality of sludge produced at the Lanseria WwTW will comply with an "A1a" classification as per the Guidelines for the Utilisation and Disposal or Wastewater Sludge (2006).

Treatment Process Units

The JW process design guideline prescribes a biological nutrient removal activated sludge (BNRAS) treatment process including nitrification / denitrification and biological excess phosphorus removal. The Lanseria BNRAS treatment works includes the following infrastructure:

- Head of Works including Screening and Degritting
- Primary Sedimentation
- Volatile Fatty Acid (VFA) Fermentation
- Flow and Load Balancing
- BNRAS Reactor in a Johannesburg Process Configuration
- Secondary Clarification
- Disinfection
- Gravity Waste Activated Sludge (WAS) Pre-thickening
- Mechanical WAS thickening by Gravity Belt Thickeners (GBT's)
- Anaerobic Digestion of Thickened WAS and Waste Fermented Primary Sludge

- Forced Struvite Precipitation
- Digested Sludge Dewatering by Belt Filter Presses (BFP's)
- Lime Dosing Installation to treat Sludge Liquors
- Solar enhanced Sludge Drying / Composting

Description of the Site

The site identified as most suitable for the development of the new Lanseria WwTW is located approximately two kilometres north east of Lanseria Airport, to the north of Northern Farm, and on the northern municipal boundary of the City of Johannesburg. The Jukskei River forms the western boundary of the site.

The site comprises four farm portions, all owned by the City of Johannesburg. The total area of the site is approximately 87.7 ha, whilst the developable area of the site is less than 36% of the total area due to the existence of numerous constraints, including right of way servitudes, electrical power line servitudes, water courses, and environmentally sensitive areas.

The site is divided by a watercourse that runs in an east-west direction in approximately the centre of the site. The developable area of the site is primarily the western portion, and the northern and southern portions that lie on either side of the central watercourse.

The site is underlain by shallow, hard rock.

Hydraulic Analysis

A hydraulic analysis has been completed for the liquid process treatment stream in order to determine the size of the conveyance system required for the WwTW, as well as to set the hydraulic control levels in each of the treatment units. The principle objective of the hydraulic analysis is to establish controlled flow, by gravity, of the bulk liquid through the treatment system. The hydraulic analysis was based on the ultimate WwTW capacity of 150 Mℓ/d, with provisions to implement the first module only. The hydraulic analysis will be refined during the next phase of the project.

Preferred Works Layout

Seven Works Layout Options were initially compiled for discussion with JW and the design team. Of these options, only two options were considered suitable for further development. Of these two options, only one option (which was named Option 3C) contained the redundancy described in the Basis of Design and Process Description. Option 3C was further modified and was renamed Option 3D. After incorporating the environmental constraints that exist on the site, Option 3D was again modified and optimised, and the revised layout has been named

Option 3E. Option 3E is the preferred Works Layout, and has been used as the basis for the further development of the design.

The works has been positioned on the western portion of the site, utilising only the developable area. The bulk outfall sewer will enter the site at its south-western corner, where it will discharge into the Head of Works. The remainder of the liquid treatment process stream has been confined to the south-western portion of the site. The gradient of the site from the south west towards the centre of the site (i.e. towards the central watercourse) allows the full liquid stream to gravitate through the site to the final discharge point, at the Jukskei River.

The emergency overflow dam is positioned at the centre of the site, in an area that is constrained by two watercourses and an electrical powerline servitude. Overflow from the Head of Works and Balancing Tanks is able to gravitate to the stormflow dam.

The sludge treatment process stream is positioned on the north-western portion of the site. Sludges will be pumped from the liquid treatment process stream, across the central watercourse, to the sludge handling and treatment installation.

Pump stations, electrical control buildings, ablution facilities, workshops and minor structures have been positioned at convenient positions along the works, so that they can efficiently fulfil their intended purpose.

A series of stepped terraces will be constructed on both treatment streams for the construction of the individual process units. The levels of these terraces have been informed by the hydraulic design.

The Main Entrance to the site and the Administration Building is located at the south-eastern corner of the site, which is the highest portion of the site.

Preliminary Design

The Concept and Viability (Preliminary) Design has been undertaken on the preferred works layout, and a detailed description of each of the process units is contained in this Preliminary Design Report. The design focussed on the following key areas:

- Civil and hydraulic engineering (design criteria and design process)
- Bulk earthworks and terrace design, including storm water management and internal roads
- Structural Engineering
- Materials of Construction
- Piping and valves
- Mechanical Engineering

- Electrical Engineering
- Control and Instrumentation

An architect forms part of the professional services team, and has been specifically included in the team to create a distinct identity for the works, particularly at the Main Entrance and the Administration Building, but also at the other functional buildings that will be developed at the works. A contemporary design approach was adopted in an attempt to create a timeless design across all the buildings. Another key design initiative was incorporating “green elements” into the project, promoting environmental sustainability, green energy and a regenerative design.

The preliminary design will be refined during the next phase of the project.

<u>Bulk Services to the Works</u>

Bulk electricity to the Works will be supplied by Eskom. The bulk electrical consumption of the works when fully developed is expected to be approximately 5MVA, and 1.25MVA for the first module. Application has been made for two sources of supply (normal and back-up) from two different Eskom 11kV networks, to ensure redundancy in supply. The two incoming sub-stations will be interlocked, to ensure that the backup source of supply switches over automatically in the event of a failure on the normal supply. This arrangement may reduce the requirement for standby diesel generators for emergency power, which is a requirement described in the JW design guideline. JW confirmed that emergency power will still be required for certain equipment. These items will be determined during HAZOP and included in the detail design.

An all-weather, surfaced Main Access Road will be constructed to service the Works. An investigation of options for the provision of access to the site indicated that the most suitable option for access would be to utilise and upgrade an existing access road to the site, from the south. This existing road is called Falkirk Road, which is off the provincial road R114 and passes the entrance to Northern Farm. This section of road is surfaced. The next section of road is a gravel, farm road (which will need to be upgraded) that runs in a northerly direction adjacent to Northern Farm, until it meets Koedoe Road which runs in a westerly direction, until it reaches the south-western entrance to the site. The length of road that will need to be upgraded is approximately 6km. A Traffic Impact Assessment has also been undertaken along the proposed access route, which will be used as specialist input to the environmental authorisation process. A Preliminary Design Report has been developed separately for the Main Access Road.

Potable water to the works will be fed from an existing pipeline that supplies Northern Farm. This pipeline originates at the Northern WwTW potable water reservoir, a portion of which will need to be upgraded. A new section of pipeline approximately 6km long will be installed from Northern Farm, along the new Main Access Road to the Lanseria Works.

Energy Neutrality

Electricity consumption comprises between 20 and 30% of the operational costs of an activated sludge wastewater treatment works. Therefore, a reduction in electricity consumption can result in a significant operational cost saving for JW, especially in light of increasing electricity prices in the country. The following key elements have been considered in the design of the works:

- Layout of the works, to make maximum use of gravity flow, and to limit pumping to where it is absolutely necessary
- Selection of energy efficient equipment
- Appropriate selection of aeration type for the BNR Reactor
- Provision for future biogas to electrical energy installation
- Solar power will not be considered due to the high theft rate experienced by JW on previous installations

Risk Management

A Risk Register has been developed for the project, and risks will be managed on an ongoing basis. At this stage of the project, the following key risks have been identified:

- Environmental Authorisation – there are two key risks associated with the authorisation process:
  - Alternative site - the environmental authorisation process required an alternative site for the works to be considered, in addition to the identified site. There is a risk that the alternative site may be authorised rather than the identified (preferred site). The EAP is liaising with GDARD to ensure that this process is managed.
  - Delay in issuing an Environmental Authorisation, or an appeal being lodged by an Interested and Affected Party (I&AP) – authorisation is currently expected in the last quarter of 2017, and construction may only commence once final authorisation has been received (after the expiry of the appeal period). The start of construction will be delayed if there are any delays in the authorisation process.
- Water Use License – the timeframe for DWS to issue a water use licence is currently not legislated, and construction may only commence after the license has been issued. The team is in discussion with DWS to ensure that the issuing of the license is expedited once the application has been submitted. The WULA is expected to be submitted in the first quarter of 2017.
- Project budget - Securing of project funding for the full value and duration of the project is critical to ensure that the project is implemented as planned. The project budget is

being refined as the design develops, and this information is being communicated to JW to inform JW's planning and budgeting processes.

- DWS effluent discharge standard – the standard that has been issued by DWS is extremely stringent with respect to nitrates, and will not be achievable using conventional activated sludge systems, given the raw wastewater characteristics. The current design has been based on a relaxed standard that had previously been issued for the Northern WwTW (which lies in the same catchment as the Lanseria WwTW). Negotiations have been initiated with DWS to discuss the relevance of the stringent discharge standard.
- Bulk Outfall Sewer – the implementation of the bulk outfall sewer is being undertaken as a separate project. The works project and the bulk outfall sewer project need to be carefully co-ordinated, as they rely on each other for their successful final commissioning. A co-ordination forum has been established between the project teams on the two projects.

Contracting Strategy for Construction and Commissioning of the Works

JW is a state-owned municipal entity which is governed by the Municipal Finance Management Act (MFMA) and the Preferential Procurement Policy Framework Act (PPPFA). This project, due to its size, will be subject to a competitive bidding process, and the appointment of contractors will need to comply with the aforementioned pieces of legislation and related regulations.

These regulations also require JW to set aside a certain amount of work on the project for previously marginalised enterprises, SMME's, the employment of local labour, and the use of labour intensive methods of construction. There are numerous opportunities in the project scope for these objectives to be realised, and these requirements will be incorporated in the procurement documentation.

The General Conditions of Contract for Construction Works, Third Edition (2015) can be used as the basis of the contract, and is recommended for the construction phase of this project.

Two broad contracting strategies may be appropriate for the execution of this project, viz. "Design by Employer" or "Management Contractor", as follows:

- Design by Employer – this type of contract is the conventional contracting approach, wherein a contractor undertakes only construction on the basis of full designs issued by JW (or JW's agent, which in this case is the Consortium).

  Seven potential contracts are envisaged, as follows:

  - One contract for the Enabling Works, to incorporate:

        - The Main Access Road
        - Potable water and borehole on site
        - Fencing around the site
    - Three contracts for the liquid treatment process stream, and three contracts for the sludge treatment process stream; one each for:
        - The Civil Engineering works
        - The Mechanical Engineering Works
        - The Electrical and Control & Instrumentation Engineering

- Management Contractor - in this type of contract, a contractor is responsible for planning and managing all post-contract activities. The contractor would then appoint sub-contractors to undertake the work associated with each of the disciplines required.

  Three potential contracts are envisaged (the contracts listed above will be undertaken as sub-contracts to these main contracts):

    - One contract for the Enabling Works
    - One contract for the liquid treatment process stream
    - One contract for the sludge treatment process stream

The Contracting Strategy will be investigated further during the next phase of the project, so that a strategy can be adopted for the Tender and Procurement phase.

<u>Occupational Health and Safety</u>

All construction work that will be undertaken as part of this project will comply with the Occupational Health and Safety Act (No. 85 of 1993), as amended. A comprehensive Health and Safety specification will be included with the procurement documentation, and contractors that are appointed to undertake construction will be required to comply with the following requirements:

- Compilation of a Health and Safety Plan
- Maintenance of the Safety Plan during construction
- Employment of a full-time Safety Officer during construction

<u>Skills Transfer</u>

Member firms of the Zitholele Consortium have a Commitment and Undertaking registered with the Engineering Council of South Africa (ECSA), and the professional engineers of member firms are registered as mentors with ECSA. All training completed under the mentorship of these individuals is fully accredited by ECSA, and will ensure a seamless professional registration process for earmarked candidates. The transfer of knowledge will take place throughout the project and will feature in every project phase.

Project Programme

A project programme, in the form of a Gantt chart, was compiled at the onset of the project in order to track progress and identify the critical path activities. The programme is updated on a regular basis. The key milestones to be achieved on the project, and current status of the project is as follows:

STAGE	DESCRIPTION	DUE DATE	% COMPLETE
1	Stage 1 – Project Initiation	19 June 2015	100%
2	Stage 2 – Reporting Stage	08 July 2016	98%
3	Stage 3 – Concept and Viability	10 April 2017	100%
4	Stage 4 – Design Development	24 Nov 2017	28%
5	Stage 5 – Documentation and Procurement	26 Apr 2018	0%
6	Stage 6 – Construction /Installation /Commissioning	12 Jan 2023	0%
7	Stage 7 – Project Close-Out	23 Feb 2023	0%
	Overall Progress		**52%**

At this stage of the project, the critical path activities that will determine the start date of construction are:

- Receipt of an Environmental Authorisation
- Receipt of a Water Use License

Project Investment

A detailed estimate of the expected construction value of the project has been compiled. This estimate is based on the following:

- A Bill of Quantities was developed for the project
- Quantities of major construction items were extracted

- Rates from recently completed, similar projects, were extracted and were escalated to current rates
- Rates for major construction items such as ready-mix concrete, reinforcing, earthworks and blasting of rock were sourced from suppliers and contractors, and were used as budget prices
- Re-use of crushed blasted rock (a large quantity of rock is expected to be excavated)

A summary of the expected project cost is as follows:

Description		**Total (excl. VAT)**
Civil Engineering Works (Liquid Stream)	R	508,955,000.00
Civil Engineering Works (Sludge Stream)	R	227,580,000.00
Electrical and Control & Instrumentation	R	106,500,000.00
Mechanical Engineering (Liquid Stream)	R	79,653,000.00
Mechanical Engineering (Sludge Stream)	R	75,499,000.00
Preliminary & General Items	R	199,638,000.00
Total (excl. VAT)	**R**	**1,197,825,000.00**

Approval of Report and Design Development Stage

This Preliminary Design Report documents the activities that have been undertaken on the project thus far. The next stage of the project is the Design Development stage, which will be followed by the Tender and Procurement stage (i.e. the tender process and appointment of contractors to undertake the construction works). Formal approval of this report is required from JW before the Consortium can proceed with the next stage.

TABLE OF CONTENTS

SECTION **PAGE**

1 INTRODUCTION AND BACKGROUND... 1
2 PROJECT OBJECTIVE 1
3 BACKGROUND 1
3.1 Details of Appointment.. 1
3.2 Scope of Work 2
3.3 Scope of Services.. 2
3.4 Details of the Project Team.. 3
4 PROJECT INCEPTION.. 4
5 FEASIBILITY AND INVESTIGATION PHASE.. 4
6 BASIS OF DESIGN.. 4
6.1 Design Wastewater Flows... 5
6.2 Design Wastewater Quality and Characteristics...................................... 7
6.2.1 Design wastewater quality.. 7
6.2.2 Design wastewater characteristics 9
6.3 Design Effluent Quality 10
6.4 Design Sludge Quality 11
7 SITE DESCRIPTION AND CONSTRAINTS.. 12
7.1 Location...12
7.2 Topography, Vegetation and Site Drainage 12
7.3 Geological setting 13
7.4 Site Constraints 15
7.4.1 Electric Power Line Servitudes..15
7.4.2 Right of Way (RoW) Servitudes...16
7.4.3 Telkom Overhead Lines 16
7.4.4 Natural Streams (Water Courses) 16
7.4.5 Environmental Constraints 16
7.4.5.1 Wetland and Wetland Buffer..16
7.4.5.2 Class 1 Ridge...17
7.4.5.3 Riparian Zone and Riparian Buffer 17
7.4.5.4 Available property area 17
8 WORKS PHASING STRATEGY.. 17
9 PROCESS DESIGN.. 19
9.1 Treatment Process Selection 20
9.1 Mainstream (Liquid) Treatment 24
9.1.1 Head of Works 24
9.1.2 Storm Flow Dam 26
9.1.3 Primary sedimentation..26
9.1.4 VFA fermentation 28
9.1.5 Flow balancing 29
9.1.6 Biological nutrient removal 30
9.1.7 Tertiary treatment...36
9.1.8 Metal salt addition 37
9.2 Sludge Treatment 38
9.2.1 Waste activated sludge pre-thickening 38
9.2.2 Mechanical waste activated sludge thickening 40
9.2.3 Cell lysis...41
9.2.4 Sludge stabilisation 42
9.2.5 Struvite precipitation...44

9.2.6 Sludge dewatering 46
9.2.7 Lime dosing and treatment 48
9.2.8 Sludge drying 50
9.3 BIOWIN® Modelling 50
10 HYDRAULIC DESIGN 52
10.1 Liquid Treatment Train 52
10.1.1 Design Criteria 52
10.1.2 Design Flows 52
10.1.3 Hydraulic Analysis 53
10.1.4 Results and Discussion 53
11 WORKS LAYOUT DESIGN 58
11.1 Development of Works Layout Options 58
11.2 Design Philosophy 59
11.2.1 Liquid Treatment Process Stream 59
11.2.2 Sludge Treatment Process Stream 59
11.2.3 Main Access and Administration Building 59
11.3 Geotechnical Investigation 60
12 DESIGN OF PROCESS UNITS 60
12.1 REFERENCE DRAWINGS 60
12.2 HEAD OF WORKS 60
12.2.1 Design 60
12.2.2 Materials of Construction 64
12.2.3 Piping and Valves 64
12.2.4 Mechanical 64
12.2.5 Electrical 65
12.2.6 Control and Instrumentation 65
12.3 PRIMARY SEDIMENTATION TANK 66
12.3.1 Design 66
12.3.2 Materials of Construction 67
12.3.3 Piping and Valves 67
12.3.4 Mechanical 68
12.3.5 Electrical 68
12.3.6 Control and Instrumentation 68
12.4 FLOW AND LOAD BALANCING TANKS 69
12.4.1 Design 69
12.4.2 Materials of Construction 70
12.4.3 Piping and Valves 70
12.4.4 Mechanical 71
12.4.5 Electrical 71
12.4.6 Control and Instrumentation 71
12.5 STORM FLOW DAM 71
12.5.1 Design 72
12.5.1.1 Design assumptions 72
12.5.1.2 Design Data 72
12.5.1.2.1 Sizing of Structures 74
12.5.2 Mechanical 75
12.5.3 Electrical 75
12.5.4 Control and Instrumentation 75
12.6 BIOLOGICAL NUTRIENT REMOVAL REACTOR 75
12.6.1 Design 76
12.6.2 Materials of Construction 80
12.6.3 Piping and Valves 80

12.6.4 Mechanical 80
12.6.5 Electrical 81
12.6.6 Control and Instrumentation 81
12.7 SECONDARY CLARIFIER....81
12.7.1 Design....82
12.7.2 Materials of Construction....83
12.7.3 Piping and Valves 83
12.7.4 Mechanical....83
12.7.5 Electrical 84
12.7.6 Control and Instrumentation 84
12.8 DISINFECTION 84
12.8.1 Design....84
12.8.1.1 Design assumptions....84
12.8.1.2 Design Data 85
12.8.1.3 Disinfection Facility 85
12.8.1.3.1 Sizing of structures....87
12.8.1.4 Wash Water Pump Station 90
12.8.2 Mechanical....90
12.8.3 Electrical 91
12.8.4 Control and Instrumentation 91
12.9 FERMENTATION 91
12.9.1 Design....91
12.9.2 Materials of Construction....93
12.9.3 Piping and Valves 93
12.9.4 Mechanical....93
12.9.5 Electrical 94
12.9.6 Control and Instrumentation 94
12.10 WASTE ACTIVATED SLUDGE THICKENING....94
12.10.1 Design....94
12.10.2 Materials of Construction....95
12.10.3 Piping and Valves 96
12.10.4 Mechanical....96
12.10.5 Electrical 98
12.10.6 Control and Instrumentation 98
12.11 ANAEROBIC DIGESTERS AND HEATING 98
12.11.1 Design....98
12.11.2 Materials of Construction....99
12.11.3 Piping and Valves 100
12.11.4 Mechanical....100
12.11.5 Electrical 102
12.11.6 Control and Instrumentation 102
12.12 STRUVITE PRECIPITATION....103
12.12.1 Design....103
12.12.2 Materials of Construction....103
12.12.3 Piping and Valves 103
12.12.4 Mechanical....103
12.12.5 Electrical 104
12.12.6 Control and Instrumentation 105
12.13 SLUDGE DEWATERING AND DRYING....105
12.13.1 Design....105
12.13.2 Materials of Construction....106
12.13.3 Piping and Valves 106
12.13.4 Mechanical....106

12.13.5 Electrical 107
12.13.6 Control and Instrumentation 107
12.14 LIME DOSING AND TREATMENT AND FILTRATE RETURN 108
12.14.1 Design....108
12.14.2 Materials of Construction....108
12.14.3 Piping and Valves 109
12.14.4 Mechanical....109
12.14.5 Electrical 110
12.14.6 Control and Instrumentation 110
12.15 INTERCONNECTING PIPEWORK....111
12.15.1 Electrical 113
12.15.2 Control and Instrumentation 113
12.16 EARTHWORKS AND TERRACES 113
12.17 BULK SERVICES 115
12.17.1 Main Access Road 115
12.17.1.1 Access Roads Evaluation 115
12.17.2 Bulk Electricity....120
12.17.3 Potable Water 121
12.17.3.1 Background 121
12.17.3.2 Scope of new Pipeline 121
12.17.3.3 Pipeline Design Criteria 122
12.18 SITE SERVICES....122
12.18.1 Internal Roads....122
12.18.1.1 Design Guidelines 122
12.18.1.2 Design Criteria....123
12.18.1.3 Pavement Design 124
12.18.2 Storm water Management 125
12.18.2.1 Design Guidelines 125
12.18.2.2 Design Criteria....125
12.18.2.3 Design of Culverts 126
12.18.3 Electricity....127
12.18.4 Site Lighting 127
12.18.5 Access control, alarm system and Intruder detection....127
12.18.6 Water Reticulation....127
12.18.6.1 Design 128
12.18.6.2 Design Assumptions 128
12.18.6.3 Wash Water Network....128
12.18.6.4 Potable Water Network....129
12.18.6.5 Materials of Construction 130
12.18.6.6 Pipes and Valves....130
12.19 BUILDINGS AND ARCHITECTURE 130
12.20 STRUCTURAL DESIGN 133
12.20.1 General Design Philosophy....133
12.20.1.1 Blasting During Construction 134
12.20.1.2 Concrete Cover to Reinforcement....134
12.20.2 Liquid Retaining Structures 134
12.20.2.1 Joints in Liquid Retaining Structures....135
12.20.2.2 Codes of Practice 135
i) Serviceability Limit State:....135
ii) Ultimate Limit State:....135
12.20.2.3 Material Properties and Design Data 135
12.20.2.4 General Loading, Analysis and Design of Liquid Retaining Structures....136

12.20.3 Earth Retaining Structures 136
12.20.3.1 Design Philosophy..137
12.20.3.2 Codes of Practice 137
12.20.3.3 Material Properties and Design Data 137
12.20.4 Buildings 138
12.20.4.1 Design Philosophy..138
12.20.4.2 Codes of Practice 138
12.20.4.3 Material Properties and Design Data 139
12.20.5 CONSTRUCTABILITY 139
13 OUTFALL SEWER.. 140
14 ENERGY NEUTRALITY 141
14.1 Power Saving by Selection of Aeration Type 142
14.2 Renewable Energy 143
14.2.1 Biosolids..143
14.2.2 Hydropower..143
14.2.3 Solar power..144
14.2.4 Wind energy...145
14.2.5 Energy neutrality and the Lanseria WwTW....................................145
15 ENVIRONMENTAL AUTHORISATION 146
16 RISK MANAGEMENT.. 147
17 CONTRACTING STRATEGY 149
17.1 Design by Employer..149
17.1.1 Enabling Works..149
17.1.2 Liquid Treatment Process Stream 150
17.1.3 Sludge Treatment Process Stream...150
17.2 Management Contractor 150
17.2.1 Enabling Works..150
17.2.2 Liquid Treatment Process Stream 151
17.2.3 Sludge Treatment Process Stream...151
18 OCCUPATIONAL HEALTH AND SAFETY 151
19 PROGRAMME 152
20 PROJECT INVESTMENT... 154
21 LOCAL LABOUR OPPORTUNITIES.. 155
22 SKILLS TRANSFER 155
22.1 Stage 1 – Project Inception..156
22.2 Stage 2 – Project Concept and Viability 156
22.3 Stage 3 – Design Development 156
22.4 Stage 4 – Documentation and Procurement 156
22.5 Stage 5 – Contract Administration and Inspection.......................................157
22.6 Stage 6 – Project Close-out 157
23 WAY FORWARD 157

LIST OF TABLES

Table 1: Members of the Zitholele Consortium 3
Table 2: Lanseria WwTW design flow rates 6
Table 3: Median raw wastewater quality 8
Table 4: Design wastewater quality for the Lanseria WwTW 8
Table 5: Wastewater characterisation / fractionation 9
Table 6: Anticipated discharge standards for the Lanseria WwTW 10
Table 7 : Additional Works Components to be Constructed in Phase 1 18
Table 8: Primary sedimentation tank design parameters 27
Table 9: Fermenter design parameters 28
Table 10: Lanseria WwTW balancing tank volumes 30
Table 11: Activated sludge model parameters and design criteria 31
Table 12: Sizing for each of the 6 x 25 Ml/d treatment capacity bioreactors 33
Table 13: Average oxygen demand for aerobic cells of each of the 6 bioreactors 34
Table 14: Secondary clarifier design parameters 35
Table 15: Secondary clarifier design parameters 36
Table 16: Gravity WAS thickener design parameters 38
Table 17: GBT design parameters 40
Table 18: Anaerobic digester design parameters 42
Table 19: Struvite precipitation design parameters 46
Table 20: BFP design parameters 47
Table 21: Lime reaction tank and lime clarifier design parameters 49
Table 22: Biowin® base case steady state modelling effluent quality 51
Table 23 : Summary of Liquid Treatment Train Flow Distribution 52
Table 24 : Pumps selection data 90
Table 25: Waste activated sludge thickening mechanical equipment 96
Table 26: Anaerobic digester mechanical equipment 100
Table 27: Struvite precipitation mechanical equipment 103
Table 28: Dewatering and sludge drying mechanical equipment 106
Table 29: Lime dosing and treatment and filtrate return mechanical equipment 109
Table 30 : Summary of Interconnecting Pipework 111
Table 31: Design of Potable Water Pipeline 122
Table 32: Internal Road Network 123
Table 33: Road Design Criteria 124
Table 34: Road Pavement Design 125
Table 35: Stormwater Design Criteria 126
Table 36: Summary of Peak Flows 126
Table 37: Summary of Project Progress 153
Table 38: Summary of Capital Cost Estimate 154

LIST OF FIGURES

Figure 1 : Diurnal dry weather flow pattern used for Lanseria WwTW design	7
Figure 2 : Site showing Farm Portions	12
Figure 3 : Lanseria WwTW simplified liquid stream flow diagram	22
Figure 4 : Lanseria WwTW simplified sludge stream flow diagram	23
Figure 5 : Longitudinal section through typical culvert crossing	127
Figure 6 : Colour Pallet and Textures	131
Figure 7 : Section of Admin Building showing Green principles to be implemented	133

LIST OF APPENDICES

Appendix A : Scope of Works
Appendix B : Project Programme
Appendix C : Drawing Register
Appendix D : Risk Register
Appendix E : Detailed Cost Estimate

LIST OF SUPPORTING REPORTS

13082-42-Rep -001	Project Inception Report
13082-45-Mem-001	Skills Transfer Plan
13082-45-Mem-002	Options for Potable Water Supply to the Works
13082-45-Mem-003	Site Alternatives - Works Layout Technical Assessment
13082-45-Mem-005	Process Design Approach
13082-45-Mem-006	Technology Selection (Plant Visits)
13082-45-Rep-001	Basis of Design
13082-45-Rep-002	Bulk Electrical Supply
13082-45-Rep-003	Process Description
13082-45-Rep-004	Access Roads Evaluation
13082-45-Rep-005	Works Layout Options
13082-45-Rep-006	Sludge Liquor Treatment
13082-45-Rep-009	Traffic Impact Assessment
13082-45-Rep-010	Energy Neutrality
13082-45-Rep-011	Technology Selection
13082-45-Rep-013	Access Road PDR
Report No. 5164/606	Northern Farm Development: Geotechnical Feasibility Study

Northern Farm Development: Detailed Geotechnical Investigation

Lanseria WwTW Supplementary Geotechnical Investigation

LIST OF ACRONYMS

ADWF	Average dry weather flow
AS	Activated sludge
BFP's	Belt filter presses
BNR	Biological nutrient removal
BNRAS	Biological nutrient removal activated sludge
BS	British Standards
CIDB	Construction Industry Development Board
CHP	Combined Heat and Power
COD	Chemical oxygen demand
CoJ	City of Johannesburg Metropolitan Municipality
CSP	Concentrated solar power
DO	Dissolved Oxygen
DBF	Di Basic Filtrate
DWS	Department of Water and Sanitation
E coli	Escherichia Coli
EAP	Environment Assessment Practitioner
ECSA	Engineering Council of South Africa
EIA	Environmental Impact Assessment
EIA regulations of 2014	Environmental Impact Assessment Regulations: GN 982-985 of 04 December 2014
EIR	Environmental Impact Report
EC	Electrical Conductivity
FC	Faecal Coliforms
FL	Floor Level
GBT's	Gravity belt thickeners
GDARD	Gauteng Department of Agriculture and Rural Development
GDRT	Gauteng Department of Roads and Transport
GRP	Glass Reinforced Plastic

HAZOP	Hazard and Operability Study
HDPE	High Density Polyethylene
HDGMS	Hot Dipped Galvanised Mild Steel
HoW	Head of Works
I/O	Input/Output
JRA	Johannesburg Roads Agency
JW	Johannesburg Water SOC Limited
LED's	Light-emitting diodes
LWwTW	Lanseria Wastewater Treatment Works
MCC	Motor Control Centre
m.a.s.l.	meters above sea level
MFMA	Municipal Finance Management Act
MLSS	Mixed liquor suspended solids
NB	Nominal Bore
NEMA	National Environmental Management Act, 107 of 1998, as amended
NEMWA	National Environmental Management: Waste Act, 59 of 2008, as amended
NWA	National Water Act, 36 of 1998 and regulations
NEMAQA	National Environmental Management: Air Quality Act, 39 of 2004
NHRA	National Heritage Resources Act, 25 of 1999
NEMBA	National Environmental Management: Biodiversity Act, 10 of 2004
NEMPAA	National Environmental Management: Protected Areas Act, 57 of 2003
NDN	Nitrification Denitrification
PDDWF's	Peak Daily Dry weather flows
PDWF	Peak Dry Weather Flow
PEP	Project Execution Plan
PFD's	Process Flow Diagrams
PLC	Programmable Logic Controller
PSM	Project Specifications Mechanical

PST's	Primary Sedimentation Tanks
PV	Photovoltaic
PVC	Polyvinyl Chloride
PWWF	Peak wet weather flow
RAS	Return activated sludge
RoW	Right of Way
PDR	Preliminary Design Report
PPE	Personal Protective Equipment
PPPFA	Preferential Procurement Policy Framework Act
SABS	South African Bureau of Standards
SANRAL	South African National Roads Agency SOC Limited
SANS	South African National Standards
SCADA	Supervisory Control and Data Acquisition
SLS	Serviceability Limit State
SMME's	Small, Medium and Micro-sized Enterprises
SS	Suspended solids
TKN	Total Kjeldahl Nitrogen
TOC	Top of Concrete
TP	Total phosphorus
TSS	Total suspended solids
TWL	Top water level
Tx	Eskom Transmission
UDB	Urban Development Boundary
ULS	Ultimate Limit State
UPS	Uninterrupted Power Supply
uPVC	Unplasticized Polyvinyl Chloride
VFA	Volatile Fatty Acid
VSD	Variable speed drives

VSS	Volatile suspended solids
WAS	Waste activated sludge
WKJ	Western Klein Jukskei
WwTW(s)	Wastewater Treatment Works
WUL	Water Use License
WULA	Water Use Licence Application

ACKNOWLEDGMENTS

Zitholele Consortium would like to acknowledge the contribution of the extended project team in the compilation of this document, including the design engineers, draughtsmen and technical support. We would also like to extend our sincere appreciation to Johannesburg Water's Management and Operational teams that contributed to refining the process engineering design, and those that provided valuable input at the various preliminary design and technical review workshops.

1 INTRODUCTION AND BACKGROUND

Johannesburg Water SOC Ltd. (JW) appointed the Zitholele Consortium in December 2014 for the provision of Professional Services for the implementation of “a New Waste Water Treatment Works (WwTW) at Lanseria”. A pre-feasibility study conducted by the JW Wastewater Partnership in 2009, and concluded in 2013, identified a “green-fields” site, located immediately adjacent to Northern Farms in Lanseria, as feasible for the construction of three 50 Mℓ/d modules of an activated sludge WwTW. The implementation of the three modules will be phased over a number of years.

The scope of the assignment includes the planning and concept design of the ultimate treatment capacity of the works of 150 Mℓ/d, but the full implementation and commissioning of the first 50 Mℓ/d module.

The Zitholele Consortium has embarked on the first phase of the project, viz. the design, procurement and management of the implementation of the first 50 Mℓ/d module.

The environmental authorisation processes are being undertaken by an independent Environment Assessment Practitioner (EAP), with the Consortium providing the technical specialist input to the process. The environmental authorisation process commenced in October 2015 when the EAP was appointed by JW.

2 PROJECT OBJECTIVE

JW’s objective is to construct and commission a 50 Mℓ/d module of the new Lanseria WwTW, which is to be located in Lanseria, to the north of Johannesburg. The planning and concept design phases of the project should also address the layout and design of the ultimate Works capacity of 150 Mℓ/d.

The new Works will treat sewage generated in the northern suburbs of Johannesburg, and is expected to supplement the capacity of JW’s existing Northern WwTW.

3 BACKGROUND

3.1 Details of Appointment

The Zitholele Consortium was appointed by JW in December 2014 to provide the full scope of professional services for the planning, design and implementation of the new Works. This followed a competitive bidding process that was initiated by JW initially in the first quarter of 2014, reactivated in the latter part of 2014, and completed in December 2014, which resulted in the appointment of the Consortium.

3.2 Scope of Work

The initial Scope of Work included in the tender documents that were issued as part of the tender process for professional services can be summarised as follows:

- Head of Works
- Primary Treatment and Flow and Load Balancing
- BNR Reactors
- Secondary Treatment
- Chlorination
- Primary Sludge Fermentation
- Waste Activated Sludge Thickening
- Anaerobic Digesters
- Sludge Dewatering
- Sludge Drying and Composting
- Wet Weather Stormflow Management
- Bulk Services to the site
- Internal Services
- Administration Building, Control Buildings and Ancillary Buildings

Refer to Appendix A: Scope of work as included in the original tender document.

3.3 Scope of Services

The Scope of Services to be provided on this project are as follows:

- Project Management
- Process Engineering
- Hydraulic Engineering
- Structural Engineering
- Civil Engineering
- Electrical engineering
- Mechanical and Fire Engineering
- Control and Instrumentation Engineering
- Architectural Services
- Quantity Surveying Services
- Construction Management Services
- Site Management Services including Resident Engineering
- Safety Management Services

All services will be provided in terms of Board Notice 117 of 2013: Guideline Scope of Services and Tariff of Fees of Persons Registered in terms of the Engineering Profession Act, 2000 (Act No. 46 of 2000), published in government Gazette No. 36529, 3 June 2013.

The following types of services are included:

- Normal Services
- Additional Services

3.4 Details of the Project Team

The Zitholele Consortium comprises the following team members (with a description of the professional services that each team member will provide):

Table 1: Members of the Zitholele Consortium

Team Member Name	Professional Services Offered
Zitholele Consulting	Project Management Hydraulic Engineering Civil Engineering Structural Engineering Mechanical Engineering Fire Services Construction Management Site Management, Resident Engineering
Golder Associates Africa	Process Engineering Hydraulic Engineering Civil Engineering Mechanical Engineering Fire Services Construction Management Site Management, Resident Engineering
Malani Padayachee & Associates	Civil Engineering Structural Engineering Site Management, Resident Engineering
DJJC Consulting Engineers	Electrical Engineering Control and Instrumentation Engineering
Artek 4 Architectural and Design	Architecture Fire Services
Leeanka Property Holdings	Quantity Surveying
Nemai Consulting	Occupational Health & Safety Management

4 PROJECT INCEPTION

A Project Inception report was prepared to guide the implementation of the project (Report no. 13082-42-Rep-001), wherein the following key aspects were addressed:

- Project management approach
- A Project Execution Plan (PEP), based on the Engineering Council of South Africa's Guideline Scope of Services
- Technical and engineering guidelines and standards
- Project financial controls
- Project team and resources
- Knowledge transfer strategy
- Project schedule and programming
- Technical input for regulatory approval for the environmental, water and waste aspects, via an independent Environmental Assessment Practitioner
- Health and Safety support and systems

5 FEASIBILITY AND INVESTIGATION PHASE

A detailed Feasibility and Investigation Study was undertaken by the design team prior to embarking on the Concept and Viability Design phase of the project. The following aspects were addressed:

- Development of a project Basis of Design.
- Preliminary process model development and process design (base case)
- Treatment technology options identification, evaluation and recommendations for selection.
- Plant layout options development and recommendations for selection.
- Bulk services aspects specifically related to the potable water supply; access road and bulk electrical power supply.
- Value addition aspects to the project including energy neutrality, nutrient recovery and water reclamation and reuse.

Please refer to the "List of Supporting Reports" for a list of the set of reports and technical memorandums that were developed during this stage.

6 BASIS OF DESIGN

This section presents the development of the anticipated wastewater flows, associated nutrient loads and wastewater characteristics for which the Lanseria Wastewater Treatment Works (WwTW) will be designed.

The Lanseria WwTW is a greenfields WwTW and the incoming outfall sewer has not yet been constructed and therefore direct flow measurement and sampling of the actual wastewater that will be treated at the Lanseria WwTW is not possible. It is however known that the wastewater flow to the Lanseria WwTW will originate from (i) the Western Klein Jukskei Basin (currently pumped to Northern Works), (ii) the Diepsloot Basin (currently pumped to Northern Works) and (iii) the remaining Lanseria catchment area.

Therefore, the anticipated wastewater flows and associated nutrient loads were developed based on the following:

- Sampling of the Northern Works raw and settled wastewater;
- Sampling of the Dainfern Pump station raw wastewater (Western Klein Jukskei gravity outfall);
- Sampling of the Zandspruit Pump station raw wastewater (Western Klein Jukskei pumped outfall);
- Sampling data received from Johannesburg Water ("Northern Works Water Quality Data for 2013 – 2014);
- Sampling data received from Johannesburg Water ("Zandspruit Raw Sewage Quality Data for August 2012 to September 2012);
- "Optimum Locality and Phasing of Additional Treatment Capacity in the Northern Drainage Basin", GLS Consulting (October 2011);
- "Lanseria Area Bulk Sewer: Preliminary Design Report", LTE Consulting Engineers (August 2014).

6.1 Design Wastewater Flows

The ultimate peak dry weather flows to the Lanseria WwTW are expected to be as follows:

- Western Klein Jukskei Basin: 49.4 Mℓ/d;
- Diepsloot Basin: 27.6 Mℓ/d;
- Rest of catchment: 73.0 Mℓ/d.

The contributions of the basins listed above add up to an ultimate capacity for the Lanseria WwTW of 150 Mℓ/d. The Lanseria WwTW will be constructed in three phases, each phase providing a 50 Mℓ/d treatment module. Phase 1, this project, will provide the process design and layout for the ultimate 150 Mℓ/d plant, however only the first 50 Mℓ/d treatment module will be constructed.

As the outfall sewer servicing the Lanseria WwTW has not been constructed, no direct flow measurements are available. Therefore, flow measurements from the Northern WwTW, which is located in close proximity to the Lanseria WwTW site, were utilised to obtain a diurnal flow pattern and peaking factors that can be applied to the future Lanseria rising main sewer as well as the design of the Lanseria WwTW. **Table 2** below shows the peaking factors and Figure 1 shows the dry weather diurnal flow pattern that will be used for the design of the Lanseria WwTW.

The peak wet weather factors listed in **Table 2** above are in accordance with the Johannesburg Water "Guidelines for the Design of Wastewater Treatment Unit Processes, August 2015".

Table 2: Lanseria WwTW design flow rates

	Lanseria WwTW Phasing		
	Phase 1	**Phase 2**	**Phase 3**
Average wastewater flows:			
Mℓ/day	50	100	150
m^3/sec	0.58	1.16	1.74
Peak dry weather wastewater flows:			
Peak factor	2.05	1.81	1.69
Mℓ/day	102.5	181.0	253.5
m^3/sec	1.18	2.09	2.93
Peak wet weather flows:			
Peak factor	3.0	2.7	2.4
Mℓ/day	150	270	360
m^3/sec	1.74	3.13	4.17

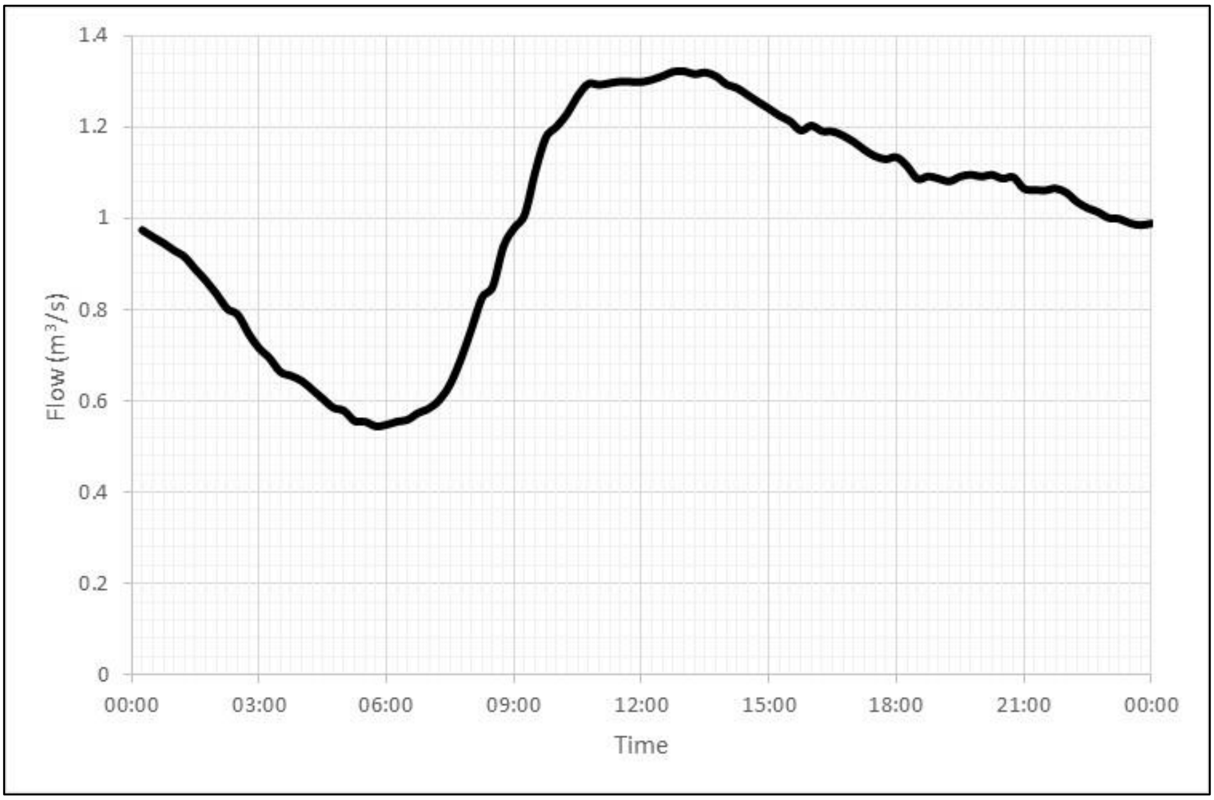


Figure 1 : Diurnal dry weather flow pattern used for Lanseria WwTW design

6.2 Design Wastewater Quality and Characteristics

6.2.1 Design wastewater quality

The raw wastewater quality to be used for the design of the Lanseria WwTW is based on data from a number of sources, as sampling of the actual wastewater to be treated at the Lanseria WwTW is not possible because the rising main sewer to the site is currently still in the planning phase. The anticipated raw wastewater quality for the Lanseria WwTW was estimated using wastewater quality data from the following sources:

- Zandspruit Pump Station (Western Klein Jukskei Basin);
- Dainfern Pump Station (Diepsloot Basin);
- Northern WwTW' head of works.

The wastewater quality data obtained for the sources listed above reflects a combination of historical data provided by Johannesburg Water and data obtained from sampling regimes performed during the feasibility phase of this project. **Table 3** below shows a summary of the median (50th percentile) wastewater quality data from the sources discussed above.

Table 3: Median raw wastewater quality

Median raw wastewater quality from different sources utilised to estimate Lanseria WwTW raw wastewater quality

Water quality parameter	Northern Works (21 – 22 July 2015)	Dainfern Pump Station (5 – 6 August 2015)	Zandspruit Pump Station (5 – 6 August 2015	Historical Zandspruit Pump Station	Knight Piesold Treatment Capacity Report
COD (mg/ℓ)	592	708	537	686	530
TSS (mg/ℓ)	326	603	243	138	240
VSS (mg/ℓ)	-	502	200	-	-
TKN (mg/ℓ)	50	56	42	46	46
Ammonia (mg/ℓ)	28	33	28	35	26
Total P (mg/ℓ)	5.9	6.6	6.0	7.5	20
Ortho-P (mg/ℓ)	2.4	3.5	3.5	5.9	14
Alkalinity (mg/ℓ as $CaCO_3$)	221	243	237	-	-
Ca (dissolved, mg/ℓ)	26	32	22	-	-
Magnesium (dissolved, mg/ℓ)	8.4	11	9.0	-	-
pH	7.3	7.3	7.5	7.2	-

The Northern WwTW and Dainfern Pump Station data set is considered the most comprehensive, and therefore this database was used to estimate the raw wastewater quality for which the Lanseria WwTW will be designed. **Table 4** below summarizes the raw wastewater quality that will inform the Lanseria WwTW design.

Table 4: Design wastewater quality for the Lanseria WwTW

Water quality parameter	Unit	Raw Wastewater 50th percentile	Raw wastewater 95th percentile	Settled wastewater 50^{th} percentile	Settled wastewater 95^{th} percentile
Chemical oxygen demand (COD)	mg/ℓ	560	706	392	494
Total suspended solids (TSS)	mg/ℓ	307	412	154	206
Volatile suspended solids (VSS)	mg/ℓ	211	344	106	172
Total Kjeldahl Nitrogen (TKN)	mg/ℓ	48	60	43	54

Water quality parameter	Unit	Raw Wastewater 50th percentile	Raw wastewater 95th percentile	Settled wastewater 50th percentile	Settled wastewater 95th percentile
Ammonia nitrogen (NH_3 as N)	mg/ℓ	26	33	26	33
Total phosphorus (TP)	mg/ℓ	5.6	7.6	5.1	6.9
Orthophosphate (PO_4^{3-} as P)	mg/ℓ	2.2	3.1	2.2	3.1
pH	pH units	7.3	7.5	7.3	7.5
Alkalinity (As $CaCO_3$)	mg/ℓ	220	265	220	265

No provision has been made for industrial wastewater in the calculations of the design wastewater quality for the Lanseria WwTW as it is currently unknown what development will occur in future within the Lanseria catchment.

Diurnal variations for COD, TSS, TKN and TP were also developed, and these are presented in Report No. 13082-45-Rep-001 Basis of Design Report.

6.2.2 Design wastewater characteristics

The wastewater characteristics related to the key wastewater constituents that will be used for the design of the Lanseria WwTW are based on the historical databases as well as the more recent sampling and analysis undertaken during the feasibility stage of this project. The proposed wastewater constituents (fractions) are summarised in **Table 5** below.

Table 5: Wastewater characterisation / fractionation

Wastewater characterisation / fractionation for the Lanseria WwTW raw wastewater

Parameter	Abbreviation	Biowin® default	Lanseria Works proposal
COD fractions:			
Readily biodegradable fraction of COD	f_{bs}	0.16	0.25
VFA fraction of fbs	f_{ac}	0.15	0.14
Soluble un-biodegradable fraction of COD	$f_{s,us}$	0.05	0.046
Particulate un-biodegradable fraction of COD	$f_{s,up}$	0.13	0.09
Volatile solids fraction	VSS/TSS	0.75	0.75
COD / VSS ratio	f_{cv}	1.48	1.48
Nitrogen fractions:			

Parameter	Abbreviation	Biowin® default	Lanseria Works proposal
Fraction of ammonia in TKN	f_{na}	0.66	0.59
Particulate fraction of organic N	f_{nox}	0.5	0.5
Un-biodegradable TKN	$f_{n,ous}$	0.02	0.02
Total phosphorus fractions:			
Fraction of ortho-phosphate in TP	f_{po4}	0.5	0.5
P fraction of fs,up	$f_{sup,p}$	0.011	0.01

6.3 Design Effluent Quality

The discharge quality parameters and associated standards for the Lanseria WwTW have not been negotiated and finalised with the Department of Water and Sanitation. The final target discharge quality profile will be specified in a formal Water Use Licence to be issued by the Department. Table 6 below shows the special discharge standards as usually applied to inland WwTWs as well as the discharge standards currently in effect for the JW WwTWs located in the same catchment. It has been agreed with Johannesburg Water that the discharge standards as applicable to the current WwTWs in the same catchment (labelled 'Anticipated Discharge Standards in Table 6 below) will be used as the target treated effluent quality for the Lanseria WwTW.

Table 6: Anticipated discharge standards for the Lanseria WwTW

Parameter	Units	Special Discharge Standard	Anticipated Discharge Standard
Chemical Oxygen Demand (COD)	mg/ℓ	30	75
Total Suspended Solids concentration (TSS)	mg/ℓ	10	25
Ammonia	mg/ℓ as N	1	2
Nitrate	mg/ℓ as N	1.5	10
Ortho-phosphate	mg/ℓ as P	1	< 1
pH		5.5 – 7.5	5.5 – 9.5
Chlorine	mg/ℓ	0	-
Electrical Conductivity (EC)	mS/m	100	Incoming + 75
Escherichia Coli (E coli)	Per 100 mℓ	0	150

For process design purposes, the discharge standards listed under anticipated discharge standards in **Table 6** above have been adopted. Should the special standards as listed in Table 6 be applied, the following must be noted:

The nitrate discharge standard of 1.5 mg/ℓ may not be achievable by an activated sludge system, given the expected raw wastewater quality. Johannesburg Water prefers to implement the Johannesburg process configuration for their activated sludge systems, as this configuration has produced reliable nutrient removal on wastewaters from the greater Johannesburg catchments for many years. The process will be optimised for denitrification as far as practical, however additional processes may be required if the nitrate discharge standard of 1.5 mg/ℓ is imposed as part of the Water Use Licence. The nitrification / denitrification reactor for treating the sludge liquor, as well as the methanol dosing installation that was included in the tertiary treatment were suggested in order to meet the very low nitrate discharge standard. While the Lanseria WwTW as described in this preliminary design report will be able to produce an effluent that complies with Johannesburg Waters current discharge standards in the North, the aforementioned processes may have to be reconsidered should a nitrate discharge standard of 1.5 mg/ℓ apply. Further, a process configuration change may also have to be considered, because other process configurations have greater denitrification potentials than the Johannesburg process configuration. It is however important to note that none of the available activated sludge process configurations are expected to be able to produce an effluent that complies with the special standard nitrate effluent standard, given the predicted raw wastewater quality for the Lanseria WwTW. However, an alternative process configuration may be able to produce an effluent with a lower nitrate concentration than the Johannesburg configuration is able to produce. The alternative process configuration must however be able to produce an effluent that complies with the other discharge standards as well, and the trade-offs and potential risks must be fully understood. This will be investigated further during the detail design phase.

Further, the special limit discharge standard for COD of 30 mg/ℓ may also be difficult to achieve, considering that under 50th percentile conditions the unbiodegradable soluble COD concentration in the influent is approximately 26 mgCOD/ℓ, while under 95th percentile conditions it is expected to be 32.5 mgCOD/ℓ, which is already higher than the special discharge limit. Unbiodegradable soluble COD cannot be utilised in a biological treatment system and therefore passes through the system and into the effluent unchanged. However, with the load balancing effect of the balancing tank, the COD discharge limit should be achievable most of the time.

Should future requirements include stricter discharge standards, or re-use of the treated effluent, the plant layout has been developed so that the addition of appropriate process units can be accommodated in future.

6.4 Design Sludge Quality

The quality of sludge produced at the Lanseria WwTW will comply with an “A1a” classification as per the Guidelines for the Utilisation and Disposal of Wastewater Sludge 2006. Johannesburg Water’s current sludge disposal method is to deliver the sludge to farms around Gauteng, where it is applied to agricultural lands as soil conditioner and fertiliser. For this reason, it is imperative that the sludge produced at the Lanseria WwTW complies with the "A1a" classification, so it can legally be used for application in agriculture and horticulture.

7 SITE DESCRIPTION AND CONSTRAINTS

7.1 Location

The site identified as most suitable for the development of the new Lanseria WwTW is located approximately 2km's north east of the Lanseria Airport and to the north of Northern Farm, on the northern municipal boundary of the City of Johannesburg. The Jukskei River forms the western border of the site.

The site falls within the Diepsloot Nature Reserve, and borders the Kareebosrand Conservancy and the Rhenosterspruit Nature Conservancy to the north.

The site consists of four farm portions viz. 28, 29, 30 and 31 of the farm Rietfontein No. 532-JQ, as shown in **Figure 2**. The total area of the property is 87.7 ha. These farm portions are currently owned by the City of Johannesburg.

The farm portions to the north and south of these farm portions are not owned by the City of Johannesburg but by private owners.

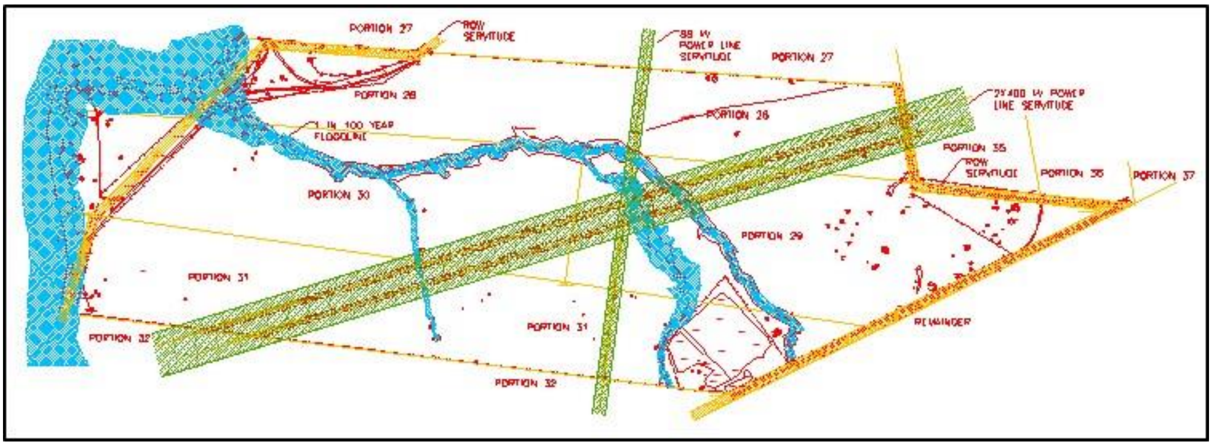


Figure 2 : Site showing Farm Portions

Refer to **Volume 2**: Site Locality Plan (Drawing number 13082-73-01-01-P10).

7.2 Topography, Vegetation and Site Drainage

The site is covered in undulating savannah type grasslands, crossed from east to west and south to north by perennial tributaries of the Jukskei River. The general gradient of the site ranges from 1 in 9 to 1 in 15 towards the streams crossing the site, with a general gradient of about 1 in 11. The drainage system of rivers and streams heads towards the north western corner of the site in deeply weathered and incised channels. Marshy wetlands occur on portions of the southern tributaries possibly as the result of groundwater seepage arising from the irrigation of treated wastewater effluent on the adjacent farm portions.

7.3 Geological setting

The site is underlain by the intrusive Halfway House granite consisting of gneiss, magmatite and porphyritic granodiorite. The weathering of the area is clearly shown in the side slopes of the river channels where the grey brown silty sands predominate. Side slopes in some of the areas are vertical and near vertical. An intrusive geotechnical investigation was undertaken on the site in 2009 (as part of the pre-feasibility study), the results of which are documented in “Report 5164/606 Geotechnical Feasibility Study Portions 28, 29, 30, 31 Rietfontein No. 532 JQ.”

A detailed Geotechnical Investigation was undertaken in 2013 and a Supplementary Geotechnical Investigation in 2016. The Supplementary Investigation was undertaken after the Works layout has been finalised, whereby additional test pitting was done to supplement the matrix of testing that had been done during the detailed investigation. These reports are listed in the supporting reports table.

The results of the supplementary investigation indicated similar geotechnical conditions to the 2013 investigation conducted by Knight Piésold. The site is underlain by granite, which is intruded by scattered thin dolerite dykes. The Jukskei River meanders along the western border of the site, while a stream that flows west into the river intersects the site.

The site can be divided in two areas according to the prevalent geotechnical conditions. The low-lying areas next to the river and streams are generally covered by alluvium with thicknesses that vary from 1,7m (upslope areas) to more than 4m in the stream section, which are underlain by thin residual granite soil and granite bedrock.

The upslope areas are generally covered by a thin layer of colluvium and underlain by residual granite and granite bedrock at shallow depths (average at 1,5m depths).

The construction of the WWTW structures will be conducted in various phases. Most of the structures will be constructed during the first phase, while large structures, which includes the remainder of the balancing tanks, primary settling tanks, biological reactors and clarifiers while be constructed during later phases. All the platforms required for the various structures (in Area 1) will be constructed during the first phase development.

The platforms will be constructed via a cut-to-fill method and it is understood that the excavated rock material will be utilised for the backfilling of the platforms on the downslope areas. The test pits results, with the platform levels, indicate that excavation for the platforms will vary generally between depths of 1m and 5m into bedrock, while backfilling thicknesses will vary from 3m to as much as 16m. It may be recommended to lower the level of the platforms to provide sufficient materials for the backfilling purposes.

It is recommended that the slopes between the platforms should have an allowable slope of between 1:1,5 and 1:2 (V:H). These slopes would not require any further support and would be resistant to erosion from the gravelly nature of the materials. This option is recommended as the most cost effective and will assist in the construction of access ramps from one platform to another.

Foundations for the heavy loaded structures on the platforms should be placed either on bedrock that will be excavated through the constructed platforms if occurs within an economical depth or founded on the platform utilizing bearing pressures of 200kPa maximum. The remainder of the structures to be constructed during the later phases would require excavation depths of generally less than 1m. The excavation for the heavily loaded structures for the first phase can be reduced, should the platforms be lowered, or if several smaller platforms were created.

Bedrock generally occurs at shallow depths at the remainder of the infrastructure, except in the low-lying areas next to the stream. At these positions, over-excavation is required to remove the alluvium with low consistencies to reduce expected differential settlement. Backfilling of the foundations may be conducted either by processed rock material or by G5/G6 quality material to provide suitable localised platforms for the individual structures. Alternatively, the structures close to the streams could be repositioned upslope along areas where bedrock occurs at shallow depths.

It is recommended that backfilling should include a test section prior to the construction of the platforms to determine the suitable number of passes required by a large roller compactor for optimal compaction. Compaction of the G5 or G6 quality materials for larger structures would require placement of the materials in less than 150mm compacted at least to 98% of Modified AASHTO maximum dry density at optimum moisture content. The compaction for the floor of the sludge drying beds, sludge stockpile area or storm-flow dam should reach between 93% and 95% of Modified AASHTO maximum dry density. Berms required at these structures should be designed according to the material strength parameters. Any concrete placed on the residual granite soils should include measures to reduce the effect of the corrosion and aggressiveness properties of the soil.

The access road is generally underlain by suitable roadbed materials at shallow depths. Excavation below the access road should reach depths of 0,4m onto residual granite for the section from the Head of Works towards the position of the four-way stop (DPL16). The remainder of the road only requires the removal of the upper 0,2m to reach dense to very dense residual granite. Nearby quarries can provide suitable base and road stone materials and bitumen products required for the construction of the access road.

Groundwater seepage was not encountered in the test pits, but it is recommended to provide sufficient dewatering equipment since a shallow perched water table may be expected during the rainfall season or excavation may encounter the groundwater table at the low lying areas.

7.4 Site Constraints

There are four servitudes registered on the properties, viz. two Electric Power Line (Eskom) servitudes, and two Right of Way (RoW) road servitudes, as shown in **Figure 2.**

There are also three water courses traversing the site in an east-west direction, which combine into one tributary that discharges into the Jukskei River.

Refer to **Volume 2**: Existing Services and Site Constraints (Drawing number 13082-73-01-01-P00).

7.4.1 Electric Power Line Servitudes

There are two, Eskom owned, 400kV overhead powerlines (transmission lines) running parallel to each other in a north-east south-west direction through the Works. Each powerline has an associated 47m wide servitude according to the title deed, but the power lines were installed 35.36m apart from each other which has resulted in a total servitude width of 82.4m (instead of 94m). This servitude divides the site into two areas, viz. a north-west area and a south-east area.

According to the transmission lines servitude wayleave “no construction or excavation work shall be executed within 27.5m from any Eskom powerline structure, and/or within 27.5m from any stay wire”. It also states that “the use of explosives of any type within 500m from Eskom Transmission (Tx) services shall only occur with Eskom Tx’s permission”.

There is also an Eskom owned 88 kV sub-transmission overhead powerline running in a north-south direction, with a registered servitude width of 21.91m. According to the wayleave on this servitude “no mechanical excavators may be used under or in close proximity to Eskom services without the prior approval of Eskom authorised representatives”. Also “no excavations may be executed closer than five metres from the underground cables and six metres from overhead lines unless an Eskom authorized representative is on site. Cross trenching must be done to establish the exact position of underground cables”.

7.4.2 Right of Way (RoW) Servitudes

Two RoW servitudes are registered on the properties, on the eastern and western boundaries, to enable access for local residents that live adjacent to these properties, and for service providers such as Eskom and Telkom.

The RoW servitude on the western boundary runs through the western portion of the site. Should land on the isolated portion be used to accommodate any part of the Works, piping and access for the Works will have to be accommodated through the servitude. Fencing would also have to be erected on either side of the servitude, to protect the Works and to protect the servitude.

It is recommended that this western RoW servitude be rerouted to the western boundary of the site, so that the servitude and the access road can be accommodated outside the Works footprint.

7.4.3 Telkom Overhead Lines

A topographical survey of the site and surrounds was undertaken, which indicates that Telkom overhead communication cables servicing the residents in the area are located within the RoW servitude.

7.4.4 Natural Streams (Water Courses)

A tributary to the Jukskei that originates further east of the site, flows in an east-west direction through the site, which divides the site into two areas, i.e. a northern area and a southern area. This will result in bridge/s having to be constructed to enable access from the one side of the Works to the other.

There is also a water course originating near the southern border of the site, which joins the tributary of the Jukskei.

The 1:100 year floodlines for each of these watercourses (including that of the Jukskei River) reduces the developable area of the site.

7.4.5 Environmental Constraints

7.4.5.1 Wetland and Wetland Buffer

Due to the nature of the area around the water courses running through the site there are areas within the site marked as Wetland Areas. These areas have an associated 50m buffer area along the perimeter of the Wetland Area, i.e. the Wetland Buffer Areas. This constraint significantly reduces the site area that may be used for the Works, as no part of the Works should be located within Wetland or Wetland Buffer Areas.

The Gauteng Department of Agriculture and Rural Development (GDARD), which is the Environmental Permitting Authority, may not approve a Works layout if any part of the layout is located within these areas, or specific approval from GDARD should be sought to allow encroachment in these areas.

7.4.5.2 Class 1 Ridge

An area of the site has been classified as a “Class 1 Ridge”, i.e. an environmentally sensitive area. This area has an associated 200m buffer area along its perimeter, i.e. a Ridge Buffer Zone. According to GDARD, a maximum of 5% of the Works layout may encroach into the Ridge Buffer Zone.

7.4.5.3 Riparian Zone and Riparian Buffer

The Jukskei River forms the western boundary of the site, which has a Riparian Zone associated with it. This area also has an associated 100m buffer area along its perimeter, i.e. a Riparian Buffer.

The Riparian Zone and Riparian Buffer further reduces the developable area on the site.

7.4.5.4 Available property area

The 1 in 100 year floodline, the Eskom servitudes, and the ROW servitudes reduce the developable area of the site by 22.6% to 77.4 ha. The Environmental constraints reduce the developable area by a further 41.4% which results in a developable area of 31.5 ha.

8 WORKS PHASING STRATEGY

The planning and concept design phases of the project have addressed the layout and design of the ultimate Works capacity of 150 Mℓ/d. This ultimate capacity is to be achieved by implementing three modules of 50 Mℓ/d each. The timing of the implementation of each module will depend on the pace and nature of development in the contributing catchments.

According to the master planning report (dated March 2011, and updated in August 2016), the future phases of the Works will need to be commissioned as follows (depending on the development scenarios described in that report):

- 30 Mℓ/day - 5 years
- 40 Mℓ/day - 10 years

- 50 Mℓ/day - 15 years
- 140 Mℓ/day - 20 years
- 150 Mℓ/day - ultimate

The first phase of the project will be limited to the design, construction and commissioning of a 50 Mℓ/d module of the Works.

However, some components of the Works will be constructed to achieve the ultimate treatment capacity of 150 Mℓ/d. The specific components that will be constructed during this first phase and the reasons that they need to be constructed for Phase 1 are as follows:

Table 7 : Additional Works Components to be Constructed in Phase 1

Works component	Reason for constructing as part of first phase
Bulk Earthworks and Terraces	All terraces will be constructed to accommodate the process units required for the ultimate 150 Mℓ/d Works. The site is underlain by shallow, hard rock which will require blasting to create the terraces. Blasting will be difficult in the latter phases as it may damage structures that have already been constructed, particularly water retaining structures.
Internal Access Roads	The roads to facilitate access around the site will be constructed in conjunction with the terraces. In most cases, each terrace has only one access point.
Storm Water Management	Storm water management measures will be implemented on all terraces and along all roads.
Wash Water Network and Potable Water Network	The wash water and potable water networks are designed in a ring main configuration; hence the entire ring main has to be constructed
Head of Works (HoW)	The HoW structure cannot be developed in phases, due to the configuration of the structure, i.e. common channel sections, splays before and after screening, stone trap, etc. However mechanical equipment will only be installed for the first module.
Fermenters	Two fermenters are required for the ultimate 150 Mℓ/d Works. Both fermenters will be constructed to ensure redundancy in the system. The pump station feeding the fermenters and extracting sludge from the

Works component	Reason for constructing as part of first phase
	pump station will also be constructed in the first phase. The fermenter sizing and number of fermenters to be provided will be revisited during the detailed design phase.
Stormflow Dam	The construction of the dam is largely an earthworks exercise, and will require that rock be blasted during construction. All blasting that is required for the project will be completed in the first phase. It is uneconomical to construct three separate dams for each of the modules. Three separate dams will also require a larger footprint area, which would encroach further on the wetland areas.
Chlorine Contact Channel	The configuration of the contact channel renders a phased approach impractical. The structure has been designed as one integral structure.
Pump Stations	Pump Stations that would require expansion during the latter phases are proposed to be constructed for the ultimate 150 Mℓ/d Works. However, only the pump sets and piping that are required for the first module will be installed in the first phase. (Primary Sludge, Fermented Sludge, WAS and Wash Water Pump Stations)
Buildings	The Administration Building will be built in its entirety, as it would be difficult to provide it in phases. The Workshop will be built in its entirety. Most Control Buildings will only be built as required for the first phase.

9 PROCESS DESIGN

This Section presents the preliminary process design and description for the Lanseria WwTW. A brief process description, design assumptions / criteria and the redundancy philosophies are included for each process unit. Further information can be found in Report No. 13082-45-Rep-003, Process Description for the Base Case Works Design. Process Flow Diagrams (PFDs) for the process design can be found in Volume 2: Drawings of this Report.

9.1 Treatment Process Selection

The Johannesburg Water "Guidelines for the Design of Wastewater Treatment Unit Processes, August 2015" prescribe a biological nutrient removal activated sludge (BNRAS) treatment process including nitrification / denitrification and biological excess phosphorus removal. The Lanseria BNRAS treatment plant includes the following infrastructure:

- HoW (head of works) including screening and degritting;
- Primary sedimentation;
- Volatile Fatty Acid (VFA) fermentation;
- Flow and load balancing;
- BNRAS reactor in Johannesburg process configuration;
- Secondary clarification;
- Disinfection;
- Gravity Waste activated sludge (WAS) pre-thickening;
- Mechanical WAS thickening by gravity belt thickeners (GBT's);
- Anaerobic digestion of thickened WAS and waste fermented primary sludge;
- Forced struvite precipitation;
- Digested sludge dewatering by belt filter presses (BFP's);
- Lime dosing installation to treat sludge liquors;
- Solar enhanced sludge drying / composting.

Figure 3 below shows a simplified liquid stream flow diagram for the Lanseria WwTW, and **Figure 4** shows the corresponding simplified sludge stream flow diagram.

By including primary sedimentation tanks, it is inferred that the Lanseria WwTW be designed to treat settled wastewater. However, in practice JW Operations do not operate their existing Works as settled wastewater treatment plants. Through years of experience, JW Operations have fine-tuned the operation of their Works to optimise biological N and P removal, thereby ensuring that their WwTWs produce the best possible treated effluent quality.

One of the outcomes of the aforementioned relates to the operation of the primary sludge fermenters. All primary sludge produced at the primary sedimentation tanks is fed to the primary sludge fermenters, however almost no waste fermented primary sludge is wasted to the anaerobic digester installations. By not wasting fermented primary sludge, the fermented primary sludge is allowed to carry over with the elutriant into the biological reactors, which means that the biological reactors are in fact treating raw wastewater (i.e. the full incoming COD load) rather than settled wastewater (i.e. the full incoming COD load less the primary sludge COD load). JW operations have found that by operating their primary sludge fermenters in this manner, they are able to significantly enhance the biological N and P removal capacity of their activated sludge plants.

Feeding raw wastewater to a bioreactor that has been designed to treat settled wastewater has the following effects on the bioreactor:

- Sludge production within the bioreactor increases, resulting in an increase in the Mixed Liquor Suspended Solids (MLSS) concentration of the activated sludge, and
- Significantly increased oxygen demand.

JW operations responds to the increased biological reactor MLSS by increasing the WAS volume (thereby decreasing the sludge age of the biological reactor) until the MLSS concentrations are within the normal operating range. This results in significantly larger sludge volumes being wasted than would be the case for treating settled wastewater, and the increase in WAS volumes can overload the sludge handling and treatment installation of the respective WwTW, which would have been designed to treat the lower WAS volumes generated by a biological reactor treating settled wastewater.

For this reason JW have requested that the sludge handling and treatment facilities for the Lanseria WwTW be sized to accommodate the larger WAS volume resulting from the manner in which JW operates their WwTWs. This request was incorporated into the design of the sludge handling and treatment process units described below, and where applicable two unit process sizes are presented, one as designed for treating settled wastewater, and an amended size to cater for an increased WAS flow due to feeding the bioreactors raw wastewater.

JW further indicated that the bioreactor sizing shall not be adjusted for treating raw wastewater (i.e. the bioreactor sizing is based on treating settled wastewater), however cognisance of the increased oxygen demand shall be taken during the sizing of the aeration system.

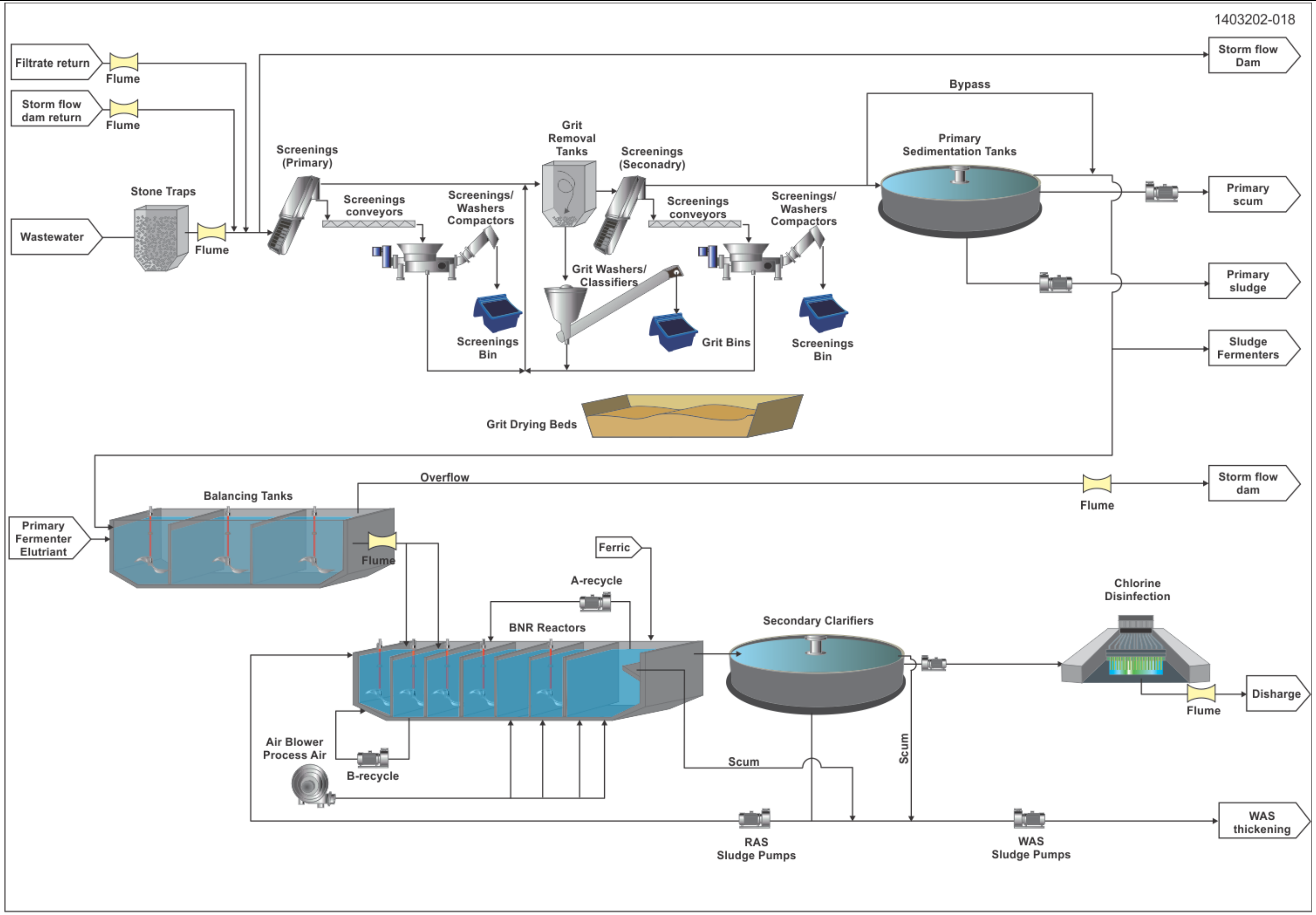


Figure 3 : Lanseria WwTW simplified liquid stream flow diagram

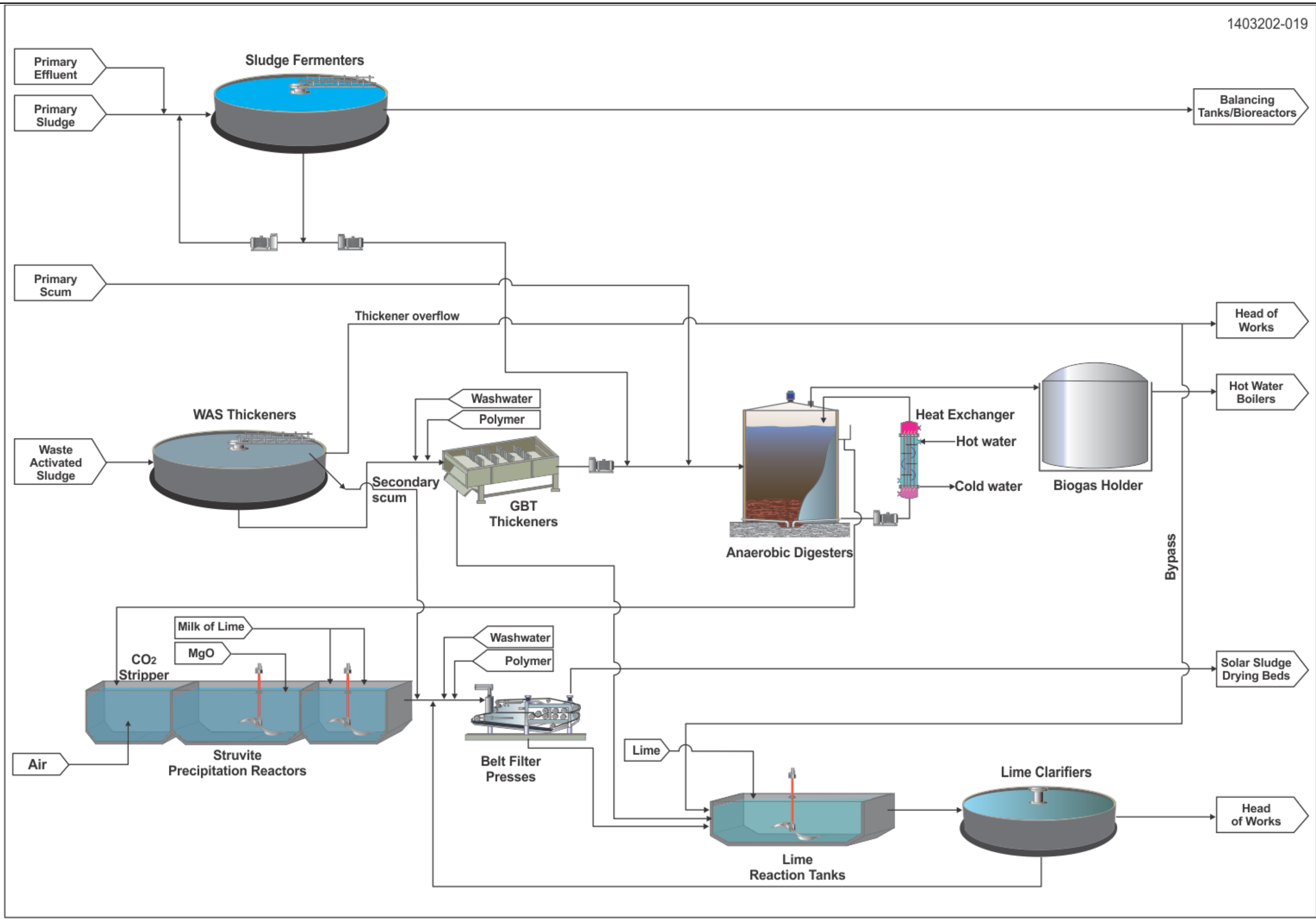


Figure 4 : **Lanseria WwTW simplified sludge stream flow diagram**

9.1 Mainstream (Liquid) Treatment

9.1.1 Head of Works

The head of works is shown on process flow diagram (PFD) 13082-72-4-PFD-01 and 13082-72-4-PFD-02. It is anticipated that one outfall sewer will convey the incoming raw wastewater to the Lanseria WwTW. The outfall sewer discharges by gravity into the Lanseria WwTW head of works. The head of works consists of the following:

- Stone traps (duty / standby, 2.0m x 2.5m x 1m each) to remove stones down to a minimum size of 25 – 50 mm. Two stone traps will be provided, so that one may be cleaned while the other is in use;
- Main incoming flow measurement by means of a venturi flume;
- One hydraulic bypass to bypass storm peaks to stormflow dam;
- Four front raked mechanical coarse (12 mm) bar screens fitted with hydraulic screenings conveyor and two screenings washer / compactors (duty / standby);
- Two emergency bypass channels to bypass the coarse screening installation, each fitted with hand raked bar screens (50 mm);
- Six hydraulically assisted vortex degritters, each fitted with a compressed air and high pressure wash water grit loosening system and an air lift pump grit removal system, and two screw classifiers with agitated cyclone hoppers and inclined screws (duty / standby);
- Four rotating drum fine screens (6 mm) fitted with hydraulic screenings conveyor and two screenings washer / compactors (duty / standby);
- Emergency bypass channel to bypass fine screening installation, fitted with hand raked bar screen (10 mm).

The wastewater enters the head of works at the stone traps. It flows through one stone trap, while the other is isolated for cleaning. The stone removal / cleaning mechanism will be decided upon during detailed design. A venturi flume is located downstream of the stone traps to measure the total incoming wastewater flow.

Downstream of the flow measurement the flow is hydraulically split into four coarse screening channels. Each channel can be isolated upstream and downstream of the respective coarse screens by means of sluice gates. Just upstream of the split, a hydraulic overflow is provided, which will redirect all storm peaks that are larger than the peak wet weather flow (PWWF) to the stormflow dam. Two bypass channels are provided for the coarse screening installation, where all flows up to PWWF can bypass the coarse screens should the screens blind, or should more than one coarse screening channel be isolated. Both bypass channels are fitted with manually raked coarse bar screens. The wastewater combines downstream of the coarse screening channels, before it is hydraulically split between the hydraulically assisted vortex degritters.

The wastewater is hydraulically split between six hydraulically assisted vortex degritters. Each of the six degritter trains can be isolated by means of sluice gates installed upstream and downstream of each respective degritter. The wastewater is again combined downstream of the vortex degritter installation.

Downstream of the vortex degritter installation the wastewater is hydraulically split between four fine screening channels. Each channel can be isolated upstream and downstream of the respective fine screens by means of sluice gates. One bypass channel has been provided for the fine screening installation, where all flows up to PWWF can bypass the fine screens should the screens blind, or should more than one fine screening channel be isolated. The bypass channel is fitted with a manually raked fine bar screen. The wastewater combines downstream of the fine screening channels, from where it flows in one channel towards the primary sedimentation installation.

Return water from the coarse screening, degritting and fine screening installations is reintroduced into the inlet channel of each respective installation.

A drying bed / slab will be provided at the head of works. This drying bed / slab may be utilised in emergencies should the grit receiving skips be full or unavailable, and it can also be utilised to receive sand and other material removed from other process units during routine cleaning / maintenance. Excess water from the drying bed / slab is returned to the HoW, upstream of the vortex degritters.

The HoW has been sized to hydraulically accommodate the PWWF. The entire civil portion of the head of works will be provided under Phase 1, however only two coarse screening channel, two vortex degritters and two fine screening channels will be equipped with mechanical equipment. The remaining civil infrastructure will be filled with sand and backfilled with screed, to be utilised and equipped under Phases two and three.

<u>Head of works redundancy philosophy</u>

Each coarse screening channel, vortex degritter and fine screening channel has the capacity to take one third of the PWWF. One of each the coarse screens, vortex degritters and fine screens can be taken offline and the remaining three in operation are still able to take the full PWWF.

For Phase 1, two coarse screens, two vortex degritters and two fine screens will be provided, which in effect can be used as a duty / standby system should this be required.

Two coarse screens will share one hydraulic screenings conveyor (sluicing channel), and the same philosophy applies to the fine screens hydraulic screenings conveyors. No redundancy is provided for in terms of screenings conveyors. Two coarse screenings washer / compactor will be provided, sized for the ultimate plant capacity. They will operate on a duty / standby basis. The same philosophy is carried through to the grit classifiers and the fine screenings washer / compactors.

9.1.2 Storm Flow Dam

The stormflow dam is shown on PFD 13082-72-4-PFD-01.

One 20,000m^3 lined earthen storm flow dam is provided for. The Johannesburg Water "Guidelines for the Design of Wastewater Treatment Unit Processes, August 2015" recommends a nominal hydraulic retention time for a storm flow dam as 1 to 2 hours of the difference between PWWF and average dry weather flow (ADWF). The Lanseria WwTW storm flow dam was sized to provide a nominal hydraulic retention time of 2.3 hours of the difference between PWWF and ADWF.

Storm flows higher than the expected PWWF will hydraulically be diverted from the head of works, upstream of the coarse screening installation, to the storm flow dam. Wastewater flows will gravitate to the storm flow dam.

The stormflow dam has an emergency overflow which spills to the river, should the dam be over full. The emergency spills to the river are measured and recorded. Three pumps (two duty and one standby) are provided to pump the content of the stormflow dam back to the head of works. The return flow from the storm flow dam is measured, and re-introduced to the head of works downstream of the raw wastewater flow measurement infrastructure, and upstream of the coarse screening installation.

The full 20,000 m^3 storm flow dam will be provided under Phase 1.

Storm flow dam redundancy philosophy

No redundancy is provided in terms of the storm flow dam.

9.1.3 Primary sedimentation

The primary sedimentation process is shown on PFD 13082-72-4-PFD-03.

The wastewater flows from the head of works in a channel to the primary sedimentation division box, where it is divided between six primary sedimentation tanks (2 per 50 Mℓ/d Module). A bypass is provided just upstream of the primary sedimentation division box, where the wastewater can be diverted directly to the balancing tanks. This bypass also acts as an emergency bypass, hydraulically diverting wastewater that cannot pass through the primary sedimentation division box to the balancing tanks. The design parameters for each primary clarifier are listed in **Table 8** below.

The overflow from the primary sedimentation tanks (settled wastewater) flows under gravity to the balancing tank installation. The underflow (primary sludge), abstracted from the bottom of the primary sedimentation tanks, gravitates to the mixed primary sludge sump. Three primary sludge pumps (two duty / one standby) convey the primary sludge to the fermentation installation. The primary sludge pumps and sump will have the option to divert the primary sludge to the fermented sludge sump (this will allow the fermenters to be bypassed) from where it can be pumped directly to the anaerobic digesters. The pumped primary sludge is a measured flow.

Table 8: Primary sedimentation tank design parameters

Parameter	Units	ADWF	PDWF	PWWF
No. of primary sedimentation tanks	No.	6		
Diameter	m	35.0		
Sidewall depth	m	4.0		
Floor slope	-	1:6		
Volume	m^3	3846.5		
Upflow rate (6 operational)	m/h	1.10	1.95	2.60
Solids loading rate (6 operational)	$kg/m^2.h$	0.33	0.80	1.07
Upflow rate (5 operational)	m/h	1.30	2.34	3.12
Solids loading rate (5 operational)	$kg/m^2.h$	0.40	0.96	1.29

Each primary clarification tank is equipped with a full diameter scraper mechanism and half diameter peripheral drive bridge, one scum removal box, scum baffle and v-notch overflow weir.

Two primary sedimentation tanks will be provided for Phase 1.

Primary scum

Primary scum gravitates from the scum removal boxes to a primary scum concentrator, where the excess water is removed and routed to the balancing tanks. The concentrated scum is collected in the primary scum sump which is equipped with one duty and one standby primary scum pumps, from where it is pumped to the anaerobic digesters.

Primary sedimentation tank redundancy philosophy

The primary sedimentation tanks are designed based on 5 duty operational units, 1 redundant unit for the ultimate 150 Mℓ/d plant, with two units provided per 50 Mℓ/d module. Therefore, each individual unit is sized for 15% above the design flow. For Phase 1, where two primary sedimentation tanks are provided, the full redundancy will not be available. The primary sedimentation tanks are designed to accommodate the full PWWF.

9.1.4 VFA fermentation

The volatile fatty acid (VFA) fermentation process is shown on PFD 13082-72-4-PFD-11.

The primary sludge from the primary sludge pump station is pumped to the sludge compartment of the fermenter division box, where it is hydraulically split between two primary sludge fermenters. The fermenters provide sufficient retention time for the primary sludge to ferment, thereby producing VFA's. The overflow of the fermenters (elutriant) contains the VFA's, and the elutriant gravitates directly to either (i) the anaerobic zones of the bioreactors, or (ii) to the balancing tanks. The underflow of the fermenters (fermented sludge) gravitates to a mixed fermented sludge sump, from where it is either recycled via three recycle pumps (two duty / one standby) to the fermenter division box, or wasted via two waste pumps (duty / standby) directly to the anaerobic digesters.

A portion of settled wastewater is abstracted and diverted to a settled wastewater sump. Two settled wastewater pumps are provided (duty / standby) to pump a measured volume of settled wastewater into the settled sewage compartment of the fermenter division box, where it will be hydraulically split between the two fermenters. The settled wastewater is added to aid flushing of the volatile fatty acids (VFA's) produced in the fermenters from the sludge into the elutriant (overflow) of the fermenters.

The design parameters for each fermenter are listed in **Table 9** below.

Table 9: Fermenter design parameters

Parameter	Units	Minimum Flow	Average Flow	Maximum Flow
No. of fermenters	No.		2	
Diameter	m		20	
Sidewall depth	m		5	
Floor slope	-		1:6	
Volume per fermenter	m^3		1 570	
Sludge retention time	d	3.1	4.2	5.2
Upflow rate*	m/h	0.27	0.31	0.72

*Upflow rates take cognisance of the settled wastewater 'elutriation washout' flow

The Johannesburg Water "Guidelines for the Design of Wastewater Treatment Unit Processes, August 2015" design criteria for fermenters specifies a solids retention time in the fermenters of between 2 and 6 days. The solids retention time for the fermenters at the Lanseria WwTW ranges between 3.1 and 5.2 days. The Guidelines state that provision shall be made for introducing of a volume of settled wastewater equal to three times the maximum primary sludge flow to act as 'elutriant washout'. The fermenters at the Lanseria WwTW are designed to receive an average settled wastewater flow of one times the maximum primary sludge flow and a maximum of three times the maximum primary sludge flow.

Each fermenter is equipped with a full diameter scraper mechanism with full diameter picket fence and half diameter centre-drive bridge and v-notch overflow weir.

Both fermenters will be provided for Phase 1, and it is recommended that they are operated on a one duty fermenter and one standby fermenter basis for Phase 1.

The number of fermenters provided will be revisited during the detail design phase. Should it be decided to provide three rather than two fermenters, the diameter of each fermenter will reduce to 15 m. For this scenario two fermenters would be provided for Phase 1 and one additional fermenter would be provided for Phase 3.

Fermenter redundancy philosophy

No redundancy is provided for the Lanseria WwTW fermenters. Should one fermenter be taken out of commission, the remaining fermenter will be able to accommodate half the primary sludge flow, or operate at double the upflow velocities.

9.1.5 Flow balancing

Flow balancing is shown on PFD 13082-72-4-PFD-04.

The overflow from the primary sedimentation tanks (settled wastewater) flows to a balancing tank division box, where the settled wastewater flow is hydraulically divided between three sets of balancing tanks. One set of two balancing tanks is provided for each 50 Mℓ/d treatment module.

The two balancing tanks that make up one set for each 50 Mℓ/d treatment module will share a common wall, and they can be operated as two independent balancing tanks or as one combined balancing tank. All balancing tanks are mechanically mixed, to avoid organic material settling out in the balancing tanks. All balancing tanks is equipped with an emergency overflow that automatically routes all excess flow to the storm flow dam, when the balancing tanks are filled to over their design capacity. All excess flow will flow to the storm flow dam under gravity.

The volume of each balancing is based on a cumulative inflow derived from the diurnal flow pattern shown in **Figure 1** above. **Table 10** below lists the design volumes of the flow balancing tanks. The design volumes have been increased by 5 % to provide for dead storage and accumulation of debris and grit within the balancing tanks.

Table 10: Lanseria WwTW balancing tank volumes

Parameter	Units	Volume
Combined balancing tank volume for ultimate 150 Mℓ/d capacity	m^3	37 440.0
Volume of each set of balancing tanks serving one 50 Mℓ/d module	m^3	12 480.0
Volume of each balancing tank compartment	m^3	6 240.0

The outlet of each balancing tank is equipped with a control valve and flow meter, allowing the outflow of wastewater from each balancing tank to be automatically controlled. The wastewater from each set of balancing tanks combines into one division box, from where it is hydraulically divided between two 25 Mℓ/d BNRAS treatment modules. The settled wastewater is routed to the pre-anoxic and anaerobic compartments of each 25 Mℓ/d BNRAS treatment module. A manual valve and a flow meter is provided for each feed so that the volume of wastewater fed to each pre-anoxic and anaerobic compartment can be manually adjusted.

One set of two balancing tanks will be provided for Phase 1.

<u>Balancing tank redundancy philosophy</u>

The balancing tanks are designed based on a 5 duty units, 1 redundant unit philosophy for the ultimate 150 Mℓ/d plant, with two units provided per 50 Mℓ/d module. Therefore, each individual unit is sized for 15% above the actual design volume.

9.1.6 Biological nutrient removal

The activated sludge reactors and blowers are shown on PFD 13082-72-4-PFD-05 and 13082-72-4-PFD-06. The secondary clarifiers are shown on PFD 13082-72-4-PFD-07.

<u>Activated sludge reactor</u>

The design wastewater characteristics and parameters are listed in Table 4 and Table 5 above. Further design assumptions and operating parameters used for the preliminary process design of the activated sludge reactors are listed in **Table 11** below. The settled wastewater flow is treated in three separate 50 Mℓ/d modules, each module consisting of two adjoining, but completely independent bioreactors with a 25 Mℓ/d treatment capacity each.

The process configuration of the bioreactors is the Johannesburg system consisting of the following zones in series:

- Pre-anoxic Zone;
- Anaerobic Zone;
- Anoxic Zone;
- Aerobic Zone.

The a-recycle transfers mixed liquor from the end of the aerobic zone to the beginning of the anoxic zone, and a b-recycle transfers mixed liquor from the end of the anaerobic zone to the beginning of the pre-anoxic zone. Return activated sludge (RAS) from the secondary clarifiers is introduced at the beginning of the pre-anoxic zone, and the feed wastewater is split between the beginning of the pre-anoxic zone (0% – 15%) and the beginning of the anaerobic zone (85% - 100%). Under normal circumstances waste activated sludge (WAS) is wasted from the RAS stream to minimise the volume of WAS pumped to the sludge thickening installation. A facility is however provided to waste WAS directly from the bioreactors, however this should be done only under emergency situations, because the WAS thickening installation is designed for waste from the RAS stream.

Table 11: Activated sludge model parameters and design criteria

Parameter	Units	
Minimum temperature	ºC	13.0
Maximum temperature	ºC	23.0
MLSS (minimum)	mg TSS/ℓ	2 000.0
MLSS (maximum)	mg TSS/ℓ	6 000.0
Operating MLSS summer	mg TSS/ℓ	3 000.0
Operating MLSS winter	mg TSS/ℓ	5 000.0
Sludge age winter	d	16
Sludge age summer	d	10

Based on the preliminary process design, the total reactor volume required for the ultimate 150 Mℓ/d treatment capacity is 69 165 m^3. This means that each of the six 25 Mℓ/d treatment capacity bioreactors require a capacity of 11 528 m^3, however due to the redundancy philosophy (see below) this increases to 13 833 m^3. Each reactor will be provided with one pre-anoxic cell, one anaerobic cell, two anoxic cells and three aerobic cells.

The Johannesburg Water “Guidelines for the Design of Wastewater Treatment Unit Processes, August 2015” design criteria for the bioreactors specifies a minimum aerobic mass fraction of 0.6 of the total volume, which leaves 0.4 as unaerated mass fraction. However, should a nitrate discharge limit of 1.5 mg/ℓ be specified in the WUL, it is recommended to increase the unaerated mass fraction to 0.5. In order to provide Johannesburg Water with flexibility regarding the unaerated mass fraction, it is recommended to convert the last anoxic compartment into a swing zone, so that a portion of it can be aerated by switching the aeration on, which would provide an aerated mass fraction of 0.6, or it can be converted to additional anoxic capacity by switching the aeration off, providing an unaerated mass fraction of 0.5 or 0.55. The additional unaerated mass fraction will increase the denitrification potential of the bioreactor, and therefore reduce the effluent nitrate concentration, if and when required.

Table 12 below lists the cell sizes and mass fractions applicable to each of the 25 Mℓ/d treatment capacity bioreactors.

Table 12: Sizing for each of the 6 x 25 Ml/d treatment capacity bioreactors

	Units	0.60 Aerobic Mass Fraction	0.55 Aerobic Mass Fraction	0.50 Aerobic Mass Fraction
Pre-anoxic cell	m^3	692	692	692
Pre-anoxic mass fraction		0.05	0.05	0.05
Anaerobic cell	m^3	1 383	1 383	1 383
Anaerobic mass fraction		0.10	0.10	0.10
Anoxic cell 1	m^3	1 729	2 075	2 420
Anoxic cell 2	m^3	1 729	2 075	2 420
Anoxic mass fraction		0.25	0.30	0.35
Aerobic cell 1	m^3	2 767	2 536	2 305
Aerobic cell 2	m^3	2 767	2 536	2 305
Aerobic cell 3	m^3	2 767	2 536	2 305
Aerobic mass fraction		0.60	0.55	0.50
Total volume	**m^3**	**13 833**	**13 833**	**13 833**
Unaerated mass fraction		0.40	0.45	0.5
Aerated mass fraction		0.60	0.55	0.50
Anoxic cell 2 (without swing zone)		-	1 383	1 038
Swing zone volume		-	692	1 382

The internal dividing walls between the cells will be submerged walls (submerged weirs), to ensure scum forming on the surface of the reactor passes through the reactor in the direction of flow. In addition, a descumming point will be placed above the location where WAS will be withdrawn to allow for manual descumming should this be necessary. Unaerated cells will be mechanically mixed by means of vertical shaft, radial flow mixers equipped with auxiliary axial flow impellers to prevent scum formation around the mixer shafts.

Air will be introduced into the mixed liquor contained in the aerobic zones by means of a fine bubble diffused aeration system. The air volumes can be adjusted by manipulation of the air supply to the reactors by means of suitable air flow control valves, in combination with variable speed drive blowers and / or automatic adjustment of the blower's inlet guide vanes and the variable diffuser vanes. The degree of adjustment will be determined by continuous online measurement of the Dissolved Oxygen (DO) and Ammonia. Low DO concentrations have been noted as one of the main reasons for the production of MLSS with poor settling characteristics (known as bulking sludge). This defines a condition in the activated sludge process that can cause high effluent suspended solids and poor treatment performance. The aeration equipment will therefore be sized to maintain a dissolved oxygen concentration of 2 mg/ℓ in the bulk liquid of the first two aerobic cells, and 1 mg/ℓ for the last aerobic cell, to minimise DO recycle to the anoxic zone via the a-recycle. Sufficient aeration capacity will however be installed in the last aerobic cell to cater for winter conditions, when the oxygen demand tends to move towards the end of the aerobic zone.

Each of the six bioreactors will have its own dedicated air supply header and duty blower. A shared standby blower is supplied for each set of two bioreactors. The expected average oxygen demands for the aerated cells calculated for the preliminary process design are summarised in **Table 13** below. The oxygen demands were calculated for two scenarios, (i) bioreactors treating settled wastewater and (ii) bioreactors treating raw wastewater to take account of the manner in which JW operate their primary sludge fermenters. Peak oxygen demands, taking account of the diurnal COD, TKN and ammonia loads will be applied during detailed design.

Table 13: Average oxygen demand for aerobic cells of each of the 6 bioreactors

	Units	SOR Standard Oxygen Requirement (Settled Wastewater)	AOR Actual Oxygen Requirement (Settled Wastewater)	SOR Standard Oxygen Requirement (Raw Wastewater)	AOR Actual Oxygen Requirement (Raw Wastewater)
Winter conditions (16 d sludge age)					
Oxygen demand - aerobic cell 1	kgO/d	3 600	12 000	4 450	14 820
Oxygen demand - aerobic cell 2	kgO/d	3 360	11 200	4 250	14 170
Oxygen demand – aerobic cell 3	kgO/d	2 850	9 500	3 400	11 320
Total oxygen demand	kgO/d	9 810	32 700	12 100	40 310
Summer conditions (10 d sludge age)					
Oxygen demand - aerobic cell 1	kgO/d	4 700	14 006	4 950	14 751
Oxygen demand - aerobic cell 2	kgO/d	3 000	8 940	4050	12 070
Oxygen demand – aerobic cell 3	kgO/d	1 850	5 513	2350	7 003
Total oxygen demand	kgO/d	9 550	28 459	11 350	33 824

Three a-recycle pumps (2 duty, 1 standby) and two b-recycle pumps (1 duty, 1 standby) will be provided for each bioreactor. Activated sludge will be discharged from the bioreactors over adjustable weirs located at the downstream side of the third aerobic cell.

Provision is made to waste WAS from either each bioreactor directly, or alternatively from the RAS flow to each bioreactor.

Two activated sludge reactors will be provided for Phase 1, providing a 50 Mℓ/d treatment capacity.

Bioreactor redundancy philosophy

The bioreactors are designed based on a 5 duty units, 1 redundant unit philosophy for the ultimate 150 Mℓ/d plant, with two units provided per 50 Mℓ/d module. Therefore, each individual unit is sized for 15% above the actual design volume.

Secondary Clarification

Mixed liquor from each bioreactor gravitates to a flow division box, where the activated sludge is hydraulically divided between two secondary clarifiers. A total of twelve secondary clarifiers are provided for the ultimate 150 Mℓ/d capacity, four for every Phase. The design parameters for each secondary clarifier are listed in **Table 14** below.

Table 14: Secondary clarifier design parameters

Parameter	Units	ADWF	PDWF	PWWF
No. of secondary clarifiers	No.	12		
Diameter	m	33.0		
Sidewall depth	m	4.0		
Floor slope	-	1:6		
Volume	m^3	3 420		
Upflow rate (3 per module operational)	m/h	0.8	1.6	-
Solids loading rate (incl. RAS solids, 3 per module operational)	$kg/m^2.d$	120.0	188.0	-
Upflow rate (4 per module operational)	m/h	0.6	1.2	-
Solids loading rate (incl. RAS solids, 4 per module operational)	$kg/m^2.d$	102.0	142.0	-

The overflow from each set of two secondary clarifiers will first common up for sampling purposes and thereafter flows under gravity to the disinfection installation. The underflow (RAS) from each set of two secondary clarifiers, gravitates to a dedicated RAS screw pump stations for each respective bioreactor, and is returned to the pre-anoxic compartment of each bioreactor. The RAS flow to each bioreactor is measured. Each RAS screw pump station is equipped with two screws, one duty and one standby per bioreactor.

The WAS from each bioreactor is withdrawn from each respective bioreactor's RAS flow, downstream of the screw pump station. Each WAS flow is measured and the WAS from all bioreactors collects in a shared WAS sump, from where it is pumped to the gravity WAS thickening installation by two (duty / standby) WAS pumps. Scum from the bioreactors and the secondary clarifiers is also routed to the shared WAS sump and pumped together with the WAS to the gravity WAS thickening installation.

Each secondary clarification tank is equipped with an inlet flocculation well / baffle, a full diameter spiral configuration scraper mechanism and half diameter peripheral drive bridge, one scum removal box, scum baffle, Stamford baffle on cantilever launder and v-notch overflow weir.

Four secondary clarifiers will be provided for Phase 1. However, the number and sizing of the secondary clarifiers will be revisited and confirmed during detail design, by means of a full solids flux analysis on the secondary clarifiers.

Secondary scum

Secondary scum gravitates from the scum removal boxes to the WAS sump, from where it pumped together with the WAS to the gravity WAS installation.

Secondary clarifier redundancy philosophy

The secondary clarifier design is based on 2 duty per Reactor and 4 per 50 Mℓ/day module therefore if one clarifier is taken out of service for maintenance the flow to its Reactor will have to be decreased and the flow to the other Reactor increased.

9.1.7 Tertiary treatment

Disinfection

The disinfection process is shown on PFD 13082-72-4-PFD-09.

The overflow from the secondary clarifiers (treated effluent) gravitates to the chlorine contact division box, where it is hydraulically divided between three chlorine contact channels. A bypass is provided which routes the flow to the flow collection box downstream of the chlorine contact channels, effectively bypassing the channels. **Table 15** below lists the design parameters for the chlorine contact channels.

Table 15: Secondary clarifier design parameters

Parameter	Units	ADWF	PDWF	PWWF
No. of chlorine contact channels	No.	3		
Volume per channel	m^3	1 050		
Retention time per channel	min	30	15	-

Each contact channels discharges into a shared collection box, from where the treated and disinfected effluent is metered and discharged to the River. A turbulent zone will be incorporated either at the outlet of the channels or further downstream to cater for re-aeration of the treated effluent and help dissipate residual chlorine in the treated effluent.

Sludge accumulating at the bottom of the channels can be withdrawn into a chlorine contact sludge sump. Provision is made for the withdrawal of scum from the chlorine contact channel division box, and the scum is also routed to the chlorine contact sludge sump. Two pumps (duty / standby) are provided to pump the sludge and scum to the WAS sump at the secondary clarifiers, from where it joins the WAS and secondary clarifier scum which is pumped to the WAS gravity thickening.

A standard Johannesburg Water Di Basic Filtrate (DBF) chlorine dosing installation will be provided, capable of dosing variable quantities of DBF into the treated effluent with a dosing range of between 3 mg/ℓ as chlorine equivalent and 10 mg/ℓ as chlorine equivalent at ADWF.

<u>Redundancy philosophy for chlorine contact channels</u>

No redundancy is incorporated for the chlorine contact channels.

<u>Further / future tertiary treatment</u>

Sufficient space will be provided around the tertiary treatment terrace to allow for future process units to be added if necessary. The effluent suspended solids (SS) standard of 10 mg/ℓ is low, however Johannesburg Water have indicated that they currently achieve this at their other works, and an additional process for SS removal (e.g. sand filtration) is therefore currently not necessary.

9.1.8 Metal salt addition

A standard Johannesburg Water ferric chloride storage and dosing installation will be provided to dose ferric chloride into the aerobic zones of the bioreactors. The ferric chloride installation will act as a backup phosphate removal system, should problems be experienced with the biological excess phosphorus removal process. The ferric chloride storage and dosing installation will be located adjacent to the BNR reactor terrace. Should site conditions allow, it will be located on a higher level than the bioreactors, to allow gravity dosing of the ferric chloride, should the dosing pumps be not available / operable.

9.2 Sludge Treatment

9.2.1 Waste activated sludge pre-thickening

The WAS pre-thickening process is shown on PFD 13082-72-4-PFD-12.

The combined WAS, secondary clarifier scum and chlorine contact channel sludge are pumped to the gravity WAS thickener division box, where it is hydraulically divided between the gravity WAS thickeners. A total of four gravity WAS thickeners are provided for the ultimate 150 Mℓ/d capacity. Two gravity WAS thickeners will be provided for Phase 1, and one additional gravity WAS thickener for Phases 2 and 3 respectively. The design parameters for each WAS thickener are listed in **Table 16** below, for the following 2 scenarios (i) sized for WAS flow produced by treating settled wastewater, and (ii) sized for WAS flow produced by treating raw wastewater due to JW operations protocol of operating their primary sludge fermenters.

Table 16: Gravity WAS thickener design parameters

Parameter	Units	Average	Peak
Settled Wastewater Design			
No. of gravity WAS thickeners	No.	4	
Diameter	m	17.0	
Sidewall depth	m	5.0	
Floor slope	-	1:6	
Solids loading rate (3 in operation)	kg/m^2.d	29.9	32.5
Solids loading rate (4 in operation)	kg/m^2.d	21.6	24.4
Raw Wastewater Design			
No. of gravity WAS thickeners	No.	4	
Diameter	m	22.0	
Sidewall depth	m	5.0	
Floor slope	-	1:6	
Solids loading rate (3 in operation)	kg/m^2.d	29.3	32.5
Solids loading rate (4 in operation)	kg/m^2.d	21.4	24.5

The design of the gravity WAS thickeners is based on the solids loading rate applied to each thickener rather than an upflow rate. When raw wastewater is treated in the bioreactor, the sludge production in the bioreactor increases, and therefore the mass of sludge wasted from the bioreactor increases. The increase in the mass of waste sludge in turn increases the sludge loading rate in the gravity WAS thickeners, and therefore larger diameter gravity thickeners are required for the scenario where the bioreactors treat raw wastewater as opposed to settled wastewater. As per JW's request, the infrastructure will be sized as per the raw wastewater scenario.

The WAS gravity thickener overflow flows under gravity to the filtrate pump station, from where it is returned to the head of work. Provision is made to route the gravity thickener overflow to the lime dosing installation (described below) for phosphate and solids removal, should high phosphate concentrations and / or solids carryover occur in the WAS gravity thickeners.

The thickened WAS withdrawn from the bottom of the gravity WAS thickeners is expected to be thickened to between 1 and 2%. The gravity thickened was flow under gravity to two gravity thickened WAS storage sumps, which are mechanically mixed. Provision is made for coarse bubble aeration to be installed at the gravity thickened WAS storage tanks in future, to avoid nutrients being released into the bulk liquid under unaerated conditions. Johannesburg Water has indicated that the coarse bubble aeration system shall not be installed for Phase 1. The gravity thickened WAS storage tank provides a two-day retention time to offer some storage capacity, should the downstream mechanical thickening infrastructure experience operational problems.

Each gravity WAS thickener is equipped with an inlet stilling well, a full diameter spiral configuration scraper mechanism and full diameter fixed bridge with a centre drive for the sludge scraper, one scum removal box, scum baffle, v-notch overflow weir.

Gravity WAS thickener scum

The scum from the gravity WAS thickeners gravitates from the scum removal boxes to a dedicated scum sump located at the filtrate pumps station, from where it pumped to the digested sludge storage tanks located upstream of the dewatering installation. Provision is also made to divert the gravity WAS thickener scum to the drying beds provided at the anaerobic digesters. The gravity WAS thickener scum, which also contains the scum from the bioreactors and the secondary clarifiers is sent directly to dewatering and not to the anaerobic digesters, to avoid filamentous organisms entering the anaerobic digesters, which may cause foaming within the anaerobic digesters.

Gravity WAS thickener redundancy philosophy

The gravity WAS thickener design is based on a 3 duty, 1 redundant basis. Under normal circumstances all four thickeners will be operational, however should one be taken offline, the remaining three are able to take the full WAS flow (sourced from the RAS streams) from the bioreactors.

9.2.2 Mechanical waste activated sludge thickening

The mechanical WAS thickening process is shown on PFD 13082-72-4-PFD-13.

The gravity pre-thickened WAS is further thickened in a mechanical thickening installation, from an expected 1 – 2 % to between 5 – 7%. Gravity belt thickeners (GBT's) are provided for the mechanical thickening of the WAS. The GBT's will have a belt width of 2.0 m – 2.5 m.

The gravity pre-thickened WAS is stored in the mechanically mixed gravity thickened WAS storage tanks, upstream of the mechanical thickening installation. Three GBT feed pumps (2 duty, 1 standby) pump the pre-thickened WAS into a ring main feed to the GBT's. The sludge feed offtake to every GBT is fitted with a flow meter and modulated control valve installation and the sludge feed to each individual GBT is SCADA controlled. A facility to bypass the entire mechanical thickening installation is provided, whereby the sludge is bypassed directly to the GBT thickened sludge sump, from where it can be fed to the anaerobic digesters.

The number of GBTs required were calculated for two scenarios, (i) settled wastewater treated in the bioreactors and (ii) raw wastewater treated in the bioreactors to take cognisance of how JW operate their primary sludge fermenters.

The gravity thickened WAS flow is expected to be low, and therefore for the settled wastewater scenario, 3 GBTs are required for the ultimate 150 Mℓ/d capacity, with one additional redundant unit provided, bringing the total number of GBTs required to 4. Provision for 2 GBT's would be made for Phase 1, 1 additional GBT would be added for Phase 2, and 1 further GBT would be added for Phase 3.

For the raw wastewater scenario, 4 GBTs are required for the ultimate 150 Mℓ/d capacity, with one additional redundant unit provided, bringing the total number of GBT's required to 5. Provision for 2 GBT's would be made for Phase 1, 1 additional GBT would be added for Phase 2, and 2 further GBT's would be added for Phase 3.

The design parameters for the GBT's are listed in **Table 17** below.

Table 17: GBT design parameters

Parameter	Units	Average	Peak
Settled Wastewater Scenario			
No. of GBT's	No.	4	
Belt width	m	2.0 – 2.5	
Solids loading rate	kg/hr per m belt width	205	231
Hydraulic loading rate	m^3/hr	22.0	40.0

Parameter	Units	Average	Peak
Raw Wastewater Scenario			
No. of GBT's	No.	5	
Belt width	m	2.0 – 2.5	
Solids loading rate	kg/hr per m belt width	262	312
Hydraulic loading rate	m^3/hr	30.0	50.0

As per JW's request, the number of GBT's provided will be as per the raw wastewater scenario.

The GBT thickened sludge is conveyed to the mechanically mixed GBT thickened sludge sump, from where it is pumped to the anaerobic digesters. The GBT filtrate gravitates to the lime dosing and treatment installation, which is discussed in section 9.2.7 below.

The GBT's are housed in a combined two story thickening and dewatering building, and the mechanically mixed gravity thickened sludge sump, the mechanically mixed GBT thickened sludge sump and the washwater sumps are located directly adjacent to the building.

A shared dry polymer storage and makeup facility is provided (shared between the GBT and filter belt press installations). The polyelectrolyte make-up equipment is capable of making up a 0.25% - 0.35% solution from polyelectrolyte beads, and polymer makeup and storage/dosing tanks are provided, as per the Johannesburg Water specifications. Downstream of the polymer dosing pumps the polymer is diluted from 0.25% - 0.35% to 0.1% by addition of dilution water drawn from the plant washwater system. Inline mixers are provided to mix the dilution water into the polyelectrolyte dosing solution prior to the diluted polymer entering the respective sludge lines. Duty and standby polymer dosing pumps are provided for each GBT. Washwater is provided from a pressurised washwater system, with dedicated washwater pumps for the GBT installation.

GBT redundancy philosophy

One dedicated standby GBT will be available for each of the Phases. This will be revisited during the detailed design phase.

9.2.3 Cell lysis

Cell lysis is the process whereby the cell walls of the bacteria contained in the waste activated sludge are ruptured, thereby releasing previously bound organics into solution and changing the rheology of the sludge. Depending on the technology implemented, a reduction in total waste activated sludge volume may also be achieved.

Cell lysis technology is usually implemented to (i) increase the amount of biogas produced by the anaerobic digesters, (ii) reduce the sludge volume and (iii) reduce polymer consumption during dewatering due to better dewaterability of the treated sludge.

The application of a cell lysis technology just upstream of the anaerobic digesters will be investigated during the detail design phase. Even though Combined Heat and Power (CHP) is not part of the scope of this project, and the benefit of increased biogas production may not be immediately realised, the other benefits of cell lysis with respect to sludge reduction and dewaterability may warrant an application for the Lanseria WwTW even if CHP is only implemented in future.

9.2.4 Sludge stabilisation

The sludge stabilisation process is shown on PFD 13082-72-4-PFD-14 and 13082-72-4-PFD-16.

Anaerobic digestion is the preferred sludge treatment technology to stabilise waste sludges at the Lanseria WwTW. The thickened WAS and the primary and / or waste fermented sludges are conveyed in separate pipelines to the anaerobic digester distribution tower. From the tower, the feed sludge is hydraulically divided between six anaerobic digesters. The design parameters for the anaerobic digesters are listed in Table 18 below, for two scenarios (i) bioreactor treating settled wastewater and (ii) bioreactor treating raw wastewater to take cognisance of the JW operations operational philosophy regarding the primary sludge fermenters.

Table 18: Anaerobic digester design parameters

Parameter	Units	Average	Peak
Settled Wastewater Scenario			
No. of anaerobic digesters	No.	6	
Volume (per digester)	m^3	2 500	
Feed sludge concentration* WAS PS Waste fermented sludge	%	5 - 7 1 – 2 3 - 5	
Organic loading rate (5 online)	$kgVS/m^3/d$	2.2	
Organic loading rate (6 online)	$kgVS/m^3/d$	1.8	
Sludge flow rates	m^3/d	530	670
Retention time (5 online)	D	23	15
Retention time (6 online)	D	28	23
Raw Wastewater Scenario			
No. of anaerobic digesters	No.	6	
Volume (per digester)	m^3	3 000	

Parameter	Units	Average	Peak
Feed sludge concentration** WAS	%	5 - 7	
Organic loading rate (5 online)	kgVS/m³/d	2.5	
Organic loading rate (6 online)	kgVS/m³/d	2.1	
Sludge flow rates	m³/d	580	730
Retention time (5 online)	D	26	20
Retention time (6 online)	D	31	25

*The majority of the feed to the digesters will be GBT thickened WAS at 5 – 7 % and waste fermented primary sludge, however there may be times when primary sludge will be added.

**All feed to the digesters will be GBT thickened WAS at 5 – 7 %.

As per JW's request, the anaerobic digesters will be sized as per the raw wastewater scenario, however the digester sizing will be revisited and optimised during detailed design. The anaerobic digesters are provided with a conical headspace of 3.0m and a conical floor with a 1:5 slope. They are designed as flow through anaerobic digesters, meaning that as sludge is fed into the digesters, digested sludge will exit. A sludge draw-off pipe is provided from the bottom cone of that anaerobic digesters to (i) enable removal of sand and grit and (ii) to fully drain the digesters if necessary. The bottom drain leads to either the grit drying beds provided at the sludge handling installation, where the grit can be deposited and dried, or to a digester sludge sump located at the filtrate return pump station, from where the digester content can be pumped back to the distribution tower and distributed amongst the online digesters, or to the digested sludge sump situated upstream of the dewatering installation. Provision is made for a scum / foam removal system within the headspace of the anaerobic digesters.

Digested sludge flows under gravity to two mechanically mixed digested sludge storage tanks with a combined sludge storage capacity of 4 days, via the struvite precipitation reactor, which is described in section 9.2.5 below. From the digested sludge storage tank, the digested sludge is pumped to the dewatering installation.

Heating and mixing is provided for the anaerobic digesters. The biogas produced by the anaerobic digester process is collected from each digester, and stored in a biogas holder. One approximately 1500 m^3 biogas holder is provided four (4 hour biogas storage). The biogas is used to fuel methane fired hot water boilers, which provide the hot water for digester heating. One duty and one standby boiler is provided for every three anaerobic digesters, with one hot water pump per anaerobic digester with a shared standby hot water pump between three digesters. The hot water is pumped to one tube in tube heat exchanger per anaerobic digester. Two chopper pumps (duty / standby) are provided per digester to pump sludge through the heat exchangers.

A decision regarding the anaerobic digester mixing mechanism has not been taken. Three options have been identified (i) hydraulic jet mixing, (ii) external draught tube mixing and (iii) plunger mixing. A final decision will be taken during detailed design.

Two anaerobic digesters will be provided for Phase 1.

Anaerobic digester redundancy philosophy

Two anaerobic digesters will be provided per Module. Their design will be such that 5 anaerobic digesters will be able to treat the full sludge flow for the ultimate 150 Mℓ/d capacity, with 1 redundant digester.

9.2.5 Struvite precipitation

The struvite precipitation process is shown on PFD 13082-72-4-PFD-15.

The anaerobically digested sludge gravitates to a struvite precipitation installation. The struvite precipitation installation is included to provide forced struvite precipitation in a controlled environment. This will (i) eliminate struvite precipitation in the downstream infrastructure, pipework and mechanical equipment and (ii) remove the bulk of the phosphate and a portion of the ammonia from the liquid fraction of the anaerobically digested sludge.

Struvite is a naturally forming precipitate often found in anaerobically digested sludge, wherever phosphate, ammonia and magnesium are found together in the optimal concentrations that favour struvite formation. Struvite is made up of equimolar proportions of phosphate, ammonia and magnesium. It is therefore proposed to dose magnesium oxide, as magnesium is the limiting constituent in the Lanseria solids / sludge treatment process, in order to remove the phosphate and a portion of the ammonia from the digested sludge and therefore from the anaerobically digested sludge liquors. Forcing struvite to precipitate just downstream of the anaerobic digesters will also eliminate the struvite precipitation potential within all infrastructure located downstream of the forced struvite precipitation process. The main advantage of struvite precipitation as a form of sludge liquor treatment for the removal of phosphates is that struvite precipitation also removes some ammonia from the sludge liquors, thereby also reducing the nitrogen load recycled back to the mainstream treatment process.

The forced struvite precipitation process consists of a small reactor, divided three compartments:

- CO_2 stripping compartment: Coarse bubble aeration strips the CO_2 from solution, thereby increasing the pH of the bulk liquid. Provision for milk of lime addition is made, should the CO_2 stripping not result in a sufficiently high pH;

- Mechanically mixed struvite precipitation reactor: Magnesium is dosed to achieve the optimum magnesium concentration for struvite precipitation, and retention time is provided for the struvite crystals to grow;
- Mechanically mixed lime precipitation compartment: Provision for dosing additional milk of lime for removal of residual phosphates;
- Recycle pumps to recycle a portion of the sludge from the end of the precipitation reactor to the CO_2 stripping compartment for struvite seeding.

Due to the scaling nature of struvite, the struvite precipitation reactor is designed to limit scale formation by including the following functions:

- Mixing in the form of bubble aeration in the first compartments, where struvite crystals are expected to nucleate and start growing. Use of aeration ensures that there are no moving parts on which struvite can attach itself,
- Struvite precipitation is inherently a very fast process, and therefore it is expected that most of the crystals will form within the first aerated compartments;
- Extended residence time and mechanical mixing in the second compartments, with enough residence time and mixing to ensure that equilibrium in terms of struvite precipitation is reached, and no more struvite will then precipitate downstream of this reactor;
- A smooth coating will be used on the reactor walls to limit struvite precipitation due to surface roughness.
- Treating of digested sludge (instead of filter belt press filtrate), where the solid particles in the sludge can act as seeding material for crystal attachment which will limit crystal formation on other surfaces, such as the reactor walls.

Two struvite precipitation reactors are provided for, both capable of treating the full peak digested sludge flow. Both struvite precipitation reactor will be provided for Phase 1.

Further detail on the struvite precipitation process can be found in Report No: 13082-42-Rep-004, Sludge Liquor Treatment.

Table 19 below lists the design parameters for the struvite precipitation reactor, which are applicable to both of the following scenarios, (i) bioreactors treating settled wastewater, and (ii) bioreactors treating raw wastewater to take account of the JW operations operating philosophy regarding the primary sludge fermenters.

Table 19: Struvite precipitation design parameters

Parameter	Units	
No. of struvite precipitation reactors	No.	2
Volume of CO_2 stripping compartment (per reactor)	m^3	75
Volume of mixing compartment (per reactor)	m^3	75
Volume of lime precipitation compartment per reactor)	m^3	20
Total volume of reactor	m^3	170
Retention time (peak flow) CO_2 stripping compartment	h	1.5
Retention time (peak flow) mixing compartment	h	1.5
Retention time (peak flow) lime precipitation compartment	h	0.5
Recycle ratio	-	1:1
Average sludge flow	m^3/d	450
Peak sludge flow	m^3/d	750

The sludge exiting the struvite precipitation reactor flows under gravity to the mechanically mixed digested sludge sump. The struvite crystals will remain suspended in the sludge, and be dewatered together with the sludge, so that the sludge retains its nutritive value.

Struvite precipitation reactor redundancy philosophy

Full redundancy is provided for the struvite precipitation reactor.

9.2.6 Sludge dewatering

The sludge dewatering process is shown on PFD 13082-72-4-PFD-17.

The anaerobically digested sludge is mechanically dewatered by means of belt filter presses (BFP's). The sludge cake will have a consistency of 18 – 22%. The BFP's will have a belt width of 2.0 m – 2.5 m.

The digested sludge is stored in the mechanically mixed digested sludge storage tanks, upstream of the mechanical dewatering installation. Two digested sludge storage tanks are provided, with a combined digested sludge storage capacity of 4 days. Each tank has a capacity of 1200 m^3. Three BFP feed pumps (2 duty, 1 standby) pump the digested sludge into a ring main feed to the BFP's. The sludge feed offtake to every BFP is fitted with a flow meter and modulated control valve installation and the sludge feed to each individual GBT is SCADA controlled.

The number of BFP's required were calculated for two scenarios, (i) settled wastewater treated in the bioreactors and (ii) raw wastewater treated in the bioreactors to take cognisance of how JW operate their primary sludge fermenters.

For the settled wastewater scenario, 4 BFP's are required for the ultimate 150 Mℓ/d capacity, with one additional redundant unit provided, bringing the total number of BFP's required to 5. Provision for 2 BFP's would be made for Phase 1, 1 additional BFP would be added for Phase 2 and 2 further BFP's would be added for Phase 3.

For the raw wastewater scenario, 5 BFP's are required for the ultimate 150 Mℓ/d capacity, with one additional redundant unit provided, bringing the total number of BFP's required to 6. Provision for 2 BFP's would be made for Phase 1, 2 additional BFP's would be added for Phase 2, and 2 further BFP's would be added for Phase 3.

The design parameters for the BFP's are listed in **Table 20** below, for both scenarios described above.

Table 20: BFP design parameters

Parameter	Units	Average	Peak
Settled Wastewater Scenario			
No. of BFP's	No.	5	
Belt width	M	2.0 – 2.5	
Solids loading rate	kg/hr per m belt width	250	330
Hydraulic loading rate	m^3/hr per m belt width	3.3	4.3
Raw Wastewater Scenario			
No. of BFP's	No.	6	
Belt width	M	2.0 – 2.5	
Solids loading rate	kg/hr per m belt width	250	340
Hydraulic loading rate	m^3/hr per m belt width	3.6	4.5

As per JW's request, the number of BFP's provided will be as per the raw wastewater scenario.

The dewatered sludge cake is conveyed to an out-loading station via a conveyor belt. From the out-loading station the sludge cake is picked up by a front end loader and delivered to the enhanced solar sludge drying installation, which is discussed in section 9.2.8 below.

The BFP's are housed in a combined two story thickening and dewatering building, and the digested sludge sump and the washwater sumps are located directly adjacent to the building. A shared dry polymer storage and makeup facility is provided (shared between the GBT and BFP installations). The polyelectrolyte make-up equipment is capable of making up a 0.25% - 0.35% solution from polyelectrolyte beads, and polymer makeup and storage/dosing tanks are provided, as per the Johannesburg Water specifications. Downstream of the polymer dosing pumps the polymer is diluted from 0.25% - 0.35% to 0.1% by addition of dilution water drawn from the plant washwater system. Inline mixers are provided to mix the dilution water into the polyelectrolyte dosing solution prior to the diluted polymer entering the respective sludge lines. Duty and standby polymer dosing pumps are provided for each BFP. Washwater is provided from a pressurised washwater system, with dedicated washwater pumps to the BFP installation.

BFP redundancy philosophy

One dedicated standby BFP will be available for every phase. This will be revisited during the detailed design phase.

9.2.7 Lime dosing and treatment

The lime dosing and treatment process is shown on PFD 13082-72-4-PFD-20.

The GBT and BFP filtrate gravitates to the lime dosing installation. The lime dosing installation is a standard Johannesburg Water lime dosing installation and it is provided to remove residual phosphates and settleable solids from the sludge liquors. The lime also helps assists in breaking down residual polymer, which is present in the mechanical thickening and dewatering filtrates. Provision is made to also divert the gravity WAS thickener overflow to the lime dosing and treatment installation, should high phosphate and / or solids concentrations be present in the overflow from the gravity WAS thickeners.

The lime dosing installation at Lanseria consists of the following infrastructure:

- Slaked lime storage silo;
- Lime makeup tanks;
- Lime reaction tanks, mechanically mixed and configured three compartments in series;
- Lime clarifiers.

The slaked lime is delivered by truck to the slaked lime storage silo, which has a capacity of 14 days storage at peak lime consumption. Two screw feeders feed the slaked lime into two mixed lime makeup tanks. Plant water is added to make up the milk of lime.

GBT and BFP filtrate enter a division box, from where the flow is hydraulically divided to two mixed lime reaction tanks. The milk of lime is dosed by gravity to the lime reaction tanks. The lime and water mixture exits each lime reaction tank into the lime clarifiers. The overflow from the lime clarifiers gravitates to the filtrate pump station, from where it is pumped to the head of works by three filtrate pumps (two duty / one standby). The lime sludge is withdrawn from the bottom of the lime settlers to a sump at the lime sludge pump station. Two pumps in duty / standby configuration will pump the sludge to the digested sludge storage tanks for dewatering.

Table 21 below lists the design parameters for the lime reaction tanks and the lime clarifiers. The unit processes were sized for two scenarios, (i) bioreactors treating settled wastewater and (ii) bioreactors treating raw wastewater to take cognisance of the JW operational philosophy regarding the primary sludge fermenters.

Table 21: Lime reaction tank and lime clarifier design parameters

Parameter	Units	Average	Peak
Settled Wastewater Scenario			
Lime Reaction Tanks			
No. of lime reaction tanks	No.	2	
Retention time (all reactors in operation)	min	70	45
Volume per reactor	m^3	175	
Lime Clarifiers			
No. of lime clarifiers	No.	2	
Upflow rate	m/hr	0.50	0.94
Diameter	m	21.0	
Raw Wastewater Scenario			
Lime Reaction Tanks			
No. of lime reaction tanks	No.	3	
Retention time (all reactors in operation)	min	92	45
Volume per reactor	m^3	250	
Lime Clarifiers			
No. of lime clarifiers	No.	3	
Upflow rate	m/hr	0.43	0.84
Diameter	m	22.0	

The lime reaction tanks and clarifiers were sized to be able to accept the gravity WAS thickener overflow volume occasionally, when high phosphorus concentrations or solids carry over are noted at the gravity WAS thickener overflow. The unit processes were sized to receive the gravity WAS thickener overflow only if WAS is withdrawn from the RAS flow and not from the bioreactors.

As per JW's request, the lime reactors and clarifiers will be sized as per raw wastewater scenario. In order to minimise the diameters of the lime clarifiers, three lime reaction tanks and three lime clarifiers will be provided. Two of each will be provided for Phase 1.

Each lime clarifier is equipped with a full diameter centre drive scraper mechanism and full diameter fixed bridge, one scum removal box, scum baffle, v-notch overflow weir.

Scum is withdrawn from the scum boxes and gravitates to the gravity WAS thickener scum sump located at the filtrate pump station, from where it is pumped to the digested sludge sump for dewatering.

Lime treatment redundancy philosophy

Should one lime reactor or clarifier be out of commission, half the capacity will be available for the 2 reactor / clarifier configuration (settled wastewater scenario) and three-quarters the capacity will be available for the 3 reactor / clarifier configuration (raw wastewater scenario).

9.2.8 Sludge drying

The sludge drying process is shown on PFD 13082-72-4-PFD-19.

Sludge drying at the Lanseria WwTW is affected by means of enhanced solar sludge drying. The enhanced solar sludge drying equipment is proprietary equipment, and designed by the equipment suppliers.

Enhanced solar sludge drying unit consists of a greenhouse type structure, to achieve the desired internal temperature required for the accelerated drying. Sludge turners are installed at regular intervals, which turn and mix the sludge to enhance the drying process even further. Extractor fans and openings are installed in the greenhouse structure to ensure the moisture saturated air exits the structure and is replaced by dryer air. The dry sludge is deposited at the far end of the enhanced solar sludge drying installations, picked up by front end loaders and deposited on the dry sludge storage area.

Preliminary indications are that six enhanced sludge solar drying installations will be required, each being 11 m wide and 110 m to 120 m long, and that the dry sludge will exit the drying process at a concentration of approximately 85 %.

The dry sludge storage slab is sized to store 6 days of dry sludge, and its area is approximately 5000 m^2. JW have indicated that they would prefer a larger dry sludge storage slab, and the sizing of the dry sludge storage slab will be relooked at during detail design.

9.3 BIOWIN® Modelling

The preliminary process design base case was modelled in Biowin® as a steady state model only. **Table 6** below shows the results for the treated effluent of the Biowin® base case steady state modelling.

The Lanseria WwTW was modelled in its preliminary process design for summer and winter conditions, with a nitrifying / denitrifying (NDN) process for the sludge liquors, and without. An unaerated sludge mass fraction of 0.55 was assumed.

Table 22: Biowin® base case steady state modelling effluent quality

Parameter (Treated Effluent)	Units	Summer (with NDN)	Winter (with NDN)	Summer (no NDN)	Winter (no NDN)
Chemical Oxygen Demand (COD)	mg/ℓ	46.36	49.04	45.80	47.5
Total Suspended Solids concentration (TSS)	mg/ℓ	N/A	N/A	N/A	N/A
Ammonia	mg/ℓ as N	0.07	0.41	0.08	0.45
Nitrate	mg/ℓ as N	6.39	4.13	7.30	5.23
Ortho-phosphate	mg/ℓ as P	0.02	0.05	0.15	0.18
pH		6.6	6.5	6.7	6.6
Chlorine	mg/ℓ	N/A	N/A	N/A	N/A
Electrical Conductivity (EC)	mS/m	N/A	N/A	N/A	N/A
Escherichia Coli (E coli)	Per 100 mℓ	N/A	N/A	N/A	N/A

From **Table 6** it can be seen that the effluent nitrate concentration in summer is predicted to be 6.39 mg/ℓ and 4.13 mg/ℓ in winter, with a NDN reactor to reduce the residual ammonia concentration in the sludge liquors. The predicted effluent nitrate concentrations do not conform to the anticipated nitrate discharge standard of 1.5 mg/ℓ, however they do conform to the anticipated relaxed standard of 10 mg/ℓ. Without providing an NDN reactor, the predicted effluent nitrate concentrations increase to 7.3 mg/ℓ and 5.23 mg/ℓ for summer and winter respectively, which still conforms to the anticipated relaxed nitrate discharge standard.

Furthermore, **Table 6** also shows that under steady state conditions, the effluent COD concentrations are also higher than the anticipated COD discharge limit of 30 mg/ℓ.

The process design will be optimised during the detail design to achieve the lowest effluent nitrate possible, however indications are that the anticipated effluent nitrate discharge standards cannot be met, with or without provision of an NDN reactor, and that a further process may have to be added to decrease the effluent nitrate concentration to the discharge limit value, should the relaxation in effluent nitrate concentration not be granted.

During the detailed process design, diurnal Biowin® simulations will be presented for the Lanseria WwTW, to ascertain the effect of the diurnal nutrient flows and loads on the effluent quality.

10 HYDRAULIC DESIGN

10.1 Liquid Treatment Train

A hydraulic analysis has been completed for the liquid treatment train in order to size the conveyance system of the WWTW as well as to set the hydraulic control levels in each of the treatment units. Subsequently the terrace levels for each treatment unit have been set.

The principle objective of the hydraulic analysis is to establish a controlled flow by gravity of the bulk liquid through the treatment system.

The hydraulic analysis is based on the ultimate WWTW capacity of 150 Mℓ/day with provisions to implement the first module only.

10.1.1 Design Criteria

The following documents were utilized for the hydraulic design:

- Process Description Report (13082-45-Rep-003-Process Description Report) with its associated Process Flow Diagrams (PFDs)
- *Johannesburg Water Guidelines for the Design of Wastewater Treatment Unit Processes Rev 16*.
- Lanseria WWTW Flow Distribution Sheets on drawing numbers 13082-72-4-PFD-22 and 13082-72-4-PFD-23 attached as **Volume 2** to this report**.**

10.1.2 Design Flows

The design flows as computed in the Lanseria WWTW are summarized in

Table 23.

Table 23 : **Summary of Liquid Treatment Train Flow Distribution**

SUMMARY OF LIQUID TREATMENT TRAIN FLOW DISTRIBUTION (Mℓ/day)			
SECTION	**ADWF**	**PDWF**	**PWWF or Max**
Head of Works	155.9	271.9	378.4

Primary Sedimentation Tanks	155.9	271.9	378.4
Fermentation Primary Sludge Settled Sewage	 2.0 2.7	 2.7 4.05	 2.7 8.1
Flow and Load Balancing Tanks	154.2	265.1	367.5
BNR Tanks Inflow RAS	 154.2 86.0	 265.1 115.7	 265.1 150.0
Secondary Clarification Tanks Inflow Sludge Withdrawal	 239.6 86.0	 374.5 115.7	 412.5 150
Disinfection Facility	153.5	258.4	262.1
Outlet Works	148.3	251.7	255.4

10.1.3 Hydraulic Analysis

The MathCAD version 2000 Professional model, developed by MathSoft Inc. was used to perform all hydraulic computations for the liquid treatment train. The model was chosen for analysis because all equations and expressions are shown in the same graphical format they are created and computed. The format enables ease of navigation through the numerous calculations throughout the design stage when preparing and reviewing the calculations.

10.1.4 Results and Discussion

The hydraulic calculations are performed and presented in reverse flow direction from the Outlet works to the Head of Works. The reason for back flow calculations is Downstream Control whereby hydraulic conditions in the treatment train are controlled by conditions on the downstream side of any point and not on the upstream side.

<u>Outlet Works</u>

- The Outlet Structure is the last structure in the Liquid Treatment Train which has a bearing on the hydraulic calculations. It conveys the final treated effluent flow from the Chlorine Contact Channels.

- The hydraulic control point for the Outlet Structure is a 10m overflow weir. The 10m weir length yields an acceptable water height of 296mm over the weir when discharging the peak discharge flow of 255.4 Mℓ/day.
- The Outlet Structure has been positioned on the boundary of the 1 in 100-year flood plain buffer line.
- The top water level (TWL) at the Outlet Structure is 1281.967 m.a.s.l. (metres above sea level).
- The interconnecting pipeline from the Outlet Structure to the Disinfection Facility is designed as an 1800mm nominal bore (NB) concrete pipe. The pipe diameter yields a flow velocity of 1.2 m/s at the peak discharge flowrate. The flow velocity at average discharge flowrate is 0.7 m/s. Both velocities at peak and average discharge flowrates are within acceptable limits.

Disinfection Facility

- The Chlorine Contact Channels are the only structures at the Disinfection Facility that convey the bulk liquid.
- The Chlorine Contact Channels have 3 hydraulic control points.
- The first hydraulic control point, in reverse flow direction, is a 17m overflow weir located at the outlet of the Chlorine Contact Channels. The 17m weir length yields an acceptable water height of 211mm over the weir when discharging the peak discharge flow of 262.1 Mℓ/day.
- The TWL at the 17m overflow weir is 1282.390 m.a.s.l.
- The second hydraulic control point is a 5.65m overflow weir for each channel.
- The TWL at the 5.65m overflow weir is 1282.680 m.a.s.l.
- The third and last hydraulic control point in the Chlorine Contact Channels is a 6m overflow Inlet Weir.
- The TWL at the 6m overflow Inlet Weir is 1283.495 m.a.s.l.
- The Top of Concrete (TOC) for the Chlorine Contact Channels was set as 1284.000 m.a.s.l.
- The Terrace Level for the Disinfection terrace is set at 1283.000 m.a.s.l.
- The interconnecting pipeline from the Chlorine Contact Channels to the Secondary Clarifiers has various pipe diameters ranging from 1800mm NB to 900mm NB concrete pipes. All flow velocities at the peak discharge flowrate range from 1 m/s to 1.4 m/s. The flow velocities at the average discharge flowrate range from 0.6 to 0.9 m/s.

Secondary Clarifiers

- The TWL in the outlet box of the Secondary Clarifiers is 1284.600 m.a.s.l.
- The floor of the clarifier launders is set at 1284.700 m.a.s.l. which is 100mm above the TWL in the outlet box.

- A 450mm wide launder for the Secondary Clarifiers has been designed which yields a flow depth of 375mm at the peak dry flow.
- The water height of the V-notch weirs is 45mm and TWL is 1285.425 m.a.s.l.
- The Top of Concrete (TOC) for the Secondary Clarifiers was set as 1286.130 m.a.s.l.
- The Terrace Level for the Secondary Clarifiers was set at 1288.130 m.a.s.l.
- The Secondary Clarifiers feed pipe has been sized as 900mm ND steel pipe.
- Flow distribution to the Secondary Clarifiers is attained through a circular division structure with 4.5m long overflow weirs.
- The TWL in the division structure is 1286.095 m.a.s.l.
- The interconnecting pipeline from the Secondary Clarifiers to the BNR Reactor has been designed as a 1500mm nominal bore (NB) concrete pipe. The pipe diameter yields a flow velocity of 1.3 m/s at the peak discharge flowrate. The flow velocity at average discharge flowrate is 0.9 m/s.

<u>BNR Reactor</u>

- The BNR Reactor has four hydraulic controls situated at overflow weirs.
- The first hydraulic control is a 10m overflow weir from the outlet of the Aerobic Zone. The 10m weir length yields an acceptable water height of 140mm over the weir when discharging the peak discharge flow of 80.9 Mℓ/day. The flowrate comprises the combination of the PDWF and the Recycled Activated Sludge (RAS) but it excludes the a-Recycle.
- The TWL at the outlet weir is 1288.625 m.a.s.l. This TWL is constant throughout the aerated zones of the Reactor because all the aerated zones are in plug flow arrangement.
- The second hydraulic control point in the Reactor is a 10m overflow weir between the second anoxic zone and the first aerobic zone. The 10m weir length yields an acceptable water height of 170mm over the weir at the flowrate of 112.1 Mℓ/day. The flowrate comprises the combination of the PDWF, RAS and the a-Recycle flow.
- The TWL at the weir between the anoxic zone and the aerobic zone is 1289.000 m.a.s.l.
- The third hydraulic control point in the Reactor is a 10m overflow weir between the Anaerobic Zone and the first Anoxic Zone. The 10m weir length yields a water height of 140mm over the weir at the flowrate of 80.8 Mℓ/day.
- The TWL at the weir between anaerobic zone and the anoxic zone is 1289.100 m.a.s.l. This weir has been designed as a submerged weir for scum management purposes (to be discussed further under the BNR Reactor section of this report).
- The fourth and last hydraulic control point in the Reactor is a 10m overflow weir between the Pre-Anoxic zone and the Anaerobic zone. The 10m weir length yields

a water height of 135mm over the weir at the flowrate of 38.3 Mℓ/day. The flow is a combination of 15% of the PDWF from the Balancing Tank and the B-Recycle flow.

- The TWL at the weir between pre-anoxic zone and the anaerobic zone is 1289.196 m.a.s.l. This weir has also been designed as a submerged weir for scum management purposes.
- Using 1289.196 m.a.s.l. as the maximum TWL in the BNR Reactor, the TOC for the structure was set as 1289.690 m.a.s.l.
- The terrace level for the BNR Reactors is set at 1288.700 m.a.s.l.
- The main interconnecting pipeline from the BNR Reactor to the Reactor Flow Division Structure is a 1050mm NB concrete pipe which discharges in the Anaerobic zone. The pipe diameter yields a flow velocity of 0.7 m/s at a flowrate of 50 Mℓ/day. The pipeline from the Pre-Anoxic zone is a 375mm NB concrete pipe which is connected to the main 1000mm NB pipe in a concrete box just upstream of the Pre-Anoxic zone.
- The Reactor Flow Division Structure has two 4.5m long overflow weirs to feed each of the BNR Reactors for a single module.
- The 4.5m weir length yields a water height of 170mm over the weir at the flowrate of 50.0 Mℓ/day.
- The TWL in the BNR Reactor Flow Division Structure is 1289.705 m.a.s.l.

Flow Balancing Tank

- The Balancing Tank has been designed with 1000mm NB stainless steel outlet pipes. The flow velocity in the pipelines is 1.5 m/s at a flow of 50 Mℓ/day.
- The TWL in the Balancing Tank is 1294.190 m.a.s.l. and the TWL in the Balancing Tank under normal flow conditions is 1294.195 m.a.s.l.
- The interconnecting pipe from the Balancing Tank to the Balancing Tank Flow Division Structure is 1500mm NB concrete pipe which also yields a velocity of 1.5 m/s at the same flow of 50 Mℓ/day.
- The TWL in the Balancing Tank Flow Division Structure is 1294.905 m.a.s.l.
- The Balancing Tank has been designed with an overflow pipeline which discharges at the Emergency Stormflow Dam. The overflow weir level has been set at 1294.240 m.a.s.l.
- The TOC has been set to 1294.750 and the terrace level to 1293.750.
- The overflow pipeline to the Emergency Stormflow Dam has been sized as a 1650mm NB concrete pipe which yields a velocity of 1.3 m/s at the flow rate of 210 Mℓ/day. The overflow flow is the difference between the PWWF and the ADWF as prescribed in the Design Guidance.
- The overflow pipeline to the Emergency Stormflow Dam governs the TWL of the dam which has been set at 1289.200 m.a.s.l.

Primary Sedimentation Tanks (PSTs)

- The interconnecting pipe from the Balancing Tank Flow Division Structure to the Primary Sedimentation Tanks (PSTs) has been designed to convey the PWWF of 360 Mℓ/day, i.e. for all proposed three modules of the WWTW.
- The pipeline has diameters ranging from 1800mm NB to 1200mm NB concrete pipes, with the diameters reducing in size as it services less PSTs.
- The interconnecting pipeline from the outlet box of a PST has been sized as a 900mm NB concrete pipe.
- The TWL in the furthest PST in the pipeline, PST No. 6, is 1296.700 m.a.s.l. This TWL governs the setting of the launder floor level for all PSTs which is 1296.800 m.a.s.l.
- A 600mm wide launder for the PSTs has been designed, which yields a flow depth of 550mm at PWWF.
- The water height of the V-notch weirs is 70mm and TWL is 1297.690 m.a.s.l.
- The TOC for the PSTs is set as 1298.540 m.a.s.l.
- The Terrace Level for the PSTs is set at 1297.600 m.a.s.l.
- The PSTs feed pipe has been sized as a 900mm ND steel pipe.
- Flow distribution to the PSTs is attained through a circular division structure with 8m long overflow weirs.
- The TWL in the PST Flow Division Structure is 1298.690 m.a.s.l.
- The interconnecting pipeline from the PST Flow Division Structure to the Head of Works is designed as a 1800mm nominal bore (NB) structured wall HDPE pipe. The pipe diameter yields a flow velocity of 1.5 m/s at PWWF.

Head of Works (HOW)

- The HOW has been designed to hydraulically convey the waste water in concrete channels.
- The first hydraulic control point for the HOW is the Venturi Flume which has a TWL of 1299.450 m.a.s.l. and the floor level (FL) has been set at 1298.345 m.a.s.l.
- The Fine Screens channels have been sized to be 2.6m wide and the TWL upstream of the screens is 1300.145 m.a.s.l.
- The TWL at the Vortex Degritters is 1300.080 m.a.s.l. Each Degritter has a 1.5m overflow weir length which yields a head of 0.6m at PWWF and 0.35m at ADWF.
- The Coarse Screens channel has been sized to be 1.5m wide and the TWL upstream of the screens is 1300.650 m.a.s.l.
- The bypass weir of the mechanical screens is at invert level 1300.700 m.a.s.l.
- Upstream of the Coarse Screens is an emergency overflow weir of 13m length. The overflow discharges at the Emergency Stormflow Dam. The TWL at the bypass is 1301.260 m.a.s.l.
- The TWL at PWWF at the venture flume is set at 1301.26 m.a.s.l.

The TOC for the HOW has been set at 1301.550 m.a.s.l. and the terrace level has been set at 1301.350 m.a.s.l.

11 WORKS LAYOUT DESIGN

The design of the Works layout is described in report no. 13082-45-Rep-005 Works Layout Options.

A Basis of Design report has been prepared by the consortium (Report No. 13082-45-Rep-001), that sets out the parameters that guide the design of the Works. Thereafter, a process design has been undertaken, and this together with a set of Process Flow Diagrams (PFD's) has been documented as a Process Description Report (Report No. 13082-45-Rep-003). The PFD's are used to develop various Works layout options.

Multiple constraints are present on the site, namely two Right of Way servitudes, two Eskom Power Line servitudes, three water courses that traverse the site in an east-west direction, discharging into the Jukskei River, and environmentally sensitive ridges. These constraints affect the positioning of the required process units making up the Works, resulting in the Works being positioned on either side of a watercourse, rather than on one side of a watercourse.

11.1 Development of Works Layout Options

Seven Works Layout Options, as comprehensively described in the Works Layout Report appended as supporting documents to this report, were initially compiled for discussion with Johannesburg Water and the design team, viz. Options 1A and 1B; Options 2A, 2B and 2C; and Options 3A and 3B. Of these options, only two options, viz. 2C and 3B were considered suitable for further development. These options were modified and updated as requested by the design team, and were renamed Options 2D and 3C (respectively). The balance of the options was discarded.

Finally, as only Option 3C contained the required redundancy described in the Basis of Design and Process Description, Option 2D was also discarded. Option 3C was further modified and was renamed Option 3D.

After incorporating the environmental constraints such as the Combined Wetland, the Wetland buffer, the Riparian buffer and the Class 1 Ridge buffer, the Works layout was further modified and optimised. The revised layout has been named Option 3E, and is the preferred Works Layout.

11.2 Design Philosophy

The site is constrained by several natural anomalies and bulk services infrastructure as described in Section 7.4.

11.2.1 Liquid Treatment Process Stream

The bulk outfall sewer will enter the site at the south western corner of the site, hence the Head of Works must be located at the south western corner. The remainder of the liquid process stream is therefore confined to the south west of the site, and this includes the Primary Sedimentation Tanks, the Fermenters, the Balancing Tanks, the BNR Reactor, the Secondary Clarifiers and the Chlorine Contact channel. The gradient of the site from the south west towards the centre of the site (i.e. towards the tributary to the Jukskei River) allows the full liquid stream to gravitate through the site to the final discharge point, into the Jukskei River.

The stormflow dam is positioned at the centre of the site, in an area that is constrained by two watercourses and the 400kV electrical powerline servitude. Overflow from the Head of Works and Balancing Tanks is able to gravitate to the stormflow dam.

11.2.2 Sludge Treatment Process Stream

The sludge process stream is positioned on the opposite bank of the tributary, i.e. on the north western portion of the site. Sludges will be pumped from the liquid stream treatment process, across the tributary, to the sludge handling and treatment installation.

The Waste Activated Sludge (WAS) thickeners are positioned on the higher portion of the sludge handling and treatment area, so that flow to some of the downstream process units can be gravitated. However, most of the process units situated at the sludge handling area do require pumping, such as the feed to the anaerobic digesters, the feed to the gravity belt thickeners (GBT's) and the belt filter press (BFP's) feed.

11.2.3 Main Access and Administration Building

The proposed new main access road will enter the site at the south eastern corner, which will provide the main entrance point to the site, via the Main Entrance Gate.

The south eastern corner of the site is the highest point on the site, and cannot be used for any of the process streams without significant amounts of pumping. This area was therefore utilised to position the Administration Building. This area affords the employees using the Administration Building an ideal vantage point that overlooks the entire Works.

11.3 Geotechnical Investigation

A geotechnical investigation has been undertaken during the pre-feasibility investigation. The investigation focussed largely on the area that will be occupied by the liquid process stream, with little information on the area occupied by the sludge handling and treatment infrastructure. A supplementary geotechnical investigation has therefore been commissioned on the sludge handling and treatment area, to better understand the geotechnical conditions in that area.

12 DESIGN OF PROCESS UNITS

12.1 REFERENCE DRAWINGS

Preliminary Design Drawings have been compiled during the preliminary design stage and have been referenced accordingly in the relevant sections. A drawing register is attached to the appendices. The full set of drawings is included as a separate volume to this report with a soft copy uploaded to a shared folder for scrutiny.

12.2 HEAD OF WORKS

The Head of Works (HoW) receives flow directly from the Bulk Outfall Sewer, and is located upstream of the PST's. The HoW serves as the primary treatment facility at the Works.

The design of the process units follows the recommendations contained in the JW Guidelines for the Design of Wastewater Treatment Unit Processes (Revised August 2015) – Sections 1.1 Screening at HoW, and 1.2 Grit/Detritus Removal.

12.2.1 Design

The design of the HoW was based on Process Flow Diagrams (PFD's) No. 01 and 02 (Dwg no.s 13082-72-4-PFD-01 and 02), and the hydraulic flow calculations.

The complete HoW for the ultimate 150 Mℓ/d works will be constructed in the first phase, however some components will not be used during the first phase, and mechanical equipment will not be installed in those components. The unused components will be isolated using removable precast walls, so that the unused components can be easily commissioned when the future phases are constructed.

The main channel upstream of the coarse screens is 2m wide and 1.6m high (maximum flow height is 1.1m at the maximum design inflow of 360 Mℓ/d (peak wet weather flow). A 1.7m wide venturi flume is located at the end of the main channel. The channel floor is then dropped by 450mm to ensure that the incoming flow can be accurately measured in the venture flume, in the event of blinding of the mechanical screens, or when overflow into the bypass or emergency overflow occurs.

Stone trap:

A stone trap is located directly downstream of the outfall sewer discharge. A duty / standby arrangement has been adopted, with each stone trap having dimensions of 2.5m * 2m * 1.1m deep. The flow from the outfall sewer will enter a common chamber, from where the flow will be guided using two 2m * 2m sluice gates to enter one of the stone traps. Each stone trap has a 2m * 2m sluice gate on the outlet side, which will either be open or closed, depending on which one is in use.

When a stone trap requires cleaning, the sluice gates of that stone trap will be closed, while the other trap's sluice gate remains open. This will isolate one of the stone traps from receiving incoming flow. Accumulated stones and debris can be mechanically removed using an electrically operated "clam shell bucket". The clam shell bucket is mounted on a crawl beam, which is installed across two steel A-frames, one on either side of the stone trap. The clam shell bucket is emptied into a mobile skip, which is located adjacent to the stone traps.

Flow measurement:

The total inflow into the works is measured at a venturi flume, which is located in a section of the common inlet channel. The venturi flume has a throat width of 1.7m and a maximum height of 1.5m, which will be able to accommodate the maximum design inflow of 360 Mℓ/d (peak wet weather flow).

Emergency Overflow:

An emergency overflow is provided at the "diamond section" where the inlet channel split to the coarse screens is located. Two 13m long weirs are provided at the emergency overflow, at a level that is higher than the coarse screen bypass weir. Therefore, flows higher than the estimated peak wet weather flow of 360 Mℓ/d will be diverted to the Stormflow Dam.

Manual screening of the overflow will be investigated further during the detailed design stage. Currently screening can be achieved at the discharge point to the stormflow dam, but the ideal position for screening would be at the overflow itself, prior to entering the discharge pipe.

Return flows:

Return flow from the Stormflow Dam and sludge liquor return from the Sludge Handling area is returned to the main inlet channel downstream of the venturi flume to ensure that flows that have already been measured are not re-measured.

Coarse screening:

The main 2m wide inlet channel initially divides into two 1.5m wide channels, and each of these further divides into two 1.5m wide channels resulting in a total of four 1.5m wide coarse screening channels. Each channel is equipped with a mechanical coarse screen (3 duty and 1 standby for the ultimate 150 Mℓ/d arrangement). Therefore, each coarse screen can screen the flow of one module, i.e. average flow of 50 Mℓ/d and peak wet weather flow of 120 Mℓ/d.

The channel straight length before the split into two channels and upstream of the mechanical coarse screens is designed as 5 times the channel width at the coarse screens. There is also a 100mm drop downstream in the channel floor at the coarse screens.

Two emergency bypass channels are provided, that bypass the coarse screening installation. The inlet to the emergency channels is higher than the maximum flow height in the channel. Each bypass is fitted with a manually raked screen with 50mm wide openings, to screen the wastewater that bypasses the mechanical coarse screens. A concrete roof structure with open sides is provided to cover the entire coarse screening area, so that maintenance can be undertaken in the event of inclement weather.

During normal to high flow conditions all flow via the coarse screens and their bypasses, will be collected downstream of the screens and then divided to the vortex degritters.

During low flow conditions, low internal walls provided downstream of the coarse screens will direct flows from each respective coarse screen directly to a respective vortex degritter (i.e. flow will not be combined), to prevent settling of solids due to low velocities.

Each coarse screening channel is equipped with two sluice gates that are located upstream and downstream of each mechanical coarse screen, so that the respective screen can be isolated in the event of failure or during periods of maintenance.

Screenings handling:

Dewatered and washed screenings from the coarse screens are deposited into mobile skips located adjacent to the channel. The skips will be provided in a duty / standby arrangement, and will be contained within a drained area to control spillages. Spillages are collected and returned to the inlet channel by gravity using wash water.

A concrete roof structure with open sides is provided to cover the screenings handling area.

Grit removal:

The grit removal system consists of six circular vortex degritters (five duty and one standby), each 6.5m in diameter, with entrance and exit channels of 1.3m wide. The venturi flumes are located downstream of the degritters in the exit channel to control water height through each degritter.

Each degritter is equipped with a sluice gate at the inlet and at the outlet, so that a degritter can be isolated from flow in the event of equipment failure or during periods of maintenance.

The grit will be removed from the degritter hopper by means of an air lift pump, which will transport the grit into a mechanical grit classifier.

Two mechanical grit classifiers (one duty and one standby) will be provided, and will be located in a bunded area next to the degritters. Two mobile grit skips (one duty and one standby) will also be accommodated within the bunded area. Spillages will be collected and returned to the inlet channel using wash water.

<u>Fine screening:</u>

Mechanical fine screens are located downstream of the degritters. The four 1.3m wide channels downstream of the degritters widen to 2.6m to be able to accommodate the mechanical fine screens. Low internal walls have been provided along the length of this transition area to allow low flows to be divided into all four channels.

Each channel is equipped with two sluice gates that are located upstream and downstream of each respective mechanical screen, so that the screen can be isolated in the event of failure or during periods of maintenance

The set of four channels has an associated bypass channel, which is fed over a weir, the height of which is higher than the maximum flow height in the channel. The bypass is fitted with a manual screen with 10mm wide openings, to assist the mechanical screens when the mechanical screens are either faulty, fully blinded or during a power outage. A concrete roof structure with open sides has been provided to cover the area where the mechanical screens and the manual screen are situated, so that maintenance can be undertaken in the event of inclement weather.

<u>PST Bypass:</u>

A further bypass has been accommodated in the design, to allow screened and degritted raw sewage to bypass the full set of PST’s and to discharge directly to the Balancing Tanks. This bypass is controlled with a manual sluice gate, and can be used during periods of PST maintenance, or when there is failure at the PST’s.

12.2.2 Materials of Construction

The HoW will be constructed using reinforced concrete, with dolomitic aggregate, and with 20mm filled and sealed expansion joints. A corrosion resistant epoxy coating will be applied to the internal walls.

The bunded areas in which the screenings and grit skips are contained will also be constructed using reinforced concrete, and the internal walls and floors will be treated with a corrosion resistant epoxy coating.

The equipment at the HoW will be manufactured as follows:

- Handrails: 3CR12 stainless steel or GRP;
- Sluice gates: stainless steel, grade 304;
- Screen rack and scraper mechanism: stainless steel, grade 304;
- Screen housing: 3CR12 stainless steel;
- Screenings washer/compactor: stainless steel, grade 304;
- Rake for bypass screen: 3CR12 steel;
- Screenings conveyor/trough: 3CR12 stainless steel;
- Air lift pump: stainless steel, grade 304;
- Screw type grit dewatering device: stainless steel grade 304, with abrasion resistant screw edge and replaceable tube liner or wear bars

12.2.3 Piping and Valves

- Air sparge pipe work: galvanised steel (dry), stainless steel grade 304 (wet);
- Grit conveyance pipework: stainless steel grade 304;
- Air blower pipe work: Galvanised Steel (dry), stainless steel (wet) grade 304;
- Valves: Knife gate valves with grade 304 SS fittings, Resilient Seal Valve

12.2.4 Mechanical

The following mechanical equipment will be installed:

Coarse screen area:

- Stone removal crane with clamshell bucket at stone trap
- Front Rake Coarse Screen with 12mm openings (2 no. for phase 1, and 2 no. future)
- Hydraulic Screenings Conveyor (1 no.)
- Screenings washer/compactor (2 no.)
- Screenings skip (2 no.)

Grit Removal area:

- Compressors
- Air receiver
- Blowers
- Grit classifiers (2 no., one duty, one standby)
- Grit skips (2 no., one duty, one standby)

Fine screen area:

- Drum type rotational fine screen with 6mm openings
- Hydraulic Screenings Conveyor (1 no.)
- Screenings washer/compactor (2 no.)
- Screenings skip (2 no.)

12.2.5 Electrical

The electrical demand of all the mechanical equipment at the Head of Works (HoW) is less than 50kVA. A MCC will be installed at the HoW, which will be housed in a HoW MCC Building with separate rooms for the MCC and PLC. This MCC will be supplied from the BNR reactor No 1&2 substation about 200m away. The BNR reactor No 1&2 substation will be connected in the 11kV ring supply for "standby power". The HoW MCC supplies the mechanical equipment, instruments, PLC and site lighting in the area via the HoW MCC. This MCC will be large enough to accommodate the starters for future equipment. A standby generator will also be installed for the emergency supply to the HoW MCC and an uninterrupted power supply (UPS) supplies the electronic equipment like the PLC in the event of a power failure until the standby or emergency power is restored.

12.2.6 Control and Instrumentation

The PLC in the HoW MCC controls the equipment supplied from the HoW MCC. All instruments i.e. level sensors, flowmeters etc. in the head of works area are connected to the Head of works MCC PLC for control and to relay the readings to the SCADA system in the control room.

The PLC, in automatic mode, controls the equipment at the HoW in accordance with the control philosophy to be detailed at a later stage.

12.3 PRIMARY SEDIMENTATION TANK

The Primary Sedimentation Tanks (PST's) are located downstream of the HoW, and are used to remove readily settleable suspended solids, scum and FOG from the screened and degritted wastewater, thereby reducing the organic load on the downstream biological treatment processes.

The design of the process units follows the recommendations contained in the JW Guidelines for the Design of Wastewater Treatment Unit Processes (Revised August 2015) – Section 2.1 Primary Sedimentation Tanks.

12.3.1 Design

The design of the PST's is based on the Process Description Report (13082-45-Rep-003), Process Flow Diagram (PFD) No. 03 (Dwg no. 13082-72-4-PFD-03), and the hydraulic flow calculations.

The set of six PST's is fed from a centrally located, circular flow division structure, which is capable of distributing wastewater flow equally between the PST's. A facility to stop flow to any of the PST's is included in the design, so that any PST can be isolated.

Two PST's will be constructed during the first phase, each with an internal diameter of 35m.

Each PST is provided with the following features: -

- An Inlet structure at the centre of the tank comprising:
  - A vertical inlet pipe
  - A stilling chamber around the inlet pipe at the top of the tank
- The main sedimentation tank comprising:
  - Circular holding tank with a conical floor
  - Sludge collection sump around the vertical inlet, with a sludge withdrawal pipe
  - An overflow launder with an outlet box

The overflow from the PST's (settled sewage) gravitates to the Balancing Tank. Primary sludge will be gravitated to a sump and then pumped into the Fermenters for further treatment. The scum will be gravitated into concentrators, and then pumped to the Anaerobic Digesters.

For the ultimate capacity of the works, a total of six PST's will be constructed, with one PST considered redundant. For this scenario, the maximum flow through one PST will be 0.833m^3/s (PWWF of 72 Mℓ/d).

For the first module, where only two PST's will be constructed. Each PST is able to hydraulically accept the total PWWF of 120 Mℓ/d (1.389m^3/s), in the event that one PST is taken out of operation.

The dimensions of the key components are as follows:

- Sedimentation Tank - 35m internal dia. with 4m side wall depth
- Overflow launder - 600mm wide and 810mm high (max flow depth of 587mm)
- Stilling well - 5.1m dia. and 2.4m high
- Sludge hopper - 5.7m dia.

Primary Sludge Pump Station

The primary sludge and a portion of the settled sewage from each PST is gravitated to separate sumps at the Primary Sludge Pump Station, which is then pumped to the Fermenters.

The maximum primary sludge flow at the ultimate works capacity will be 2,700m^3/d (31 ℓ/s) and the maximum settled sewage flow rate to the fermenters will be 8,100 m^3/d (93 ℓ/s).

The following sump capacities have been provided:

- Primary Sludge Sump volume = 21 m^3
- Settled Sewage Sump volume = 27 m^3

12.3.2 Materials of Construction

The PSTs will be constructed using reinforced concrete, with dolomitic aggregate.

The mechanical equipment will be manufactured as follows:

- Weir plate and scum board: 3CR12 stainless steel
- Sludge scraper (wetted components): stainless steel grade 304
- Rotating bridge: 3CR12 (from 3CR12 rolled plate, as 3CR12 structural members are not manufactured any longer) or Duplex steel (Hot dipped galvanised with polyurethane coating)
- Launder covers: Glass reinforced plastic

12.3.3 Piping and Valves

Each PST will have the following features:

- Inlet pipe: 900mm dia. stainless steel grade 304

- Outlet pipe: 900mm dia. concrete with sacrificial layer
- Sludge withdrawal pipe: 200mm dia. stainless steel grade 304
- Subsoil drainage pipes underneath the structure: 110mm dia. flexible HDPE
- Scum outlet will be fitted with a manual isolation valve downstream of the tank

12.3.4 Mechanical

Primary Sedimentation Tank:

Each PST will be equipped with a sludge scraping mechanism connected to a rotating bridge structure with a scum scraper. The scum removal mechanism will comprise scum boards and a scum collection box. An overflow weir plate will be installed on the launder wall. A bar screen will be installed over the launder outlet box for safety. The launder will be covered with removable covers for odour.

Primary Sludge Pump Station:

The Primary Sludge Pump Station will in the ultimate scenario house three primary sludge pumps (two duty and one standby) and four settled sewage pumps (three duty and one standby), with each set withdrawing from a dedicated sump. For module 1 only two primary sludge pumps will be installed (one duty and one standby) and three Settled Sewage Pumps (two duty and one standby). The details of the pumps are as follows:

- Primary Sludge Pumps: Centrifugal, self-priming pumps that can handle solids up to 75mm, each with a duty of 15.5 ℓ/s at a total head of 7m (4kW Motor)
- Settled Sewage Pumps: Centrifugal, self-priming pumps that can handle solids up to 75mm, each with a duty of 31 ℓ/s at a total head of 7m (5.5kW Motor)
- Floor drainage pump: Centrifugal, self-priming pump that can handle solids up to 38mm, with a duty of 5 ℓ/s at a total head of 10m (2.2kW Motor)

12.3.5 Electrical

The scraper mechanism on the half diameter peripheral drive bridge is fed via slip rings from the MCC in the Primary Sludge Pump Station MCC room. The MCC in the Primary Sludge Pump Station MCC room is supplied from the BNR reactor No 1&2 substation. All the bridges are fed from the same MCC in the Primary sludge pump station, for the first phase motor controls for 2 tanks will be installed and space will be allowed for 4 more in the future.

12.3.6 Control and Instrumentation

The bridge drives will operate at a fixed speed. A local start/ stop station with an emergency stop “turn to release” button will be installed at the access point to the bridge for local control and safety purposes. The status of this equipment will be monitored by the PLC in the Primary Sludge Pump Station PLC room.

12.4 FLOW AND LOAD BALANCING TANKS

The Flow and Load Balancing Tanks are located downstream of the Primary Sedimentation Tanks, are used to balance diurnal wastewater flow and load variations, and to achieve a constant or near constant flow and load rate to the BNR Reactors.

The design of the process units follows the recommendations contained in the JW Guidelines for the Design of Wastewater Treatment Unit Processes (Revised August 2015) – Section 1.3 Flow and Load Balancing.

12.4.1 Design

The design of the Balancing Tanks was based on Process Flow Diagram (PFD) No. 04 (Dwg no. 13082-72-4-PFD-04), and the hydraulic flow calculations.

The sizing of the Balancing Tanks was determined using a computed flow balance of inflow, outflow and storage over the design duration of one calendar week, by using the inflow readings for the Northern WwTW normalised for the final treatment works design capacity of 150 Mℓ/d. The required volume of 29,730m^3 was divided into five tanks, as the final works will be constructed with five duty and one standby tank. The volume required for each tank, including a 10% allowance for "dead" volume (approximate), was calculated as 6,595m^3, which resulted in tank dimensions of 40m wide * 40m long * 4.1m deep. Two tanks (compartments) will be constructed for each 50 Mℓ/d module, in a "back-to-back" configuration with a common centre wall.

The Balancing Tank division structure consists of a square tank, with a common inlet box that is fed from the PST's. The incoming flow is then split into three streams for the three works modules, via three weirs. The flow to a module is transported via a 1,500mm dia. pipe to a common inlet box connected to a Balancing Tank, from where it can be split into the two compartments. The two compartments will be able to be operated as individual tanks. The flow enters each compartment through an opening of 1500mm * 1500mm, which is located close to the floor. Each opening will be equipped with stainless steel sluice gates.

The two compartments are also hydraulically linked, via two openings of 1500mm * 1500mm that are located in the common centre wall. These openings will also be equipped with sluice gates, that can be open or closed, according too operational and/or maintenance requirements.

The floors of the Balancing Tank slopes gently to the centre of each compartment, towards an outlet sump, that is located approximately in the centre of each compartment. This sump can be used for normal operation of the tank, or for cleaning and maintenance purposes. An anti-vortex forming structure covers the top of the sump.

Each outlet sump is equipped with a 1000mm dia. pipe to transport flow to the BNR Reactor division structure. The pipes pass through a control building that houses a control valve and flow meter (on each outlet pipe). No further redundancy is incorporated into the design of this section of the Works, as each compartment can be drained individually.

The Balancing Tank is designed so that it can accommodate a portion of the PWWF, which will depend on the number of modules that have been constructed. Flow in excess of the storage capacity exits each compartment via an emergency overflow weir. The overflow weir extends through the common centre wall, so that overflow from both compartments can enter a common sump, from where a single 1500mm dia. pipe transports flow to the Stormflow Dam. Thus, during a wet weather event, flow will enter either (or both) compartment(s) first until capacity is reached. Thereafter, the excess flow is transported to the Stormflow Dam.

Each compartment is equipped with four mixers that are equally spaced in each compartment to ensure that the contents remain in suspension. The mixers are mounted from 1.7m wide walkways that will also be used to access each mixer. The walkways are protected by 1m high concrete walls on the edges.

12.4.2 Materials of Construction

The Balancing Tank will be constructed using reinforced concrete, with dolomitic aggregate, and with 20mm filled and sealed expansion joints.

The sluice gates will be manufactured using stainless steel (grade 304), and the hand-railing will be constructed using 3CR12 stainless steel.

12.4.3 Piping and Valves

The piping from the Balancing Tank Division Box to the Balancing Tank inlet structure will be constructed using a 1500mm dia. structured wall HDPE pipe, and the piping from the Balancing Tank overflow structure to the Stormflow Dam using a 1500mm dia. concrete Pipe.

The piping from the Balancing Tank to the Bio-Reactor Flow Control Building will be constructed using a 1000mm dia. stainless steel pipe (grade 304), which will be encased in mass concrete where it runs underneath the structure.

The flow control valves within the control building will be actuated knife gate type valves with a manual knife gate valve placed on either side of the flow control valve to enable ease of removal and maintenance.

12.4.4 Mechanical

The mechanical equipment to be supplied at the Balancing Tanks will consist of four vertical, surface mounted mixers of 5.5 kW each, per compartment.

12.4.5 Electrical

The mixers on the balancing tank 1&2 that will be installed with the first 50Mℓ/d module are fed from the BNR Reactor 1&2 MCC, and the future balancing tanks 3&4 and 5&6 will be fed from the future MCC's located at biological reactor 3&4 and 5&6 respectively.

12.4.6 Control and Instrumentation

The mixers will be switched on and off depending on the level in the corresponding balancing dam to prevent the mixer from aerating the bulk liquid and to protect the mixer motor.

The flow and load balancing is controlled via a flow control valve and flowmeter on the Balancing Tanks outlet pipes in the Balancing Tank Flow Control Building. The PLC in the respective biological reactor PLC room controls the flow from the balancing tank. The flow balancing aims to allow a constant flow to the biological reactor by controlling the outlet valve.

12.5 STORM FLOW DAM

The Storm Flow Dam is situated on the eastern portion of the site and it is located in close proximity to the minor and major tributary that drains to the Jukskei. The Dam is situated at a lower level than the Head of Works to enable overflow during periods of high wastewater flow to gravitate to the Storm Flow Dam. The *Johannesburg Water: Guidelines for the Design of Wastewater Treatment Unit Processes Rev 16* outlines the treatment objective of the Storm Flow Dam. It states that the Storm Flow Dam shall deal with high wastewater flows in a manner which does not:

- Impact negatively on the main stream BNR treatment process, functioning and performance and
- Does not impact negatively on the receiving water resources, downstream of the Works discharge.

12.5.1 Design

12.5.1.1 Design assumptions

Storm Flow Dam

- The Storm Flow Dam has been designed for the ultimate 150Mℓ/d plant which will consist of three 50 Mℓ/d modules
- The wet weather storm flow entering the Storm Flow Dam receives preliminary treatment in the form of screening at the inlet structure of the Dam
- The Storm Flow Dam is designed for a minimum nominal hydraulic retention time of 2 hours at the peak excess storm flow rate to achieve effective wastewater solids separation
- The Storm Flow Dam is not required to be compartmentalised

Storm Flow Dam Pump Station

- The recommended suction velocity on the pumps is 0.8m/s which conforms to industry best practice
- The recommended delivery velocity on the pumps is 1.5m/s which conforms to industry best practice
- The duration to empty the dam is 18 hours

12.5.1.2 Design Data

The following design data was extracted from the Process Description Report (13082-45-Rep-003-Process Description Report).

- **Design Wastewater Flows**
  - ADWF Phase 3 = 150 Mℓ/day
  - PDWF Phase 3 = 252 Mℓ/day
  - PWWF Phase 3 = 360 Mℓ/day

The design of the Storm Flow Dam conforms to the *Johannesburg Water: Guidelines for the Design of Wastewater Treatment Unit Processes Rev 16.*

The Storm Flow Dam terrace will consist of the following structures:

- Storm Flow Dam

The Storm Flow Dam is concrete lined to prevent the infiltration of raw sewage into the groundwater system. A concrete ramp will be constructed from the crest to the floor of the

Dam. This is to enable the Dam to be cleaned during dry periods. The Storm Flow Dam contains a sub-soil drainage system for groundwater alleviation. Leakage detection is provided for, to determine if there are leaks in any sections of the Dam. The leakage detection pipe has an outlet at a manhole that will need to be regularly monitored to determine if any panels of the Dam are leaking.

- Inlet Structure

The Inlet Structure for the Storm Flow Dam is located at the southern end of the Dam. The Inlet Structure of the Dam receives flow from an 1800mm diameter Class 100D reinforced concrete pipe. The effluent from the pipe flows into a rectangular concrete channel. A hand raked screen will be installed at the Inlet Structure to remove debris. A bypass is provided for in the event of the screens being blinded. Downstream of the screen is an inclined concrete lined Inlet Structure that leads into the Dam. The inclined segment of the Inlet Structure is provided with energy dissipaters to reduce the velocity of incoming wastewater.

- Emergency Overflow Structure

The Emergency Overflow Structure is located at the north eastern portion of the Dam. Once the Dam has reached its design capacity it will spill into the Overflow Structure. The Overflow Structure consists of a reinforced concrete spillway that discharges into an earth lined channel. The channel will be lined with Reno Mattress to facilitate erosion protection and discharge into the tributary leading to the Jukskei River.

- Draw-Off Structure

The draw off structure is a reinforced concrete box positioned at the lowest point in the Dam. If the Dam needs to be emptied for maintenance, the content of the dam will gravitate to the Draw Off Structure. The Draw Off Structure is provided with a 1000mm diameter stainless steel pipe that leads into the sump of the Emergency Overflow Pump Station.

- Storm Flow Dam Pump Station

The Storm Flow Dam Pump Station is located adjacent to the Dam. The Pump Station conveys effluent from the Dam to the Head of Works. A total of two pumps (one duty and one standby) will be housed in the Pump Station. A sump has been provided at the Pump Station to draw-off effluent from the Dam. The provision of a sump at the Pump Station is the least complex mechanism to monitor the level in the Dam.

The position of the Storm Flow Dam Pump Station will be investigated further during the next phase of the project. If the Gauteng Department of Agriculture and Rural Development

(GDARD) object to the construction of the Pump Station in the wetland buffer zone, it will have to be relocated to the upper side of the Storm Flow Dam.

12.5.1.2.1 Sizing of Structures

- Storm Flow Dam

The Storm Flow Dam is sized in accordance with the dimensional guidance provided in the *Johannesburg Water: Guidelines for the Design of Wastewater Treatment Unit Processes Rev 16.* The volume of the Dam was calculated as follows:

Volume = (PWWF – ADWF) x Hydraulic Retention Time

= (15 000m^3/hr – 6 250m^3/hr) x 2hrs

= 17 500m^3

JW requested that the area where the dam is situated be maximised to increase the capacity of the Dam. This resulted in an additional 2 500m^3 being added to the volume of the Dam. The final capacity of the Dam is 20 000m^3.

Once the volume and geometry of the Dam has been approved by JW, an assessment to determine whether the Dam will require safety approval from DWS Dam Safety Office will be conducted.

- Inlet Structure

The Inlet Structure for the Dam is sized to accommodate the overflow from the Head of Works and the diameter of the incoming pipe. The top of concrete of the Inlet Structure is higher than the crest level of the Dam to ensure that the structure does not overflow.

- Emergency Overflow Structure

The Emergency Overflow Structure is sized to allow the Dam to spill once it has reached the design capacity. The Overflow Structure is sized to accommodate the incoming flow into the Dam and additional flow from rainfall that falls onto the Dam. Any overflow will be measured.

- Draw-off Structure

The Draw-off Structure is sized to accommodate the diameter of the pipe that exits the structure to the Storm Flow Pump Station. The Draw-off Structure is submerged and allows the Dam to drain via gravity. The walls of the structure are raised to prevent grit inflow to the pumps.

- Storm Flow Pump Station

The Storm Flow Pump Station is sized to accommodate the proposed pumps that will be housed in the Pump Station. A minimum distance between plinths of 1.2m is provided to ensure sufficient space to enable maintenance of the pumps.

The pumps are sized to enable the Dam to be emptied in 18 hours which is as per the recommendation by Johannesburg Water.

12.5.2 Mechanical

Storm Flow Overflow Pump Station:

- Storm Flow Pumps: Centrifugal, self-priming pumps that allow passage of solids up to 75mm, each with a duty of 290 ℓ/s at a total head of 19m (75kW Motor)
- Floor drainage pump: Centrifugal, self-priming pump that allows solids passage of up to 38mm, with a duty of 5 ℓ/s at a total head of 10m (2.2kW Motor)

12.5.3 Electrical

The pump station is provided with its own MCC supplied from the BNR reactor No 1&2 substation. The need for emergency power for equipment supplied from this MCC will be determined during a HAZOP study.

12.5.4 Control and Instrumentation

A PLC in the PLC room at the storm flow dam controls the pumps in automatic mode of operation. The dam levels and flows will be wired into this PLC for control and monitoring purposes. Flow measurement will be done at the Emergency Overflow.

12.6 BIOLOGICAL NUTRIENT REMOVAL REACTOR

Two adjoining BNR Reactors, located downstream of the Flow and Load Balancing Tanks and upstream of the Secondary Clarifiers, are provided for each 50 Mℓ/d phase of the Lanseria WwTW. Each adjoining bioreactor has been designed with a treatment capacity of 25 Mℓ/d.

Details regarding the process design of the BNR reactors can be found in Section 9.1.6 of this report and this section highlights the key civil design features which are based on the JW Design Guidelines - Section 2.2 BNR Reactor Configuration and Layout.

12.6.1 Design

The civil design of the BNR Reactors is based on the Process Flow Diagram (PFD) No. 05 (Dwg no. 13082-72-4-PFD-05), and the hydraulic flow calculations. The Civil Drawings to be referenced range from Dwg nos. 13082-73-8-101 to 13082-73-8-804.

The wastewater feed from the Flow and Load Balancing Tanks is regulated by actuated control valves and downstream of the flow control it is hydraulically distributed to each BNR Reactor in the BNR Reactor Flow Division Structure. For each BNR Reactor, the flow is conveyed in a 1000mm dia. concrete pipe and it feeds into the Anaerobic zone of the BNR Reactor. The pipeline has been hydraulically designed to convey 100% of the flow to the Anaerobic zone. A 375mm dia. concrete pipe has also been designed to feed the pre-anoxic zone with up to 15% of the feed from the Flow and Load Balancing Tank. This pipeline originates from a concrete box placed on the 1000mm dia. pipeline and the box will be equipped with a manual sluice gate to enable throttling the feed to the pre-anoxic cell as per the prescribed range of 0% to 15%. It is expected that the position of the sluice gate will not be regularly adjusted therefore JW advised that the process should not be automated.

The generic shape of the BNR Reactor as prescribed in the JW Design Guidelines has been adhered to; the cells of the BNR Reactor have been configured in a meandering arrangement that has been spatially optimized for all 3 modules of the BNR Reactors on the terrace. The cells that have been provided per BNR Reactor as per the PFDs are the pre-anoxic cell (1 no.), anaerobic cell (1 no.), anoxic cells (2 no.) and the aerobic cells (3 no.). An additional compartment which is part of aerobic zone 3 was added at the outlet of the BNR Reactor in order to optimize the positioning of the A-Recycle pump station (this is further discussed under Aerobic Zone).

Pre-anoxic Zone

The pre-anoxic zone is sized at 11.4m x 9.0m x 6.8m deep yielding a volume of 692m^3 which complies with the requirement of 690m^3. It is fed by a submerged 375mm dia. concrete pipe which discharges 1m above the BNR Reactor's floor level to prevent any turbulence being created in the zone which should be maintained unaerated. The JW Design Guidelines prescribe an energy dissipation device at the inlet, however this has not been incorporated because any obstruction feature at the inlet depth will cause turbulence. (This will be revisited during detail design). The chamber size is adequate to dissipate the energy of the incoming flow. The pre-anoxic zone is also fed by an 800mm dia. Stainless Steel (S.S.) pipe for the B-recycle stream from the Anaerobic zone. The S.S. pipe is located 300mm above floor level to ensure that there is no turbulence caused at the discharge point.

The contents of the pre-anoxic zone will be kept in suspension by a single mixer. The activated sludge (AS) flows into the Anaerobic zone over a 10m wide submerged overflow weir. The details of the mixer are given in the mechanical equipment section.

Anaerobic Zone

The Anaerobic zone is sized at 18.4m x 11.4m x 6.7m deep yielding a volume of 1,405m^3 which complies with the requirement of 1,383m^3. It is fed by a submerged 1000mm dia. concrete pipe from the Flow and Load Balancing Tank which constitutes of 85% to 100% of the settled waste water feed. The elutriant from the primary sludge fermenters is also introduced at the beginning of the anaerobic zone. Similar to the pre-anoxic zone, the inlet pipe is located 1m above the floor level. Similar to the pre-anoxic zone, no energy dissipation structure has been added. A b-recycle pump station is located on the outer corner of the zone to recycle some of the AS to the pre-anoxic zone. The contents of the Anaerobic zone will be kept in suspension by two mixers which are centralized in the chamber and they are positioned 7.8m apart. The AS will flow into the first anoxic zone over a 10m wide submerged overflow weir.

Anoxic Zones

Two Anoxic zones are sized at 28.2m x 13.2m x 6.6m deep each, and they yield a combined volume of 4,281m^3 which complies with the requirement of 4,150m^3. In addition to receiving flow from the Anaerobic zone, Anoxic zone 1 also receives the a-recycle stream from the last Aerobic zone in the BNR Reactor. The a-recycle sludge is discharged in the Anoxic zone 1 via an open channel which has been designed with a submerged drop inlet section. The drop inlet section will ensure that the inlet is always submerged, complying with the requirements to prevent aeration in the unaerated chambers of the BNR Reactor.

Anoxic zones 1 and 2 are configured in plug flow arrangement and therefore they have the same top water level (TWL). The AS is kept in suspension by two mixers in each of the zones, i.e. a total of four mixers for both Anoxic zones 1 and 2. In each zone, the mixers are spaced at 15m apart.

Aerobic Zones

The Aerobic zones are sized to yield a total volume of 7,652m^3 which complies with the requirement of 7,608m^3. The sizes of the zones are as follows:

- 29.8m x 11.9m x 6.5m deep for Aerobic Zones 1 to 3 and
- 19.9m x 5.7m x 6.5m deep for the section of aerobic zone 3 that is located at the outlet of the BNR Reactor. This section has been added to enable the a-recycle pump station to be positioned at end of the aerobic zone. If this section was not introduced, the a-

recycle pump station would be positioned half way through the last aerobic zone which is non-compliant with the requirements.

The waste water feeds into the Aerobic zone 1 over a 10m submerged overflow weir which ensures that there is no back mixing of waste water between the aerated and the non-aerated zones. The rest of the zones are configured in plug flow arrangement and the effluent is discharged over a 10m overflow weir to an outlet box. At the end of the BNR Reactor, the a-recycle pump station has been located to recycle the sludge to the Anoxic zone 1. A suction pool for the a-recycle pump station has been created by adding a half-height wall at the very end of the aerobic zone. The dimensions of the pool are 6.3m x 6m x 6.5m deep.

The Aerobic zones will be equipped with floor mounted membrane diffusers for the fine bubble aeration system. The details of the aeration system are discussed in the mechanical section for the BNR Reactor.

A-Recycle

The A-Recycle Pump Station is located at the end of the Aerobic zones and it recycles sludge back to the beginning of the Anoxic zones. The overall footprint dimensions of the pump station, which is contained within the external walls of the BNR Reactor, are 6.5m x 4.5m. The sludge will be fed into the suction chamber of pump station through 2 ports at floor level which are 2m long and 0.5m high. Two duty axial pumps will lift the sludge into a discharge chamber 5.3m higher and the sludge will flow in an open channel that terminates at the Anoxic zone. The open channel is 1m wide by 1.7m deep and it is supported off the external wall.

Three pumps will be erected at 1.9m centre to centre spacing and the openings to the suction sump are 820mm diameter. The ports to the discharge channel are 1m wide by 800mm deep.

B-Recycle

The B-Recycle Pump Station is located in the Anaerobic zone and it recycles sludge back to the beginning of the pre-anoxic zone. The overall footprint dimensions of the pump station, which is contained within the external walls of the BNR Reactor, are 3.8m x 3.8m. The sludge will be fed into the suction chamber of pump station through 2 ports at floor level which are 1m long and 0.5m high. One duty axial pump will lift the sludge into a discharge chamber 5.7m higher and the sludge will flow in an 800mm S.S. pipe that terminates in the pre-anoxic zone.

The two pumps will be erected at 1.75m centre to centre spacing and the openings to the suction sump are 820mm diameter. The ports to the discharge channel are 1m wide by 800mm deep.

Return-Activated Sludge Pump Station

The Return-Activated Sludge (RAS) pump station recycles RAS from the Secondary Clarifiers to Pre-anoxic zone. The overall footprint dimensions of the pump station are 15m x 8.7m. The sludge will be fed into the main suction chamber of the pump station which is 8.7m long by 3.7m wide. Four Archimedean screw pump channels have been provided to accommodate 1400mm dia. screws. A port 700mm wide by 700mm high will feed each of the channels for the four screw pumps. One duty screw pump for each BNR Reactor will lift the RAS from the sump to a discharge chamber 5.5m higher. The sludge will overflow to an outlet box to feed a specific Reactor. There will be an ultrasound flow meter on the weir position to the measure the flow.

A 1000mm dia. concrete pipe will convey the RAS to the pre-anoxic zone of the Reactor and the inlet level will also be 1m above the BNR Reactor's floor level.

BNR Reactor Special Features

Some of the special features that have been incorporated in the design for the BNR Reactor are as follows:

- Services Tunnel – A tunnel that is 3.7m wide by 3.1m deep will be located between the adjoining BNR Reactors over the length of the unaerated zones. All cable racks for all the equipment will be mounted against the wall in the tunnel. Any other small equipment that will be required will be located in the tunnel.
- Walkways – The BNR Reactors will have one main central walkway to service both Reactors and other walkways branch off to provide access to mixer platforms and to other areas that require access. The main central walkway is 4m wide and the others are 1.4m wide. The width of the main central walkway is governed by space requirements with inclusion of 700mm dia. S.S. aeration header pipes. The aeration header pipes will be positioned either side of a 1.7m access corridor.
- Platforms – Each of the mixers will be mounted on 3.5m x 3.5m platforms which will be supported on 400mm square columns. The platforms will be provided with an access manhole for maintenance purposes.
- Internal walls (Ports) – All internal walls between the zones have been sized to be 450mm thick to withstand the operating differential water levels between the zones. However, the walls are not designed to withstand full water pressure on only one face of the wall. 300mm wide by 300mm high ports will be provided at floor level in order to facilitate with draining the BNR Reactor.
- Drainage – The BNR Reactor will be drained by gravity by opening sluice gates to the outlet box and also by pumping with submersible pumps located at the sump position. The pump will discharge in either the Outlet Box or alternatively in the adjoining Reactor. A gate will be provided to direct the flow to either discharge point.

12.6.2 Materials of Construction

The BNR Reactor will be constructed using reinforced water retaining concrete, with dolomitic aggregate, and with 20mm filled and sealed expansion joints.

The Ferric Dosing bund area will be constructed using reinforced water retaining concrete, with dolomitic aggregate and coated with approved corrosion protection coating.

12.6.3 Piping and Valves

The pipes for the BNR Reactor are as follows:

- B-Recycle pipe work, stainless steel grade 304
- Drainage pipe work for submersible pump, stainless steel grade 304
- Aeration header pipework, stainless steel grade 304
- Aeration manifold and laterals, PVC

12.6.4 Mechanical

The following mechanical equipment will be installed for each 25 Mℓ/d BNR Reactor:

BNR Reactor:

- Surface Mounted Mixers: 7 no. 7.5 kW
- Blowers: 3 no. 160kW (2 duty and one standby)
- A-Recycle Pumps (two duty and one standby): Pump Capacity 360 ℓ/s (each) at 5m total head (45kW motor) (All three pumps will be used for higher flows)
- B-Recycle Pumps (one duty and one standby): Pump Capacity 360 ℓ/s (each) at 5m total head (37kW motor) (All three pumps will be used for higher flows)
- Dissolved Oxygen (DO) probes with temperature indication: 3 no.
- Mixed liquor suspended solids (MLSS) probes (1 no.)

RAS Pump Station:

- RAS Screw Pumps (one duty and one standby): 360 ℓ/s at 6m head

Ferric Chloride Dosing:

- Two Ferric Storage tanks
- Two Ferric Dosing Pumps including pipework at tanks and to dosing point (Two pumps will be kept in store)

- Emergency Shower

12.6.5 Electrical

A substation for a supply larger than the electrical demand of all the mechanical equipment at the BNR Reactor, Secondary Clarifiers, WAS pump station, and the Fermenters and associated Pump Stations will be installed at the Biological Reactor. The substation will be connected in the 11kV ring supply for “standby power” This substation will supply the mechanical equipment, instruments, PLC and site lighting in the area via the BNR Reactor MCC. This 11kV cable will be routed to accommodate the future biological reactor substations. A standby generator will also be installed for the emergency supply to the biological reactor MCC to supply the equipment required by the Johannesburg Water “Guidelines for the Design of Wastewater Treatment Unit Processes, August 2015”. A UPS will supply the electronic equipment like the PLC in the event of a power failure until the standby or emergency power is restored.

12.6.6 Control and Instrumentation

A PLC in the biological reactor PLC room controls the equipment supplied from the biological reactor MCC. All instruments i.e. DO sensors, flowmeters etc. in the reactor area will be connected to the biological reactor PLC for control and to relay the readings to the SCADA system in the control room.

The PLC, in automatic mode, controls the equipment at the BNR Reactor, balancing tanks, clarifiers and pump stations in accordance with the control philosophy to be detailed at a later stage.

12.7 SECONDARY CLARIFIER

The Secondary Clarifiers are located downstream of the BNR Reactor, and are used to separate the biological solids in the mixed liquor (MLSS) from the treated effluent, and to thicken the residual activated sludge for recycling back to the BNR Reactor. These tanks produce an effluent with a low suspended solids concentration.

The design of the secondary clarifiers follows the recommendations contained in the JW Guidelines for the Design of Wastewater Treatment Unit Processes (Revised August 2015) – Section 2.3 Secondary Clarification Tanks.

12.7.1 Design

The design of the secondary clarifiers is based on the Process Description Report (13082-45-Rep-003), Process Flow Diagram (PFD) No. 07 (Dwg no. 13082-72-4-PFD-07), and the hydraulic flow calculations.

Each 25 Mℓ/d bioreactor is provided with a set of two 33m diameter Clarifiers fed from a mixed liquor suspended solids flow division structure which is capable of providing equal flow distribution among the two Clarifiers. Capability for isolating individual tanks is provided.

The JW Design Guidelines also require that at least two (2) settling tanks per reactor/module must be provided, for redundancy and or reliability reasons. Four Clarifiers will be constructed during the first phase, 2 per 25 Mℓ/d bioreactor.

Each Clarifier is provided with the following features: -

- An Inlet structure at the centre of the tank comprising:
  - A vertical inlet pipe encased in concrete
  - Four outlets into a flocculation chamber
  - A stilling chamber
- The main clarifier comprising:
  - Holding tank with conical floor
  - Sludge collection sump around the vertical inlet with a sludge withdrawal pipe
  - An overflow launder with an outlet box

The overflow from each set of two secondary clarifiers will first common up for sampling purposes and thereafter flow is directed towards the final effluent disinfection contact tanks.

<u>WAS Pump Station</u>

The sludge from each set of two Clarifiers gravitates to the sump of their RAS pump station located next to it's Bio-Reactor. The RAS screw pumps lift the sludge for recycling back to the Bio-reactor and a portion is directed to a sump at the WAS pump station from where it is transferred to the WAS thickeners. The scum from the Clarifiers gravitates into the same sump at the WAS pump station.

The final phase (first phase in brackets) will produce the following:

- Maximum WAS: 12,000m^3/d (4,000m^3/d)
- Average WAS: 5,000m^3/d (1,667m^3/d)
- Minimum WAS 2,000m^3/d (667m^3/d)

The WAS sump volume provided = 33 m^3.

The dimensions of the key components are as follows:

- Clarifier: 33m internal dia. with 4m side wall depth
- Overflow launder: 450mm wide * 600mm high (max flow depth = 300mm)
- Stilling well: 5.1m dia. * 2.7m high
- Sludge hopper: 5.1m dia.

12.7.2 Materials of Construction

The Clarifier will be constructed using reinforced concrete, with dolomitic aggregate.

The mechanical equipment will be manufactured as follows:

- Weir plate; scum board and Stamford baffle: 3CR12 stainless steel
- Sludge scraper (wetted components): stainless steel grade 304
- Rotating bridge: 3CR12 (from 3CR12 rolled plate as 3CR12 structural members are not manufactured any longer) or Duplex steel (Hot dipped galvanised with polyurethane coating)
- Launder covers: Glass reinforced plastic

12.7.3 Piping and Valves

Each Clarifier will have the following features: -

- Inlet pipe: 900mm dia. stainless steel grade 304
- Outlet pipe: 900mm dia. concrete pipe
- Sludge withdrawal pipe: 500mm dia. stainless steel grade 304
- Subsoil drainage pipes underneath the structure: 110mm Flexible HDPE
- Scum outlet will be fitted with a manual isolation valve downstream of the automated scum outlet

12.7.4 Mechanical

<u>Clarifier:</u>

Each Clarifier is equipped with a sludge scraping mechanism comprising of a rotating bridge structure with sludge scraper. The scum removal mechanism comprises scum boards and a scum collection box. An overflow weir plate is installed on the launder wall. A bar screen is installed at the launder outlet box. A Stamford baffle is installed along the bottom periphery of the launder. The launder is covered with removable/fixed covers with hinges.

WAS Pump Station:

The WAS pump station will be constructed to house, at ultimate capacity, four WAS pumps (three duty and one standby). Each pump is sized to deliver 99.4 ℓ/s at a total head of 22m (38kW motor). Only two pumps will be installed with the first phase (one duty and one standby).

Floor drainage pump: Centrifugal, self-priming pump that can handle solids up to 38mm with a duty of 5 ℓ/s at a total head of 10m (2.2kW Motor)

A mixer will be installed at the combined WAS / Clarifier Scum sump.

12.7.5 Electrical

The secondary clarifiers that will be installed with the first 50Mℓ/d plant are fed from the MCC in the BNR Reactor 1&2 MCC room, and the clarifiers 4&6 and 7&9 will be fed from the future MCC's located at BNR Reactor 3&4 and 5&6 MCC rooms respectively.

12.7.6 Control and Instrumentation

The secondary clarifier bridge drives will be running at a fixed speed. A local start/ stop station with an emergency stop "turn to release" button will be installed at the access point to the bridge for local control and safety purposes. The status of this equipment will be monitored by the PLC in the BNR Reactor 1&2 PLC room.

12.8 DISINFECTION

The Disinfection Facility is located downstream of the Final Clarifiers. Disinfecting chemicals are added to the effluent from the Final Clarifiers and passed through a Contact Tank. The Contact Tank contains three channels that are designed to allow sufficient contact time between the disinfecting chemical and the wastewater to reduce the E coli count in the effluent. The treated effluent from the Disinfection Facility is discharged into the Jukskei River.

12.8.1 Design

12.8.1.1 Design assumptions

- The WWTW will be constructed in 3 x 50Mℓ/d modules. The total capacity of the plant is 150 Mℓ/day.
- The Disinfection Facility for the 150 Mℓ/d plant will be constructed during the first phase. Therefore, the structure is designed for a PDWF of 252 Mℓ/d.
- The current design does not allow for any redundancy for the Contact Channels.

- The final effluent from the Chlorine Contact Tank is discharged via a lined channel into the Jukskei River whilst a portion of the final effluent is abstracted as wash water.
- The chlorine dosing occurs upstream of the Chlorine Contact Tank.
- The possibility of phasing in the Contact Channels will be explored during the next phase of the project, if the cost for constructing all 3 Contact Channels is too high.

12.8.1.2 Design Data

The design data for the scenario where all 3 modules are constructed was extracted from the Process Description Report (13082-45-Rep-003-Process Description Report):

- **Design Wastewater Flows**
    - ADWF Phase 3 = 150 Mℓ/d
    - PDWF Phase 3 = 252 Mℓ/d
    - PWWF Phase 3 = 360 Mℓ/d

All designs conform to the *Johannesburg Water: Guidelines for the Design of Wastewater Treatment Unit Processes Rev 16*.

12.8.1.3 Disinfection Facility

The Disinfection Facility consists of the following structures:

- Chlorine Contact Tank

The Chlorine Contact Tank is situated downstream of the Secondary Clarifiers and enables effluent that has been dosed with disinfecting chemical to gradually pass through the channel with sufficient contact time to kill E.coli bacteria. The Chlorine Contact Tank consists of a rectangular tank that is divided into three channels. The tank will be constructed from reinforced concrete.

The entrance of each channel at the Chlorine Contact Tank has a 1m x 1m opening with an upward opening sluice gate. The purpose of the sluice gate is to isolate each channel. Once flow enters each channel a scum baffle is provided to trap scum that enters the channel. Scum that has been trapped by the scum baffle will have to be manually removed by JW operational staff. A baffle wall with circular openings is provided towards the end of the three channels in the Chlorine Contact Tank. The purpose of the baffle wall is to ensure that sufficient mixing occurs when effluent exits each channel. The three channels also have floor drains which will enable the tank to be emptied by draining its contents into the Desludging Sump.

- Scum Box

The Scum Box is situated adjacent to the first compartment in the Chlorine Contact Tank. A downward opening sluice gate is provided at the entrance of the Scum Box. The intention of the Scum Box is to prevent scum from building up at the entrance of the Chlorine Contact Tank. Scum can be removed by gradually opening the sluice gate at the entrance of the Scum Box and allowing the top layer of scum to drain into the Scum Box.

- Bypass Box

The Bypass Box is situated upstream of the Chlorine Contact Tank. The purpose of the Bypass Box is to allow flow to bypass the Chlorine Contact Tank in the event of an emergency or when maintenance needs to be performed.

- Desludging Sump

The Desludging Sump is situated at the end of the Chlorine Contact Tank. The Desludging Sump receives flow from the floor drains in the Chlorine Contact Tank via a 200mm stainless steel pipe. The outlet of the stainless steel pipes into the Desludging Sump is equipped with a penstock to control flow into the sump. The sump will be used if a channel needs to be drained during maintenance or if the level in the channels needs to be reduced. The sludge from the sump will be pumped to the sump that feeds the WAS Pump Station.

- Chlorine Dosing Installation

The Chlorine Dosing Installation is situated upstream of the Chlorine Contact Tank. The installation consists of a lined reinforced concrete bunded area. The purpose of the lining is to ensure that the dosing chemical does not attack the concrete.

The bunded area holds 4 GRP tanks with a UV protective coating. The tanks contain Di Basic Filtrate (DBF) which will be used to dose effluent from the Final Clarifiers before it enters the Chlorine Contact Tank.

- Wash Water and Sludge Pump Station

The Wash Water Pump Station is located at the end of the Chlorine Contact Tank. The Pump Station will be used to pump effluent from the Chlorine Contact Tank to two separate header tanks for the liquid and sludge waste streams. It will also pump effluent from the Desludging Sump to the WAS Pump Station. A total of six pumps (three duty and three standby) will be housed in the Wash Water and Sludge Pump Station. The Pump Station will contain a sump that will be pumped out to prevent flooding from occurring in the pump station. A crawl beam will also be provided inside the Pump Station that will enable the pumps to be removed for maintenance.

12.8.1.3.1 Sizing of structures

- **Contact Channels**

The sizing of the Contact Channels is provided in the Process Description Report (13082-45-Rep-003). The report states that each channel shall have a volume of 1050m^3. Subsequent sizing of each contact channel yielded the following results:

Length = 125m

Width = 5.6m

Depth = 2.6m (1.8m + 0.8m freeboard)

Volume = 125m x 5.6m x 1.8m = 1260 m^3 per channel (excluding freeboard)

The freeboard height is informed by industry best practice and is provided to prevent the water level from overflowing the sides of the Chlorine Contact Tank. The determination of the freeboard height is based on the following factors:

- The top water level at static conditions in the Chlorine Contact Tank and
- The resultant top water level due to a sudden increase of flow upstream.

To be assured that a given percentage of flow remains in each Contact Channel for a sufficient period of time to kill off the E.Coli bacteria, the most common approach entails using a long plug flow setup to eliminate the formation of hydraulic dead zones. A calculation to determine the Length to Width ratio must be conducted to determine if the length of each channel allows sufficient contact time. The *Johannesburg Water: Guidelines for the Design of Wastewater Treatment Unit Processes Rev 16* recommends that a minimum length to width ratio of 10 is used in the design of Chlorine Contact Channel. Based on the dimensions of the Contact Channels a length to width ratio of 22.3 has been achieved. This value compares favourably with the value provided in the *Johannesburg Water: Guidelines*. The calculation of the length to width ratio is provided below:

Length to Width ratio = Length of Structure ÷ Width of Structure

= 125 ÷ 5.6

= 22.3

- **Scum Box**

The Scum Box is sized to accommodate the diameter of the pipe exiting the Box as well as the size of the sluice gate at the entrance of the Box. In light of this, the Scum Box has both a length and width of 2.6m. The top of concrete (TOC) of the Scum Box is the same level as the TOC of the Chlorination Contact Tank. This will ensure that the Scum Box does not overflow when the scum is being removed from the Chlorine Contact Tank. The total volume for the Scum Box is calculated as follows:

Volume = Length x Width x Height of Box

= 2m x 2m x 2.6m

= $10.4m^3$

- **Desludging Sump**

The volume of the Desludging Sump was calculated according to the formula below:

$T = 4V / Q_p$ (Prosser, 1977)

Where T = Time between pump starts

V = Volume of sump

Q_p = Pumping rate

$V = [(15m \times 60s) \times (0.045m^3/s)] \div 4 = 10.1m^3$

As per the equation above, the minimum volume of the Desludging Sump must be $10.1m^3$. The sizing of the Desludging Sump was informed by the volume calculation above, the dimensions of the Chlorine Contact Tank and the size of the outlet pipe from the sump. In light of these considerations, the Desludging Sump was sized as follows:

L = 1.6m

W = 17.4m

H = 3.5m

Volume = L x W x H = 1.6m x 17.4m x 3.5m

= $97.4m^3$

The Desludging Sump has a volume of $97.4m^3$ which shows that if the pumps fail an adequate storage volume is provided in the sump. The top of concrete (TOC) of the Desludging Sump is the same level as the TOC of the Chlorine Contact Tank. This ensures that the Drainage Sump does not overflow when the Chlorine Contact Tank is being emptied.

- **Bypass Box**

The Bypass Box is sized to accommodate the diameter of pipe that enters and exits the Box. In light of this, the Bypass Box has both a length and width of 2.4m with 250mm thick reinforced concrete walls. The top of concrete (TOC) of the Bypass Box is the same level as the TOC of the Chlorination Contact Tank. This ensures that the Bypass Box does not overflow. The total volume for the Bypass Box is calculated as follows:

Volume = Length x Width x Height of Box

= 1.9m x 1.9m x 2.6m

= $9.4m^3$

- **Chlorine Dosing Installation**

The tanks are sized in the Process Description Report (13082-45-Rep-003). The sizes are as follows:

DBF Storage Tanks = 3 No. off $7.5m^3$ tanks

DBF Receiving Tanks = 1 No. off $7.5m^3$ tanks

The Chlorine Dosing Installation includes 4 plinths to accommodate the 4 tanks. The bunded area will hold a volume of 110% x volume of the tanks. The design of the bunded area will be in terms of SANS 10131:2004, which states that the bund must be liquid tight and have a minimum wall height of 350mm. The internal surfaces of the concrete structure will be coated with an approved corrosion protection coating. The bunded area will drain into the inlet of the Chlorine Contact Channels.

12.8.1.4 Wash Water Pump Station

The Wash Water Pump Station is sized according to the dimensions of the pumps that are housed in the Pump Station. A minimum distance between plinths of 1.2m is provided so there is sufficient space to enable maintenance of the pumps.

The pumps are sized according to the duties provided in the table below:

Table 24 : Pumps selection data

Pumping		Q (ℓ/s)	H (m)
From	To		
Chlorine Contact Tank	WAS Pump Station	30	7
Chlorine Contact Tank	Header Tank (Sludge Stream)	30	33
Chlorine Contact Tank	Header Tank (Liquid Stream)	30	37

12.8.2 Mechanical

Wash Water Pump Station:

- Chlorine Contact Channel Sludge Pumps: Centrifugal, self-priming pumps, each with a duty of 30 ℓ/s at a total head of 7m (5.5kW Motor)
- Wash Water Pumps (Liquid Stream): Centrifugal, self-priming pumps, each with a duty of 30 ℓ/s at a total head of 37m (18.5kW Motor)
- Wash Water Pumps (Sludge Stream): Centrifugal, self-priming pumps, each with a duty of 30 ℓ/s at a total head of 33m (15kW Motor)
- Floor drainage pump: Centrifugal, self-priming pump that can handle solids up to 38mm, with a duty of 5 ℓ/s at a total head of 10m (2.2kW Motor)

Chlorine Dosing:

- One DBF receiving tank
- Two DBF holding tanks
- Two Chlorine Dosing Pumps including pipework at tanks and to dosing point
- Acid wash tank complete with pipework and fittings
- Emergency Shower

12.8.3 Electrical

The electrical demand of all the mechanical equipment at the disinfection and tertiary treatment is approximately 120kVA, the location of this plant is too far for LV distribution from the biological reactor substation. This will not only result in voltage drop issues but also protection and control issues. This MCC's can in future be fed from the MCC at the future biological reactor 5&6. A standby generator will also be installed for the emergency supply to the disinfection facility MCC and a UPS will supply the electronic equipment like the PLC in the event of a power failure until the standby or emergency power is restored.

12.8.4 Control and Instrumentation

The PLC in the Wash Water PLC Room controls the equipment in the disinfection area. All instruments i.e. Level sensors, flowmeters etc. in this area are connected to remote I/O modules installed in separate sections of the various pump station MCC's. The remote I/O modules are connected to the PLC via a bus for control and to relay the readings to the SCADA system in the control room.

The PLC, in automatic mode, controls the equipment at the disinfection, chemical dosing and pump stations in accordance with the control philosophy to be detailed at a later stage.

12.9 FERMENTATION

The Primary Sludge Fermentation Tanks are located at the PST terrace, and are used to ferment primary sludge and to maximise the production of volatile fatty acids. The secondary objective is to control particulate COD carry over in the fermenter overflow for denitrification.

The design of the process units follows the recommendations contained in the JW Guidelines for the Design of Wastewater Treatment Unit Processes (Revised August 2015) – Section 3.2 Primary Sludge Fermentation.

12.9.1 Design

The design of the fermenters is based on the Process Description Report (13082-45-Rep-003), Process Flow Diagram (PFD) No. 11 (Dwg no. 13082-72-4-PFD-11), and the hydraulic flow calculations.

Each Fermenter is fed from a division structure that divides the influent primary sludge and settled sewage equally or as required, by adjusting sluice gates at the weirs. The capability for isolating individual tanks is provided.

A set of two 20m dia. Fermenters are required for the ultimate 150 Mℓ/d works, and both will be constructed during the first phase.

Each Fermenter is equipped with the following: -

- An inlet structure at the centre of the tank comprising:
  - A vertical inlet pipe
  - A stilling chamber
- The main sedimentation tank comprising:
  - A holding tank with a conical floor
  - A sludge collection sump around the vertical inlet with a sludge withdrawal pipe
  - An overflow launder with an outlet box

Primary sludge fermentation is undertaken on a side stream of the main liquid treatment process. Primary sludge is pumped to the fermenters and the fermented liquor overflow is returned either to the Balancing Tank or directly to the anaerobic zone of the BNR Reactor. Waste fermented primary sludge is pumped to the anaerobic digester. No scum removal is provided for at the fermenters.

Fermented Sludge Pump Station

The Fermented Sludge Pump Station is provided with two sumps, one for Fermented Sludge to be recycled back to the Fermenters, and the other for Waste Fermented Sludge which is combined with the primary scum. The Fermented Sludge gravitates from each Fermenter to the recycled sludge sump, and the primary scum to the adjoining sump. The waste fermented sludge is taken through a sluice gate from the sludge recycle sump to the waste sump, where it is mixed with the primary scum before being pumped to the Digesters.

The maximum fermented sludge flow for recycling at ultimate capacity has been calculated as 2,700m^3/d (42 ℓ/s), and the maximum waste fermented sludge flow rate to the Digesters has been calculated as 1,080 m^3/d (12.5 ℓ/s).

The sump volumes provided are as follows:

- Recycled Fermented Sludge Sump volume = 21 m^3
- Waste Fermented Sludge Sump volume = 27 m^3

Design flows for final phase (first phase in brackets):

- Primary Sludge: 2,700m^3/d (900m^3/d)
- Settled Sewage: 8100m^3/d (2700m^3/d)

The dimensions of the key components are as follows:

- Fermenter Tank: 20m internal dia. with 5m side wall depth
- Overflow launder: 500mm wide * 460mm high (max flow depth 238mm)
- Stilling well: 4.5m dia. * 2.5m high
- Sludge hopper: 4.3m dia.

12.9.2 Materials of Construction

The Fermenter will be constructed using reinforced concrete, with dolomitic aggregate, and a special surface protection for acidic environments.

The mechanical equipment will be manufactured as follows:

- Weir plate: stainless steel grade 304
- Sludge scraper including hangars: stainless steel grade 304
- Fixed bridge: stainless steel grade 304, or Duplex steel (hot dipped galvanised with polyurethane coating)

12.9.3 Piping and Valves

Each Fermenter is provided with the following: -

- Inlet pipe: 400mm dia. stainless steel grade 304
- Outlet pipe: 450mm dia. structured wall HDPE pipe
- Sludge withdrawal pipe: 200mm dia. stainless steel grade 304
- Subsoil drainage pipes underneath the structure: 110mm dia. flexible HDPE

<u>Fermented Sludge Pump Station:</u>

- Suction pipes: 200mm dia. stainless steel grade 304
- Delivery Pipes: 200mm dia. stainless steel grade 304
- Valves: Stainless steel grade 304 Knife Gate Valves and Non-Return valves

12.9.4 Mechanical

<u>Fermenter:</u>

Each tank is equipped with a rotating sludge scraping mechanism. An overflow weir plate is installed on the launder wall. A bar screen is installed at the launder outlet box.

<u>Fermented Sludge Pump Station:</u>

The Fermented Sludge Pump Station houses two Fermented Sludge Recycle Pumps (one duty and one standby) and two Waste Fermented Sludge Pumps (one duty and one standby), each withdrawing from a dedicated sump.

- Fermented Sludge Recycle Pumps: Centrifugal, self-priming pumps that can handle solids up to 75mm, each with a duty of 42 ℓ/s at a total head of 6.27m (5.5kW Motor)
- Waste Fermented Sludge Pumps: Centrifugal self-priming pumps that can handle solids up to 75mm, each with a duty of 12.5 ℓ/s at a total head of 24.8m (11kW Motor)
- Floor drainage pump: Centrifugal, self-priming pump that can handle solids up to 38mm with a duty of 5 ℓ/s at a total head of 10m (2.2kW Motor)

12.9.5 Electrical

The electrical supply to the Primary Sludge and Fermented Sludge Pump Station MCC's associated with the fermentation process will come from the substation at the BNR Reactor 1&2. These MCC's will be installed in a MCC room at the pump stations.

12.9.6 Control and Instrumentation

Remote I/O modules, connected to the PLC in the biological reactor 1&2 PLC room, will be installed in the PLC rooms at the various pump stations for control and to relay the readings to the SCADA system in the control room.

The PLC, in automatic mode, controls the equipment at the fermenters and pump stations in accordance with the control philosophy to be detailed at a later stage.

12.10 WASTE ACTIVATED SLUDGE THICKENING

12.10.1 Design

The waste activated sludge (WAS) thickening takes place as part of the sludge stream that is being fed from the underflow of the secondary clarifiers. The representative process flow diagram is 3082-72-4-PFD-12. Structures forming part of the WAS thickening cluster are:

- WAS division box
- WAS thickeners
- Manholes
- Valve boxes

The feed to the WAS thickening section enters a division box located upstream of the WAS thickeners. At this division box, WAS flow gets split into 4 equal streams feeding the WAS thickeners. The division box is equipped with manual penstocks / sluice gates to allow isolation of individual WAS thickeners and automatic flow division to the remaining WAS thickeners.

The WAS thickeners are 22m diameter concrete structures, complete with:

- centre driven bridges;
- overflow weir;
- scum baffle;
- draw-off capabilities and a sidewall depth of 5.0m.

Scum from the scum draw-off gets collected in manholes downstream of the thickeners and flows to the scum sump that forms part of the filtrate pump station. Thickener overflow flows to the filtrate sump that is also situated in the filtrate pump station, with an option to bypass the overflow to the lime reaction tanks.

Thickened sludge underflow is fed to the WAS thickened sludge storage tanks via a sludge withdrawal box equipped with actuated valves. The thickened sludge storage tanks, located immediately adjacent to the mechanical thickening / dewatering building is equipped with mixers and configured in such a way as to allow a full duty/standby functionality. All the sludge underflow lines are equipped with rodding eyes and flushing assemblies for up and downstream blockage removal in line with maintenance infrastructure guidelines as per JW requirements.

For the first phase of the project, 2 off gravity WAS thickeners will be constructed with a total allowance for 4 off gravity WAS thickeners by Phase 3 of the project.

12.10.2 Materials of Construction

Materials of construction for this section of the sludge stream are as follows:

- Division Box: Concrete
- Gravity WAS Thickener tanks: Concrete
- Thickener Bridges: Coated mild steel
- EDD's: Stainless Steel
- Scum Collection Boxes: Stainless Steel
- Scum Baffles: Stainless Steel
- Overflow Weirs: Stainless Steel
- Manholes: Precast Concrete
- Valve Boxes: Concrete
- Hand stops: Stainless steel

12.10.3 Piping and Valves

The underground pipework will consist of HDPE or uPVC, while the pipework at structure interfaces are Stainless Steel.

The sludge underflow line will be equipped with electrically actuated valves that control the draw-off from the WAS thickeners. Isolating valves will be located immediately upstream and downstream of the actuated valves for servicing requirements, with flushing assemblies allowing for blockage clearing via high pressure both up and downstream of the actuated valve.

12.10.4 Mechanical

The mechanical equipment to be supplied for the Lanseria WwTW sludge thickening installation is summarised in Table 25 below. The preliminary mechanical equipment selection is based on the process flow diagrams (PFDs), and the relevant PFDs are referenced in **Table 25** below.

Table 25: Waste activated sludge thickening mechanical equipment

PFD No.	Process Train Section	Required Equipment	Equipment Number	Selected Equipment
13082-72-4-PFD-12	WAS Gravity Thickeners	Bridge	TBC	Full diameter, fixed
		Scraper	TBC	Central drive, full diameter
13082-72-4-PFD-13	Gravity Belt Thickening	Gravity Thickened WAS Storage Tanks Mixers	MX-202-01 to MX-202-04	Vertical shaft, radial mixers
		WAS Storage Tank Air Blowers	Future	Future
		GBT Feed Pumps	PGF-202-01 to PGF-202-03	Horizontal, centrifugal, self-priming pumps
		Sludge Thickening	GBT-202-01 to GBT-202-02	Gravity Belt Thickeners (Belt width 2.0 – 2.5 m)
		GBT Thickened Sludge Storage Sump Mixers	MX-202-05 to MX-202-06	Vertical shaft, radial mixers
		GBT Thickened Sludge Pumps	PTS-202-01 to PTS-202-02	Rotary lobe, positive displacement pump (potentially non-Newtonian)

WAS gravity thickeners

The gravity WAS thickener division box hydraulically divides the incoming WAS flow between the four gravity WAS thickeners. The inlet box to each gravity WAS thickener is fitted with a penstock for isolation purposes.

Each WAS gravity thickener is equipped with a full diameter fixed bridge and a full diameter sludge scraper, driven by a central drive. A scum baffle and one scum withdrawal box is provided per gravity WAS thickener, and a flat overflow weir with v-notches (200 mm deep) is provided for the overflow to enter the launder.

The scum pipes and thickened sludge draw-off pipes are fitted with manual isolation valves downstream of the tanks. Flow measurement is provided for on the common desludging pipe to assist with the detection of blockages.

Gravity thickened WAS storage tanks

The two gravity thickened WAS storage tanks are located adjacent to the mechanical thickening / dewatering building. Provision is made to equip the two tanks with coarse bubble aeration in future. Johannesburg Water has indicated they the aeration equipment shall not be installed for Phase 1.

Both tanks are mixed by means of vertical shaft, radial mixers to keep the gravity thickened WAS in suspension. Each tank is fitted with two vertical shaft mixers, providing 2 kW mixing energy each. This equates to a mixing intensity of 3 W/m^3.

Isolation valves are provided upstream and downstream of each gravity thickened WAS storage tank, to allow one tank to be isolated while the other remains in operation.

Gravity belt thickener installation

The gravity pre-thickened WAS is pumped from the gravity thickened WAS storage tanks to the GBT’s by three (2 duty / 1 standby) rotary lobe positive displacement pumps. Rotary lobed pumps were chosen for this application due to the gravity thickened WAS exhibiting non-Newtonian properties. The pre-thickened WAS is pumped to the GBT’s via a pressurised ring main type delivery system.

Polymer will be supplied from a standard Johannesburg Water specified polymer storage, makeup and dosing installation. However, as the GBT’s and the BFP’s are located in the same building, they will share a dry polymer storage and makeup facility. Dedicated polymer dilution and storage facilities are however supplied for the GBT’s, as their polymer concentration requirements may differ from those of the BFP’s. Duty / standby polymer dosing pumps are supplied for each GBT. Washwater is supplied by a dedicated GBT washwater system, supplying washwater via a pressurised washwater ring main.

GBT's with 2.0m to 2.5m belt widths will be provided. The spent washwater from each GBT drains into floor drains, from where it gravitates to the lime treatment installation. The mechanically thickened WAS is conveyed via screw conveyors to a GBT thickened storage sump, which is located adjacent to the mechanical thickening / dewatering building.

GBT thickened WAS storage sump

The GBT thickened WAS storage tank is located adjacent to the mechanical thickening / dewatering building. The tank is mixed by means of vertical shaft, radial mixers to keep the mechanically thickened WAS in suspension. The tank is fitted with two vertical shaft mixers, providing 0.5 kW mixing energy each. This equates to a mixing intensity of 50 W/m^3.

The mechanically thickened WAS is pumped from the GBT thickened storage tank to the anaerobic digester distribution tower by two (duty / standby) horizontal, centrifugal, self-priming pumps.

12.10.5 Electrical

The electrical supply to the bridge drives and will come from the substation at the belt press building. The thickened sludge pump station will have a separate MCC fed from the sludge handling substation.

12.10.6 Control and Instrumentation

The signals associated with the sludge thickening will be incorporated in the PLC at the belt press building. The thickened sludge pump station signals will be connected to remote I/O in the pump station PLC room, via a bus to the PLC in the belt press building PLC room for control and to relay the readings to the SCADA system in the control room.

12.11 ANAEROBIC DIGESTERS AND HEATING

12.11.1 Design

The anaerobic digesters are fed thickened sludge from the GBT's, sludge fermenters and the filtrate pump station as shown on process flow diagram 13082-72-4-PFD-14. Structures that form part of the anaerobic cluster are:

- Distribution tower;
- Anaerobic digesters (mixed and heated);

- Boiler houses;
- Grit drying beds.

The three incoming streams are pumped to an elevated distribution tower where a positive, equal split of flow to the respective anaerobic digesters takes place in a circular division box supported by 4 rectangular columns with stair access from ground level. Platforms provide access from the distribution tower to two of the digesters, which in turn provide access to the rest of the digesters.

Each digester can be isolated by an accessible sluice gate located at the distribution tower, with the division structure is covered by solid top, grid flooring for odour control and to allowing ease of access for maintenance.

The anaerobic digesters are designed as circular concrete structures with an inside diameter of 17.35m and a sidewall depth of 12.145m with conical roofs and floors. The slopes of the roofs and floors are 1:2 and 1:5 respectively in line with the JW guidelines. The digesters are equipped with:

- dedicated grit draw-off sump provided in the centre of each digester floor;
- mixing system;
- heating system;
- gas withdrawal system;
- decanting system.

Grit withdrawn from the grit draw-off sumps will feed the grit drying beds under gravity. Filtrate from the grit drying beds is returned to the lime reaction tank.

Draw-off points for biogas are situated in the centre of the roof which in turn feeds the biogas holding tank and boiler house(s).

For Phase 1 of the project two anaerobic digesters will be constructed with an allowance for a total a 6 digesters at ultimate capacity.

12.11.2 Materials of Construction

Materials of construction for this this section of the sludge stream is as follows:

- Distribution tower: Concrete
- Anaerobic Digesters: Concrete
- Grit drying beds: Concrete
- Boiler house: Brick building
- Boilers: As per Johannesburg Water Specifications

- Heat exchangers: As per Johannesburg Water Specifications

12.11.3 Piping and Valves

The underground pipework will consist of HDPE or uPVC, while the pipework at structure interfaces are Stainless Steel. Pipework at the boiler house pump station shall be coated mild steel, while all gas and heating pipework shall be stainless steel.

Each grit removal-, pump mixing- and heat exchanger feed line will be equipped with an isolating valve and flushing assembly allowing for blockage clearing via high pressure both up and downstream of the isolating valve.

12.11.4 Mechanical

The mechanical equipment to be supplied for the Lanseria WwTW anaerobic digester installation is summarised in **Table 26** below. The preliminary mechanical equipment selection is based on the process flow diagrams (PFDs), and the relevant PFDs are referenced in **Table 26** below.

Table 26: Anaerobic digester mechanical equipment

PFD No.	Process Train Section	Required Equipment	Equipment Number	Selected Equipment
13082-72-4-PFD-14	Anaerobic Digestion	Digester Mixing Pumps	PDM-203-01 to PDM-203-04	Pumped mixing, linear motion plunger mixing, or external draught tubes with reversible mixers: Final selection based on life-cycle costing
		Digester Heating Sludge Recycle Pump	PDR-203-01 to PDR-203-02	Horizontal, centrifugal, self-priming, cutting pump
		Heat Exchanger	HG-203-01 to HG-203-02	As per JW PSM14: Mechanical Equipment for Digester Heating and Gas Handling Equipment Section M14.5 Heat Exchanger
13082-72-4-PFD-16	Biogas Storage and Hot Water Boilers	Hot Water Boilers	HWB-205-01 to HWB-205-02	As per JW PSM14: Mechanical Equipment for Digester Heating and Gas Handling Equipment Section M14.8 Boilers
		Hot Water Circulation Pumps	P-205-01 to P205-03	As per JW PSM14: Mechanical Equipment for Digester Heating and Gas Handling Equipment Section M14.10 Hot Water Circulation Pump

PFD No.	Process Train Section	Required Equipment	Equipment Number	Selected Equipment
		Biogas Holders	ST-205-01	As per JW PSM14: Mechanical Equipment for Digester Heating and Gas Handling Equipment Section M14.13 Gas Holding Tanks

Biogas storage

The biogas collected from the headspace of each anaerobic digester is stored in the biogas holding tank. The biogas holding tank is a wet seal type holding tank, consisting of a steel inner tank, the bell, consisting of a vertical cylindrical shell and a domed or conical roof in which the gas shall be stored. The bell is located within an outer steel tank, consisting of a steel or concrete floor and a vertical cylindrical shell. The bell moves vertically within the outer tank by means of guide rails.

A biogas flare is provided which automatically flares any excess biogas when the biogas holding tank is full.

Anaerobic digester mixing

The mixing technology for the anaerobic digesters has not been decided upon. Three technologies will be evaluated during detailed design:

- Hydraulic (pumped) jet mixing
- External draught tube mixing
- Plunger mixing

For the purpose of preliminary design, the digester mixing has been assumed to be by hydraulic jet mixing, as hydraulic jet mixing is considered the worst case scenario in terms of space requirements and capital as well as operational cost. The hydraulic jet mixing consists of two mixing chopper pumps (duty / standby) per anaerobic digester, which abstract the sludge from the digester and reintroduce it into the digester via nozzles placed in certain locations inside the anaerobic digesters, thereby effecting a hydraulic mixing pattern. The mixing pump installation is located directly adjacent to each respective anaerobic digester, within a purpose built bunded and covered installation.

Anaerobic digester heating

A hot water / heat exchanger system is provided to heat the anaerobic digesters.

Two methane / diesel fired boilers are provided for each three anaerobic digesters, in two boiler houses located at opposite ends on the anaerobic digester terrace. Diesel is utilised as a backup fuel, should no biogas be available to fire the boilers. If required, a softening installation is included, to soften the boiler water to the boiler manufacturer's specifications. One dedicated centrifugal hot water pump is provided for each digester. Each hot water pump pumps hot water through the respective digesters heat exchanger, and back to the boilers for reheating. One shared standby hot water pump is provided for each set of three anaerobic digesters.

One heat exchanger is provided per anaerobic digester, and each respective heat exchanger is located directly adjacent to each anaerobic digester, within the mixing pump purpose built bunded and covered installation. The external heat exchangers will increase the temperature of the sludge within the digester, and the temperature will be maintained within tight tolerances for optimum mesophilic anaerobic sludge stabilization, i.e. 35 to 37°C.

Two centrifugal chopper pumps (duty / standby) are provided per anaerobic digester to recycle the sludge through the heat exchangers. The sludge recycle pumps are located in the same bunded and covered area as the heat exchangers and sludge mixing pumps.

12.11.5 Electrical

All equipment in the close proximity of the digesters can be in a Zone 2 or Zone 1 Hazardous area with explosive gasses present, the equipment and electrical installation will be designed taking this into consideration. The equipment selection standard now also allows for a risk-based approach. In a risk-based approach, the consequence of an explosion is also taken into account, together with the probability of an explosion. A complete zoning will be done as part of the detail design phase.

As far as possible the MCC's and control gear, for equipment inside the zones, will be positioned outside the zones and fed with flame retardant cables and connected with explosion proof glands.

12.11.6 Control and Instrumentation

All signals from the digesters will be connected to a remote I/O panel outside the zoned area. The remote I/O will be connected to the PLC in the Belt Press building which in turn will be connected to the SCADA in the control building via a fibre optic ring network.

12.12 STRUVITE PRECIPITATION

12.12.1 Design

The struvite precipitation process is located immediately downstream of the anaerobic digesters and upstream of the digested sludge storage tank, as shown on process flow diagram 13082-72-4-PFD-15. The structures that form part of the struvite precipitation cluster are:

- Struvite reactors;
- Digested sludge storage tanks.

Digested sludge from the anaerobic digesters gravitates to the struvite reactors, which in turn feeds the digested sludge storage tanks. The design of the struvite precipitation tanks is still pending the completion of a pilot plant project; hence the PDR drawings show that the digested sludge is fed directly to the digested sludge storage tanks from the anaerobic digesters.

12.12.2 Materials of Construction

The materials of construction for the struvite reactors and the digested sludge storage tanks are as follows:

- Struvite reactors: : TBC
- Digested sludge storage tanks : Concrete

12.12.3 Piping and Valves

The underground pipework will consist of HDPE of uPVC pipe, while the pipework at structure interfaces are stainless steel pipes.

12.12.4 Mechanical

The mechanical equipment to be supplied for the Lanseria WwTW struvite precipitation installation is summarised in **Table 27** below. The preliminary mechanical equipment selection is based on the process flow diagrams (PFDs), and the relevant PFDs are referenced in **Table 27** below.

Table 27: Struvite precipitation mechanical equipment

PFD No.	Process Train Section	Required Equipment	Equipment Number	Selected Equipment
13082-72-4-PFD-15	Struvite Precipitation	CO_2 Stripping Blowers	BL-204-01 to BL-204-02	Screw-type positive displacement blowers

PFD No.	Process Train Section	Required Equipment	Equipment Number	Selected Equipment
	and Digested Sludge Storage	Struvite Reactor Recycle Pumps	PRS-204-01 to PRS-204-04	Horizontal, centrifugal, self-priming pumps
		Struvite Precipitation Reactor Mixers	MC-204-01 to MC-204-06	Vertical shaft, radial mixers
		Digested Sludge Storage Tank Mixers	MX-204-07 to MX-204-10	Vertical shaft, radial mixers

The anaerobically digester sludge gravitates from the anaerobic digesters to the struvite precipitation splitter box, which hydraulically divides the sludge flow between the two struvite precipitation reactors. Penstocks are provided at each reactor inlet for isolation purposes, so that one precipitation reactor may remain in operation while the other is offline.

The CO_2 stripping compartment of each precipitation reactor is fitted with floor mounted coarse bubble air diffusers. Two shared screw type positive displacement blowers (duty / standby configuration) provide the air for both precipitation reactors.

The struvite precipitation (mixing) compartment of each precipitation reactor is mechanically mixed by vertical shaft, radial mixers. Two mixers are installed per mixing compartment, providing 1 kW of mixing power each. This equates to a mixing intensity of 27 W/m^3. The lime dosing cell of each precipitation reactor is mechanically mixed by one vertical shaft, radial mixer. Each mixer provides 1 kW mixing power, resulting in a mixing intensity of 50 W/m^3.

Two centrifugal recycle pumps are provided per struvite precipitation tank, to recycle sludge from the lime dosing cell to the CO_2 stripping compartment.

Digested sludge sumps

The digested sludge gravitates from the struvite precipitation reactors into two digested sludge storage tanks, located at the mechanical thickening / dewatering building. The digested sludge storage tank division structure hydraulically divides the sludge between the two digested sludge storage tanks. Each tank is equipped with two mechanical vertical shaft, radial mixers. Each mixer provides 4 kW mixing energy, resulting in a mixing intensity of approximately 6 W/m^3.

12.12.5 Electrical

The struvite facility will have its own MCC that will be supplied with power form the Belt Press Building MCC.

12.12.6 Control and Instrumentation

Signals from the struvite facility will be connected to remote I/O modules, connected to the PLC in Belt Press Building PLC room to relay the readings to the SCADA system in the control room.

12.13 SLUDGE DEWATERING AND DRYING

12.13.1 Design

Sludge dewatering takes place at the belt filter press section of the dewatering building as shown on process flow diagrams 13082-72-4-PFD-17 and 3082-72-4-PFD-18. The structures that form part of the sludge dewatering and drying cluster are:

- GBT & filter belt press building;
- Thickened WAS storage tanks;
- Dewatered sludge conveyor;
- Out loading station;
- Solar sludge drying beds;
- Sludge stockpile area.

Feed pumps delivers sludge from the mixed digested sludge storage tanks to the belt filter presses. For the first project phase, 2 belt filter presses will be installed with a total allowance for 6 presses at future completion. The layout of the presses has been designed to allow for easy removal in cases of maintenance or breakdowns.

Dewatered sludge is delivered to a conveyor that feeds the out loading station from where it is transported by front end loader to the solar sludge drying beds. The solar sludge drying beds will be greenhouse type structures with a mechanical turner that assists in the drying of the sludge. Drying will be further enabled by an air circulation system consisting of vents and fans that circulates dry air into and through the structure with outlet vents for the humid air. At the downstream end of the solar sludge drying beds, the dried sludge is transported by excavator to the sludge stockpiling area where it is collected by the public. Storm water run-off from the sludge stockpiling beds is diverted to the stormflow dam.

The filtrate produced by the belt filter presses is collected in sumps beneath the presses and flows to the lime reaction tank. Overflow from the WAS gravity thickener and GBT filtrate also flows to the lime reaction tank. Lime is fed to the reaction tanks, which is followed by lime clarifiers. Underflow from the lime clarifiers is pumped back to the digested sludge storage tanks and the filtrate is pumped back to the head of works. The scum from the clarifiers are pumped to the grit drying beds with a bypass option to the digested sludge storage tanks.

12.13.2 Materials of Construction

The materials of construction for the structures discussed in this section are as follows:

- GBT filter belt press building : Brick and concrete portal frame structure, with FC cladding where appropriate
- Thickened WAS storage tanks : Concrete
- Sludge conveyor : HDGMS
- Out loading station : Brick, steel cladding & concrete
- Solar sludge drying beds : Structural steel, polycarbonate cladding & concrete
- Sludge stockpile area : Concrete

12.13.3 Piping and Valves

The underground pipework will consist of HDPE of uPVC pipe, while the pipework at structure interfaces are stainless steel pipes.

12.13.4 Mechanical

The mechanical equipment to be supplied for the Lanseria WwTW sludge thickening installation is summarised in **Table 28** below. The preliminary mechanical equipment selection is based on the process flow diagrams (PFDs), and the relevant PFDs are referenced in **Table 28** below.

Table 28: Dewatering and sludge drying mechanical equipment

PFD No.	Process Train Section	Required Equipment	Equipment Number	Selected Equipment
13082-72-4-PFD-17	Digested Sludge Dewatering	Belt Filter Press Feed Pumps	PBF-206-01 to PBF-206-03	Rotary lobe, positive displacement pump (potentially non-Newtonian)
		Sludge Dewatering	BFP2016-01 to BFP2016-05	Belt Filter Presses
13082-72-4-PFD-19	Sludge Solar Drying / Stockpiling	Sludge Turner	ST-208-01 to ST-208-02	Enhanced solar drying with automated, mobile sludge turner equipment

<u>Belt filter press installation</u>

The digested sludge is pumped from the digested sludge storage tanks to the BFP's by three (2 duty / 1 standby) rotary lobe positive displacement pumps. Rotary lobed pumps were chosen for this application due to the gravity thickened WAS exhibiting non-Newtonian properties. The digested sludge is pumped to the BFP's via a pressurised ring main type delivery system.

Polymer will be supplied from a standard Johannesburg Water specified polymer storage, makeup and dosing installation. However, as the GBT's and the BFP's are located in the same building, they will share a dry polymer storage and makeup facility. Dedicated polymer dilution and storage facilities are however supplied for the BFP's, as their polymer concentration requirements may differ from those of the GBT's. Duty / standby polymer dosing pumps are supplied for each BFP. Washwater is supplied by a dedicated BFP washwater system, supplying washwater via a pressurised washwater ring main.

BFP's with 2.0m to 2.5m belt widths will be provided. The spent washwater from each BFP drains into floor drains, from where it gravitates to the lime treatment installation. The sludge cake is conveyed via a conveyor belt to the sludge cake out loading station, from where it is retrieved by front end loaders and transported to the enhanced solar sludge drying installation.

Enhanced solar sludge drying

The enhanced solar sludge drying infrastructure is proprietary equipment supplier designed equipment. Depending on the supplier, it consists of a large conveyor enclosed in a greenhouse type enclosure. Mechanical sludge turners are provided at regular intervals along the conveyor to turn / mix the sludge on the conveyor belt. The greenhouse like enclosure is fitted with extraction fans and / or opening to enable the saturated air to escape to the atmosphere and to allow dryer air from outside to enter the enclosure.

The dry sludge is deposited at the end of the enhanced solar drying facility, from where it is removed by front end loaders and deposited on the dry sludge storage area.

12.13.5 Electrical

The sludge dryers will be supplied with their own control panels that will be supplied with power form the Belt Press Building MCC.

12.13.6 Control and Instrumentation

Signals form the sludge dryers will be connected to remote I/O modules, connected to the PLC in Belt Press Building PLC room to relay the readings to the SCADA system in the control room.

The sludge dryers will in automatic mode to be controlled by their own control system.

12.14 LIME DOSING AND TREATMENT AND FILTRATE RETURN

12.14.1 Design

Lime dosing and treatment is a stand-alone process, located at the sludge handling and treatment area as shown on process flow diagrams 13082-72-4-PFD-20. The structures that form part of the lime dosing and treatment cluster are:

- Dry lime storage silo and conveyance;
- Lime make-up tanks;
- Lime reactor division box;
- Lime reactors;
- Lime clarifiers.

Dry slaked lime is delivered in bulk, and stored in the dry lime storage silo. Screw feeders feed the dry lime to the lime makeup tanks, where plant water is added, and producing milk of lime. The milk of lime gravitates to the lime reaction tanks. It is anticipated that the lime storage silo and the lime reaction tanks will be delivered and installed as a proprietary system.

Gravity belt and filter belt press filtrate, gravity WAS thickener overflow and supernatant from the digester grit drying beds enters the lime reaction tank division box, and is hydraulically split between the two lime reaction tanks. Milk of lime is added. From the lime reaction tanks the water is routed to lime clarifiers, where the lime treated sludge is settled out. The overflow from the lime clarifiers is routed to the filtrate sump at the filtrate pump station, and the lime treated sludge is pumped to the digested sludge storage tanks.

Partial redundancy is provided for the lime reactors and clarifiers, and the full installation will be provided for Phase 1.

12.14.2 Materials of Construction

The materials of construction for the lime storage, makeup, dosing and treatment infrastructure are as follows:

- Lime storage silo : Corrosion protected, painted mild steel (proprietary)
- Lime makeup tanks : Corrosion protected, painted mild steel or GRP
- Lime reactor division box : Concrete
- Lime reactors : Concrete
- Lime clarifiers : Concrete

12.14.3 Piping and Valves

The underground pipework will consist of HDPE of uPVC pipe, while the pipework at structure interfaces are stainless steel pipes.

12.14.4 Mechanical

The mechanical equipment to be supplied for the Lanseria WwTW sludge thickening installation is summarised in **Table 29** below. The preliminary mechanical equipment selection is based on the process flow diagrams (PFDs), and the relevant PFDs are referenced in **Table 29** below.

Table 29: Lime dosing and treatment and filtrate return mechanical equipment

PFD No.	Process Train Section	Required Equipment	Equipment Number	Selected Equipment
13082-72-4-PFD-20	Lime Dosing and Filtrate Pump Station	Lime Make-up Tank Mixers	MX-209-01 to MX-209-02	Vertical shaft, radial mixers
		Lime Reaction Tank Mixers	MX-209-03 to MX-209-04	Vertical shaft, radial mixers
		Lime Clarifier Bridge and Sludge Scraper	TBC	Bridge: Full diameter, centre drive. Sludge scraper full diameter.
		Lime Sludge Pumps	TBC	Horizontal, centrifugal pumps
		Filtrate Pumps	FP-209-01 to FP-209-03	Submersible/immersible, centrifugal dry well installation
		Digester Return Pumps	DSP-209-01 to DSP-209-03	Horizontal, centrifugal pumps
		Secondary Scum Pumps	TBC	Rotary lobe, positive displacement pump (potentially non-Newtonian)

<u>Lime storage and makeup</u>

Slaked lime is delivered to and stored in a lime storage silo. Two screw conveyors convey the slaked lime to two respective lime makeup tanks, where the lime is mixed with makeup water sourced from the plant water reticulation system. Each lime makeup tank is mechanically mixed by one vertical shaft, radial mixer. Each mixer provides 2 kW mixing power.

The milk of lime gravitates from each respective makeup tanks to the lime reaction tanks.

<u>Lime reaction tanks and clarifiers</u>

GBT filtrate, BFP filtrate and WAS gravity thickener overflow gravitates to the lime reaction tank division box, where the flow is hydraulically divided between three lime reaction tanks.

Penstocks are provided for isolation purposes, so that one lime reaction tank can be isolated while the other remains in operation. Milk of lime is dosed to each lime reaction tank.

Each lime reaction tank is mechanically mixed by six vertical shafts radial mixers. Each mixer provides 1 kW of mixing power, resulting in a mixing intensity of approximately 34 W/m^3.

One dedicated lime clarifier is provided per lime reaction tank, however each tank is able to feed either of the lime clarifiers. Each lime clarifier is equipped with a full diameter fixed bridge and a full diameter sludge scraper, driven by a central drive. A scum baffle and one scum withdrawal box is provided per lime thickener, and a flat overflow weir with v-notches is provided for the overflow to enter the launder.

The scum pipes and thickened sludge draw-off pipes are fitted with isolation valves.

Lime sludge is withdrawn from the bottom of each lime clarifier and routed to one shared lime sludge sump. Two centrifugal pumps (duty / standby) are provided to pump the lime sludge to the digested sludge storage tank for dewatering.

<u>Filtrate return pump station</u>

The filtrate return pump station has three sumps, (i) a filtrate sump, (ii) a scum sump and (iii) a digester sludge sump.

Filtrate from the filtrate sump is pumped to the head of works by three centrifugal pumps (2 duty / 1 standby configuration). Scum from the scum sump is pumped to either the digested sludge storage tanks for dewatering or to the digester grit drying beds by two rotary lobe positive displacement pumps (duty / standby configuration). Digester sludge from the digester sludge sump is pumped either to the digested sludge storage tanks for dewatering, or returned to the digester distribution tower by three centrifugal pumps (2 duty / one standby configuration).

12.14.5 Electrical

The lime facility will have its own outdoor MCC that will be supplied with power form the Belt Press Building MCC.

12.14.6 Control and Instrumentation

Signals from the lime facility will be connected to remote I/O modules, connected to the PLC in Belt Press Building PLC room to relay the readings to the SCADA system in the control room.

12.15 INTERCONNECTING PIPEWORK

The following design principles were applied in the design calculations of the interconnecting pipework that were used to determine pipe sizes and for selecting pipe material:

- minimum velocity of 0.7m/s where solids settling will easily occur, such as with raw sewage
- maximum velocity of pipe 1.5 m/s
- minimum cover to the crown of a pipe of 900mm

A summary of the interconnecting pipework for the works is as follows:

Table 30 : Summary of Interconnecting Pipework

Pipeline		Liquid	Pipe	
From	**To**		**Material**	**Dia. (mm)**
HoW	PST Division Box	Screened sewage	Structured wall HDPE	1800
HoW	Stormflow Dam	RAW Sewage	Concrete	1500
HoW	Balancing Tank Division Box	Screened sewage (PST Bypass)	Concrete	1800
PST Division Box	PST	Screened sewage	SS 304	900
PST	Balancing Tank Division Box	Settled sewage	Concrete	900 to 1800
PST	Primary Sludge Pump Station	Settled sewage	Structured wall HDPE	450
PST	Primary Sludge Pump Station	Primary Sludge	uPVC	200
PST	Scum concentrator	Primary Scum	uPVC	200
Primary Sludge Pump Station	Fermenter Division Box	Primary Sludge	uPVC	200
Primary Sludge Pump Station	Fermenter Division Box	Settled sewage	uPVC	300
Fermented Sludge Pump Station	Fermenter Division Box	Recycled Fermented Sludge	uPVC/SS304	200
Fermented Sludge Pump Station	Anaerobic Sludge Digesters	Fermented Sludge and PST scum	uPVC	200
PST	Balancing Tank Division Box	Settled Sewage	Concrete	900 to 1800
Fermenter	Balancing Tank Division Box	Fermenter overflow	Structured wall HDPE	450
Fermenter	Bio-Reactor Division Box	Fermenter overflow	Structured wall HDPE	450

Balancing Tank Division Box	Balancing Tank	Settled sewage	Structured wall HDPE	1500
Balancing Tank	Bio-Reactor Division Box	Settled sewage	SS 304	1000
Balancing Tank	Stormflow Dam	Settled sewage	Concrete	1500
Bio-Reactor Division Box	Bio-Reactor	Settled sewage	Concrete	1050
Bio-Reactor	Clarifier Division Box	Reactor outflow	SS 304	900
Bio-Reactor	WAS Pump Station	WAS/ Sec Scum	uPVC	200
Clarifier Division Box	Clarifier	Reactor outflow	SS 304	750
Clarifier	RAS Pump Station	RAS	Concrete	500 to 900
Clarifier	Chlorine Contact Channel	Clarifier overflow	Concrete	900 to 1800
Clarifier	WAS Pump Station	Clarifier Scum	uPVC	200
WAS Pump Station	Anaerobic Sludge Digesters	WAS/Sec Scum	uPVC	200
RAS Pump Station	WAS Pump Station	RAS	uPVC	200
Chlorine Contact Channel	River	Effluent	Concrete	1800
Washwater Pump Station	WAS Pump Station	Chlorine Channel Sludge	uPVC	200
Washwater Pump Station	HOW	Effluent	uPVC	200
Washwater Pump Station	Sludge Facility	Effluent	uPVC	200
Stormflow Dam PS	HOW	RAW Sewage	HDPE	500

The following selection principles were adopted:

Piping:

- For pipework that runs underneath a structure, stainless steel pipes will be used, encased in concrete
- For small diameter pipes (up to 250mm), uPVC pipes will be used
- For large diameter pipes, reinforced concrete pipes with a sacrificial layer (sewer pipes) will be used. Where space is constrained, structured wall HDPE pipes will be used, since connections such as bends can be welded and will therefore not require a reinforced concrete box.

Valves:

Knife Gate valves are mainly selected as they have small face to face dimensions, are light in weight, they work better with sludges and can easily be actuated.

12.15.1 Electrical

Electrically actuated valves will be powered form the nearest MCC

12.15.2 Control and Instrumentation

Electrically actuated valves will be connected to PLC in the nearest PLC room with 4-20mA signals and Potential free contacts.

12.16 EARTHWORKS AND TERRACES

The general gradient of the site ranges from 1 in 9 to 1 in 15 towards the streams crossing the site, with a general gradient of about 1 in 11. The site is divided into two main portions, which form a valley along a watercourse that runs in an east-west direction, in approximately the centre of the site. The liquid treatment process stream is located on the southern portion, whilst the sludge treatment process stream is located on the northern portion.

12.16.1 Liquid Treatment Area on Southern Portion

The southern portion of the site generally falls in a south-north direction towards the central dividing watercourse, whilst towards the western boundary; the site falls in an east-west direction.

The liquid treatment process units will be constructed on a series of stepped terraces. The terraces will generally run parallel to the electrical servitude that traverses the site, in a (general) north-east to south-west direction.

The terraces will be constructed at differing elevations, with the Head of Works terrace located on the highest relative elevation, subsequent terraces at lower relative elevations, and the Disinfection Facility terrace at the lowest relative elevation.

Reinforced concrete retaining walls will be constructed to retain the upper terraces. Closed Block retaining walls will be constructed for embankment stabilisation at the boundaries of those terraces that are not adjacent to other terraces, such as the PST terrace.

The gradient of the southern portion and the area that is available allows the full liquid process stream to gravitate from the Head of Works to the Chlorine Contact Channel.

12.16.2 Sludge Treatment Area on Northern Portion

The northern portion of the site generally falls in a north-south direction towards the central dividing watercourse, whilst towards the western boundary; the site falls in an east-west direction.

The sludge handling and treatment process units will be constructed on a series of stepped terraces, however some pumping will be required between the terraces, particularly to the anaerobic digesters, the GBT's and the BFP's.

Reinforced concrete retaining walls will be constructed to retain the upper terraces.

12.16.3 Hydraulic Profile and Terrace Levels

The levels of the various terraces are determined according to the hydraulic profile that has been developed for the works. The preliminary design levels have been discussed in detail in the Hydraulic Design section of this report.

The hydraulic design, hydraulic profile and terrace levels will be optimised during the detail design stage, so that bulk earthworks can also be optimised.

All material that will be removed from excavations will be stockpiled, for future use. The stockpiled material will be used for constructing embankments or in layer works for roads.

One of the key considerations when optimising the earthwork volumes will be to reutilise as much of the excavated material as possible, so that the removal of spoil from site is minimised.

12.16.4 Geotechnical Conditions

The geotechnical investigation that was undertaken on the site revealed that the site is underlain by the intrusive Halfway House granite consisting of gneiss, magmatite and porphyritic granodiorite. These rock formations occur relatively close to the surface, particularly on the western portions of the site. Hard rock will therefore be encountered during excavations for the bulk earthworks (i.e. the cut and fill operation that will be undertaken to construct the terraces), as well as during "restricted excavation" (i.e. for the construction of the individual structures on the terraces).

The feasibility of erecting a rock crushing plant will be investigated during the detail design stage, so that rock that is excavated can be crushed and re-used in embankment construction or in the layer works of the new roads.

12.16.5 Sequencing and Phasing of Terrace Construction

It is anticipated that, when construction commences, the terraces will be constructed first, and that the restricted excavations for the individual structures, pipe trenches, pump stations, etc. will be undertaken after the terraces have been formed. This will afford the contractor the benefit of scale when initially processing large volumes of earth to form the terraces. The terraces can then be used as a suitable platform to undertake the restricted excavations.

It is recommended that the terraces that will be required for the ultimate works capacity be constructed during the construction of the first phase. This will ensure that no major bulk earthworks are required in the latter phases of the project.

It is further recommended that restricted excavation be undertaken for only those structures that will be constructed during the first phase. This approach will assist in limiting expenditure during the implementation of the first phase.

12.17 BULK SERVICES

12.17.1 Main Access Road

The provision of access to the proposed site is included in the scope of work of the project. The Zitholele Consortium has investigated the options for providing access to the site, which is documented in the following reports:

- 13082-45-Rep-004 Access Roads Evaluation
- 13082-45-Rep-009 Traffic Impact Assessment
- 13082-45-Rep-013 Prelim Design Report for Main Access Road

12.17.1.1 Access Roads Evaluation

The Access Roads Evaluation Report (13082-45-Rep-004) noted that the site could be accessed via three possible alternatives, viz.:

- Western Access Route (this route is off the provincial road R512 (Malibongwe Drive) and accesses the WwTW via the intersection with Ashenti Road

- Southern Access Route (this route is off the provincial road R114 and accesses the WwTW via the intersection with Falkirk Road)

- Eastern Access Route (this route is off the provincial road R114 and accesses the WwTW via the intersection with Koedoe Road)

The investigation concluded that the Southern Access Route is the preferred route for the following reasons:

- The route has the advantage of being the shortest connecting route to the existing Northern Wastewater Works.
- The construction cost of the route is the lowest out of all the alternatives

12.17.1.2 Traffic Impact Assessment

A Traffic Impact Assessment (TIA) has been undertaken, as an addition to the Access Roads Evaluation, the results of which are documents in report no. 13082-45-Rep-009.

The TIA is a specialist assessment that provides input to the Environmental Impact Assessment (EIA). The TIA investigated the potential impact of the development-related traffic on existing traffic conditions on the immediate road network surrounding the development site. The report also evaluated the need for any new road upgrades that may be required to alleviate potential impacts in terms of roadway capacity, road safety and road conditions. The TIA concluded the following:

- The intersection of R511/Koedoe Road & R114 is currently operating above capacity and requires an upgrade to a signalized intersection. This is however not a critical junction for this study and it is for the City's discretion as to whether the junction is upgraded.
- During the Construction Phase, the intersection of R114/Falkirk Road, the critical access intersection to the WwTW, could require an upgrade from Two Way Stop Control (TWSC) to a signalized junction. The development will generate an additional 121 trips along Falkirk Road during the peak hour, at a worst case scenario. Should this demand materialize, the additional construction traffic will find it difficult to enter the main stream of traffic on the R114 during the afternoon peak hour. It is therefore recommended that the intersection be monitored during the construction phase, and a full signal warrant be conducted before installing a signal.
- The accumulative additional axle loading over a sustained 60 month period for construction trucks (20 concrete trucks per day) is 6600 E80's. The R114 is designed to carry 3 000 000 E80's over a design life of 20 years. The overall impact of the construction traffic during the construction period translates to advancing the need for pavement rehabilitation by 16 days. This impact is considered to be negligible.
- During the Operational Phase, when the ultimate capacity of the plant is reached, the development will generate an additional 41 trips. This volume is relatively low, and

although the analysis indicates that a signal is warranted, it is recommended that the intersection be monitored during the operational phase, and a full signal warrant be conducted before installing a signal.

Further traffic impacts related to the construction and operational phases of the development have been identified as follows:

- Additional vehicles on Falkirk and Koedoe Roads, which are gravel roads, would require additional maintenance of the gravel layer
- The increase in heavy vehicle movement during the construction phase will raise dust along Falkirk and Koedoe Roads, which is within a 6km radius of the site.
- CO_2 emissions during the construction phase are conservatively calculated at 377.52 tons per working year, and will occur for 3-5 years.
- CO_2 emissions during the operational phase are conservatively calculated at 127.92 tons per working year, and will occur for the lifetime of the facility. The average car produces 6 tons of CO_2 per year. The impact of the above emissions is therefore considered to be minor.
- Noise pollution - The noise levels of most earth moving and material handling equipment is greater than 85 dB. The site is fortunately located in a greenfields area and the route to the major road network contains very few residential properties within earshot of heavy vehicle movements.
- Impact of haulage vehicles on the road network - It is assumed that most of the construction material used will be excavated from site, and that only a minimal amount will need to be hauled by truck from external borrow pit sources.

The following mitigation measures are proposed to accommodate the additional traffic during the Construction and Operational Phases:

Conduct a Signal Warrant at the R114/Falkirk Road intersection

The additional trips generated by the development during both the Construction and Operation Phases, could require this intersection to be upgraded to a signal control.

Upgrade of Koedoe and Falkirk Road pavement

Although not critical for the mitigation of traffic impacts, the upgrade of the road from gravel to a paved facility will negate the following impacts:

Dust generation

Deterioration of the gravel road which would have required more frequent routine road maintenance

Traffic Signs

Traffic signs indicating slow moving construction vehicles should be posted along Falkirk and Koedoe Roads to improve road safety during the Construction Phase.

- an acceptable route for the access road which will lie, where practical, within the City of Johannesburg Metropolitan Municipality (CoJ);
- the design criteria for an acceptable Access Road;
- any land requirements;
- that safe access for existing users can be maintained during construction of the Access Road; and
- input of key stakeholders to the project.

The basic alignment of the existing gravel Access Road follows Falkirk (north-south leg) and Koedoe Roads (east-west leg) on the eastern and northern perimeter of Northern Farm, and following the Johannesburg-Tshwane boundaries on each leg. These perimeters of Northern Farm are already bounded by several servitudes for power lines, water mains and roads on both the Johannesburg and Tshwane sides of the boundary, and further power line servitudes are likely to be proposed. In addition, there is a long term proposal to align a section of the Gauteng Provincial Department of Roads and Transport (GDRT) route K31 along the northern boundary of Northern Farm. GDRT has indicated that although such a route is planned the alignment is sufficiently flexible to not inhibit the alignment of the Access Road to the WwTW site.

Northern Farm includes within its area a significant network of dams which perform a cleansing function on the outflow from the Northern Wastewater Treatment Works (NWwTW), located to the south, which is directed through the Northern Farm valley network. The initial option for the Access Road alignment was to avoid existing servitudes as far as possible by aligning the Access Road servitude to the west of the existing north-south servitudes and to the south of the east-west servitudes. This would place the road sections deeper within Northern Farm than the existing roads. In doing this, the existing internal farm roads on the perimeter of the various Farm land parcels would be cut off, and these would have to be replaced once again within the Access Road in order to perform their function. In addition, this route option was shortened by cutting across the north east corner of the Farm, and thereby isolating a small portion of farmland.

As more detail became available the importance of a small, but operationally strategic, gravity feed dam on the eastern side of Northern Farm was identified, which negated the original Option 1 proposed road alignment. Two further options, Options 2A and 2B were assessed. The primary difference between these options is the treatment of the east-west part of Access Road. As a result, in both Options 2A and 2B, the north-south leg (Falkirk Road), is proposed to remain in its present position. This will result in an overlap of the resultant road servitude and an existing 11 kVA power line servitude, over a part of this section of the Access Road. At the same time, it was decided to retain the continued Falkirk Road alignment northwards to Koedoe Road to avoid impacting the north east corner of Northern Farm, as was proposed in Option 1.

During stakeholder consultations it became evident that the Local Authorities/Northern Farm management would welcome the provision of an upgraded Access Road (i.e. upgrading the existing gravel road) on the perimeter of the Farm, rather than on an alignment which encroached on the Farm. There is also little risk in retaining the existing alignment of the eastern half of Koedoe Road (between the WwTW and Falkirk Road) which lies within Tshwane, since Tshwane Roads Planning Department raised no objection to the road being upgraded by JW in its present position, and in it being used for access to the Lanseria WwTW. In our discussions with the Johannesburg roads Agency (JRA), they also saw no reason why agreement could not be reached with Tshwane to utilise the existing east-west alignment for the Access Road to the WwTW.

At this stage of the design process Options 2A and 2B have been retained*.** The Access Road east-west alignment in ***Option 2A lies wholly within CoJ which would mean the road would lie to the south of an existing parallel power line servitude and require the re-establishment of the internal perimeter farm roads to the south of the Access Road. ***Option 2B***, which utilises the existing Koedoe Road alignment within Tshwane, is recommended, subject to formal agreement being reached between Johannesburg and Tshwane.

There are two significant *vlei* crossings on the Falkirk Road section which will be provided with adequate culverts to permit normal precipitation inflow to the Northern Farm area. The outflow of stormwater is controlled by the presence of existing dams and other irrigation channels but eventually leaves the Farm by an adequately sized culvert under Koedoe Road. Secondary outflows are available directly to the Jukskei River through other existing water courses during high rainfall periods.

It is intended to negotiate with Northern Farm management to use the existing Farm perimeter roads as a detour for general traffic during construction of the Access Road. This will involve improving the road structure and surface to provide for the short term use by the expected level of traffic and the provision of new fencing on both sides of the detour, with gates as necessary on the Farm side to provide access by their vehicles to internal roads and provide the necessary security to the Farm. All existing property accesses can also be safely maintained during construction and in the final road design.

It is noted in the report that the nature of the civil engineering work required for the drainage and the upgrading of the Access Road falls well within the capability of labour-intensive construction, and the site is adjacent to Diepsloot as a potential source of such labour. As such, the project has the possibility of being a showcase example of a ***Jozi@work*** initiative.

The construction of the two road sections can be phased to suit both the temporary detours and a labour-intensive initiative.

Decisions which are required to be taken in order to proceed with the Detail Design Stage include:

- Acceptance of the need to reach formal agreement with the City of Tshwane for Koedoe Road to be used as the permanent access to the Lanseria Wastewater Treatment Works;

- Agreement to proceed with the Detail Design in terms of Option 2B involving the upgrading and surfacing of Falkirk Road and Koedoe Road essentially on the existing alignment;

- Agreement with ESKOM that the existing Falkirk Road in an upgraded form can continue to share the electrical servitude as it presently does; and

- Agreement in principle to include in the Detail Design specific consideration to proceed with the project based on a labour intensive construction initiative.

12.17.2 Bulk Electricity.

The bulk electrical supply will be from Eskom. An application for a normal and backup supply of 1.25MVA of the first 50Mℓ/d plant was submitted to Eskom. This means that two Eskom incoming substations fed from different 11kV Eskom networks will be established on opposite sides of the Works. The sub stations will be interlocked, via fibre optic communication between relays, to ensure that the backup supply switches over automatically in the event of a failure on the normal supply. Furthermore, the two intake substations will be connected to an 11kV ring for added security of supply.

The bulk electrical consumption of the plant at its ultimate capacity is expected to be in the region of 4-5MVA, the 11kV ring supply cables that will be installed as part of the first 50Mℓ/d will allow for this final demand to ensure that the cables is adequately sized for the future load. All the legs of the ring network will be able to supply the full capacity of the Works. A full load flow study will be undertaken during detail design stage.

With this redundancy in place the use of standby diesel generators for emergency power might not be required as indicated in the Johannesburg Water "Guidelines for the Design of Wastewater Treatment Unit Processes, August 2015, Section 4.2. JW indicated that they would still require emergency power. The equipment to be supplied with emergency power will be decided and finalized with the Hazop study. UPS power will also be provided for PLC's and other electronic controlled equipment for continuity of supply during the changeover between normal, standby and emergency power.

12.17.3 Potable Water

12.17.3.1 Background

The following scenarios are possible sources of Potable Water to the Lanseria Works:

- Upgrading the existing Potable Water network from the Lanseria Airport to the Lanseria Works
- Connecting to the Existing Tshwane Potable Water pipeline that runs through Northern Farm
- Extending the existing Potable Water supply from the Northern Works Potable Water Reservoir (situated outside the Diepsloot Informal Settlement) to Northern Farm to the Lanseria Works
- Drilling two boreholes within the boundaries of the Lanseria Works

Due to fact that the supply from Tshwane and Lanseria are not viable it was recommended that the Potable Water Supply to the Lanseria Works should be implemented from the following two independent sources:

- The existing Potable Water Supply to Northern Farm which is fed from the Northern Works Potable Water Reservoir, will be upgraded with a new 160mm pipe from outside Northern Farm along the Main Access Road to the Lanseria Works
- Two boreholes will be drilled as an alternative supply and will be operated as one duty and one standby during the periods when the supply from the Northern Works Reservoir is not sufficient.

12.17.3.2 Scope of new Pipeline

Refer to drawing no. 13082-73-13-306 Potable Water Supply

12.17.3.3 Pipeline Design Criteria

The following table highlights the design criteria used for the design of the external potable water pipeline from the existing Northern Works Reservoir to Lanseria WWTW:

Table 31: Design of Potable Water Pipeline

Design Parameter	Design
Length	7,500 m
Pipe Diameter	160 mm
Pipe Class	Class 16
Minimum slope for pipes	> 0.2%
Pipe material	uPVC
Minimum Velocity	0.6 m/s
Maximum Velocity	1.2 m/s
Minimum Cover to top of pipes	0.8m
Scour Valves	Low points
Air Valves	Summits/High points
Bedding	Class B - Flexible Pipelines
Potable Water Demand *	0.02Mℓ/day

* The calculation for the Total Potable Water Demand is as per the table below:

Lanseria WWTW Potable Water Demand Calculation		
Permanent Employees = (Once plant is fully operational)	45 Employees	
Average Daily Water Demand (l/p/d) =	150 Litres	SANS 10252-1:2012
Total Water Demand =	6,750 Litres/day	
Peak Factor =	2.5	
Total Peak Water Demand =	16,875 Litres/day	
	16.9 m^3/day	
	0.02 ML/day	

12.18 SITE SERVICES

12.18.1 Internal Roads

12.18.1.1 Design Guidelines

The following design guideline documents have been used in the design of the civil services for Lanseria WWTW:

- Johannesburg Roads Agency (JRA): Standard Specification Drawings for Roads & Stormwater
- Guidelines for Human Settlement Planning and Design (Red Book)
- South African National Standards SANS 1200

The main entrance to the Lanseria WWTW site is located in the south eastern corner of the site. Access to the main entrance gate is via Koedoe Road.

The internal road network at the Lanseria WWTW site is made up of several roads, as detailed in the table below:

Table 32: Internal Road Network

Road Name	Road Length (m)	Road Width (m)	Road Class
Road A	1,323	7	Class 4
Road B	389	6	Class 5
Road C	109	6	Class 5
Road D	292	6	Class 5
Road E	50	6	Class 5
Road F	85	6	Class 5
Road G	98	6	Class 5
Total Length (m):	**2,346**		

A general arrangement drawing, as well as long sections of the internal roads and design details is shown in the following drawings:

- 13082-73-04-102
- 13082-73-04-103
- 13082-73-04-104

12.18.1.2 Design Criteria

The following table highlights the design criteria used for the design of the internal road network for Lanseria WWTW:

Table 33: Road Design Criteria

Design Parameter	Road Category		Reference
	Class 4 - Minor Collectors	Class 5 - Local Streets	
Carriage Way Width (surfaced)	7.4 m (7 m)	6 m	JRA
No. of lanes	2 (3.7 m each lane)	2 (3 m each lane)	JRA
Surfacing Type of Carriage Way	80 mm Interlocking Paving Blocks	80 mm Interlocking Paving Blocks	Design Assumption
Cross Fall/Chamber	2% Cross Fall	2% Cross Fall	JRA
Kerb Type - Low Side	Semi - mountable kerb with concrete in-situ gutter, Fig. 7	Mountable kerb, with concrete in-situ gutter, Fig. 8b	JRA
Kerb Type - High Side	Edge Beam	Edge Beam	Design Assumption
Shoulder Width	1.2 m	1.2 m	JRA
Surfacing Type of Shoulder	80 mm Interlocking Paving Blocks	80 mm Interlocking Paving Blocks	Design Assumption
Edge Restraint of Shoulder	Fig. 12	Fig. 12	Design Assumption
Walkway Width	1.2 m	1.2 m	JRA
Edge Restraint of Walkway	Fig. 12	Fig. 12	Design Assumption
Surfacing Type of Walkway	60 mm Interlocking Paving Blocks	60 mm Interlocking Paving Blocks	Design Assumption
Bellmouth Radii (Min.)	10 m	10 m	JRA
Centreline Curve Radii (Min.)	25 m	10 m	JRA
Maximum Speed	40 km/hr	40 km/hr	Design Assumption
Minimum Longitudinal Gradient	0.5%	0.5%	Red Book
Maximum Longitudinal Gradient	14%	14%	Red Book
Minimum K-Value	6	10	Red Book
Minimum Vertical Curve Length	80 m	80 m	Red Book
Minimum Stopping Distances	50 m	50 m	Red Book

12.18.1.3 Pavement Design

The adopted road pavement design for the internal road network for Lanseria WWTW is shown in the following table:

Table 34: Road Pavement Design

Design Parameter	Class 4 - Minor Collectors	Class 5 - Local Streets
Traffic Class	E2	E1
Category	UB	UC
Surfacing	80 mm Interlocking Paving Blocks with 20mm River Sand	80 mm Interlocking Paving Blocks with 20mm River Sand
Subbase	150 mm C4	150 mm C4
Selected	150 mm G7	150 mm G7
Sub-grade	150 mm G9	150 mm G9
In-Situ	Rip & Re-compact	Rip & Re-compact

* Walkway surfacing: 60 mm Interlocking Paving Blocks

12.18.2 Storm water Management

12.18.2.1 Design Guidelines

The proposed stormwater management system comprises the following components:

- The road network for the containment of surface runoff;
- Underground pre-cast pipe system, including kerb inlets and catch-pits;
- Discharge structure into nearby river;
- Concrete channels where required;
- Grassed earth berms where required.

A general arrangement drawing, as well as pipe long sections and design details are shown in the following drawings:

- 13082-73-04-102
- 13082-73-04-105
- 13082-73-04-106

The following guideline documents have been used in the stormwater design for the Lanseria WWTW:

- Johannesburg Roads Agency: Standard Specification Drawings
- Guidelines for Human Settlement Planning and Design (Red Book)

12.18.2.2 Design Criteria

The following table highlights the design criteria used in the stormwater design for the Lanseria WWTW:

Table 35: Stormwater Design Criteria

Design Parameter	Guideline
Design Flood Determination Method	Rational Method & Hydrocube Software Modelling
Mean Annual Precipitation	618 mm
Design Flood Recurrence Interval	Minor System - 5 Years Major System - 25 Years
Minimum Pipe Diameter	450 mm
Minimum Velocity at Full Flow	0.7 m/s
Pipe capacity	75% of flow depth
Minimum slope for pipes	1 in 100
Pipe material	Precast concrete pipe with interlocking joints
Minimum Cover to pipes (In Carriageway)	1.1 m
Minimum Cover to pipes (In walkway)	0.8 m
Maximum Manhole Spacing	75 m
Fall across manhole benching	100 mm

12.18.2.3 Design of Culverts

Four culvert crossings are required at the Lanseria WWTW site. The positions of the culvert crossings are shown on drawing 13082-73-04-102.

The peak flows were determined from a previous report compiled by Knight Piésold, "Northern Farm Flood Hydrology Report." The report was compiled in July 2008 and the purpose of the report was to determine the 1 in 100 year floodlines of the rivers that flow through the proposed site. A summary of the peak flows from the report is detailed in the table below:

Table 36: Summary of Peak Flows

(Flows in m^3/s)	1 in 20	1 in 50	1 in 100
Tributary A	3.9	5.2	6.4
Tributary B	9.8	13.2	16.5
Northern Farm Tributary *	84	111	135

* A flow of 0.231 m^3/s is to be added from Northern Works WWTW

The culvert crossings consist of the following:

- A reinforced concrete bridge deck;
- Precast concrete portal culverts; (Designed as per the SANRAL Drainage Manual design guidelines)
- A reinforced concrete base.

The elements highlighted above are shown in the following figure of a longitudinal section through a typical culvert crossing:

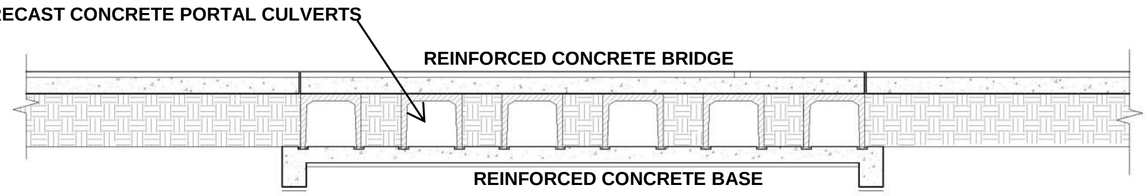


Figure 5 : Longitudinal section through typical culvert crossing

12.18.3 Electricity

Local distribution boards will be installed in all buildings to supply the small power and lighting of the building. Outdoor type distribution kiosks will also be installed for site lighting. These kiosks will also be supplied with a 3 phase welding plug for site power.

12.18.4 Site Lighting

The general site area must be lit with an average lux as required by the facilities regulations of the OHS act. Site lighting will be done with street lighting next to the roads and areas will be illuminated with High Mast Lights.

12.18.5 Access control, alarm system and Intruder detection

An intelligent access control system with biometric, video and RF ID cards/tags will be allowed for the site as well as all buildings. All access events will be recorded for record purposes

All buildings will also have intruder detection and an alarm system that can be linked to the onsite control room and to an external security company.

Intruder detection and CCTV with recording facility will also be installed along the perimeter fence.

12.18.6 Water Reticulation

The Wash Water Network is necessary to ensure that water is provided to wash down areas around the site. Final Effluent from the Chlorination Tank will be used as Wash Water. Fire Water will also be supplied from the Wash Water network as this has been accepted by the Fire Department of the City of Joburg.

The Potable Water Network ensures that potable water is provided around the site for the showers, toilets and drinking purposes.

12.18.6.1 Design

12.18.6.2 Design Assumptions

- The final effluent from the Chlorination Tank is pumped to two separate header tanks.
- Separate pumps will be used to pump Wash Water to the two header tanks. This reduces the interdependence on the pumps
- The header tanks will be utilised to store Wash Water for the structures on the liquid stream process units and on the sludge stream process units
- Potable Water will be stored in a tank adjacent to the Wash Water header tank

12.18.6.3 Wash Water Network

The proposed Wash Water Network design entails separating the Wash Water feed to the liquid stream process units and the sludge waste stream terrace. Dedicated pumps will be used to pump final effluent from the Disinfection Facility to the header tanks on the liquid and sludge waste stream terrace. Flow will then gravitate from the Header Tanks to the Wash Water points.

Where high pressure discharge is required such as at the Head of Works and the Belt Press Building booster pumps will be utilised to obtain the required pressure.

Wash Water points have been provided at the various areas below:

Liquid Stream Process Units

- Inlet structure
- Coarse Screening Area
- Vortex Degritters
- Grit Classifiers
- Fine Screening Area
- HOW Blower House
- Fermenters
- Primary Sedimentation Tanks
- Balancing Tanks
- BNR Reactor
- Secondary Clarifiers
- Chlorine Contact Channels
- DBF Dosing
- Ferric Dosing

Sludge Stream Process Units

- WAS Thickeners
- Digesters
- Grit Drying Bed
- Struvite Precipitation Area
- GBT & Belt Press Building
- Lime Clarifier
- Pump Stations

12.18.6.4 Potable Water Network

The incoming Potable Water to the site discharges into a storage tank that will be situated on the incline above the Head of Works. The Potable Water Network design entails gravitating and boosting Potable Water from the storage tank to various areas around the site.

Potable Water points are provided at the various areas below:

Liquid Stream Process Units

- Inlet structure
- Coarse Screening Area
- Vortex Degritters
- Grit Classifiers
- Fine Screening Area
- HOW Blower House
- Fermenters
- Primary Sedimentation Tanks
- Balancing Tanks
- BNR Reactor
- Secondary Clarifiers
- Chlorine Contact Channels
- DBF Dosing
- Ferric Dosing

Sludge Stream Process Units

- WAS Thickeners
- Digesters
- Grit Drying Bed
- Struvite Precipitation Area
- GBT & Belt Press Building

- Lime Clarifier
- Pump Stations

12.18.6.5 Materials of Construction

The materials that will be used are as follows:

- HDPE PE100 PN12.5 pipes for the Wash Water ring main and feed pipes,
- HDPE PE 100 PN12.5 pipes for the Potable Water ring main and feed pipes,
- Galvanised mild steel standpipes (encased in concrete inside a 110mm dia. PVC pipe) at the Wash Water points;
- Galvanised mild steel standpipes (encased in concrete inside a 110mm dia. PVC pipe) at the Potable Water points;
- Galvanised mild steel Wash Water header tanks
- Galvanised mild steel Potable Water storage tank

12.18.6.6 Pipes and Valves

Both the Wash Water and Potable Water ring feed are designed as a 160mm diameter HDPE pipe. Isolation valves are strategically placed on the pipeline to ensure that maintenance can take place if required. Scour valves are included at the lowest point of the Wash Water and Potable Water Network to ensure that both pipelines can be drained during maintenance.

12.19 BUILDINGS AND ARCHITECTURE

The scope of services of the Zitholele Consortium include the provision of architectural services, with a view of creating architecturally inspired buildings on the Works; which is lacking on existing wastewater treatment works.

Whilst the key objective of the Lanseria WwTW will remain the treatment and possible future reclamation of wastewater, an important component of this project is to attempt to change the ‘culture’ and mind set of conventional wastewater treatment facilities, by giving Architecture a lead role in the design process and thereby creating a distinct identity for the Works. The architectural objective is to develop an iconic facility that will attract learners, tourists and visitors to the facility.

12.19.1 Design Approach

A contemporary design approach has been adopted in an attempt to create a timeless design across the variety of buildings, and to explore a mature palette of colors and textures on a varied range of shapes and forms. The use of structural steel, flush-jointed facebrick and off-shutter concrete reinforces the contemporary design approach. The use of clip-on steel sun control elements was also incorporated, which assists in layering the facades creating distinct transition between open, shaded and covered spaces (refer to **Figure 6).**

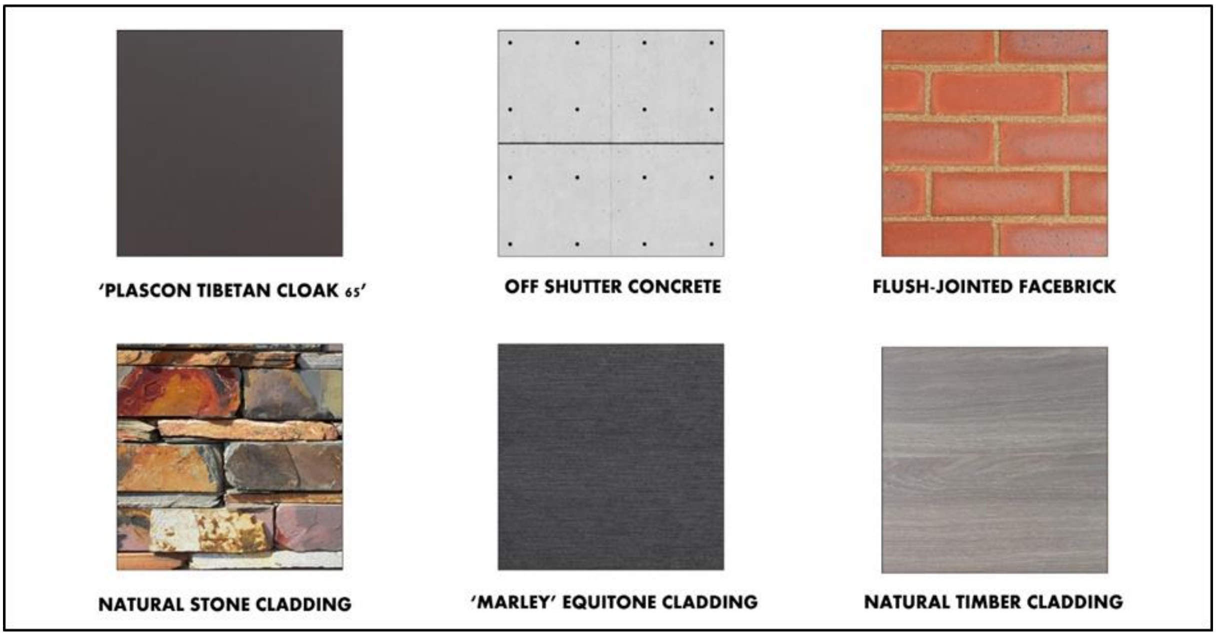


Figure 6 : Colour Pallet and Textures

Another key design initiative is to incorporate "green elements" into the project, promoting environmental sustainability, green energy and a regenerative design.

12.19.2 Architectural treatment of buildings

Full Architectural Scope of Services has been provided on the following buildings:

- Administration Building
- Guard House
- Entrance to the works

An aesthetic envelope to the structural components was provided on the following buildings:

- Workshop Building
- Primary Screening Building
- Grit Classifier Building

- Blower House
- Pump Station
- Control Building
- Monitoring Lab

12.19.3 Green Building Principles

The following green principles will be explored for the Administration Building (refer to Figure **Figure 7**):

- Photovoltaic solar panel system
- Storage for rain water collection for irrigation to reduce water consumption
- Two stage evaporative system air-conditioning
- Improve energy efficiency
- Utilize natural ventilation and improve air quality
- Sustainable and low emissivity materials
- Automated LED lighting and solar shading – motion occupancy sensors detect when spaces are not occupied and switch off fittings accordingly
- User awareness programs – workshops for staff
- Achieving thermal comfort
- Utilize strategies customized to site location
- Regular maintenance of equipment to extend lifespan
- White painted roofs to reflect solar heat gain
- Waste reduction during construction process
- Prefabrication of components of a building- faster construction and lowers waste from construction process
- Space planning- offices situated in west spaces, social spaces situated in east and north spaces, etc.
- Planting of deciduous trees in strategic locations
- Timber specified to be Forestry Stewardship Council certified
- Explore underfloor displacement system in open plan offices
- Water efficient fixtures and fittings to reduce water consumption
- Performance glass to maximize views and minimize glare and reduce heat gain

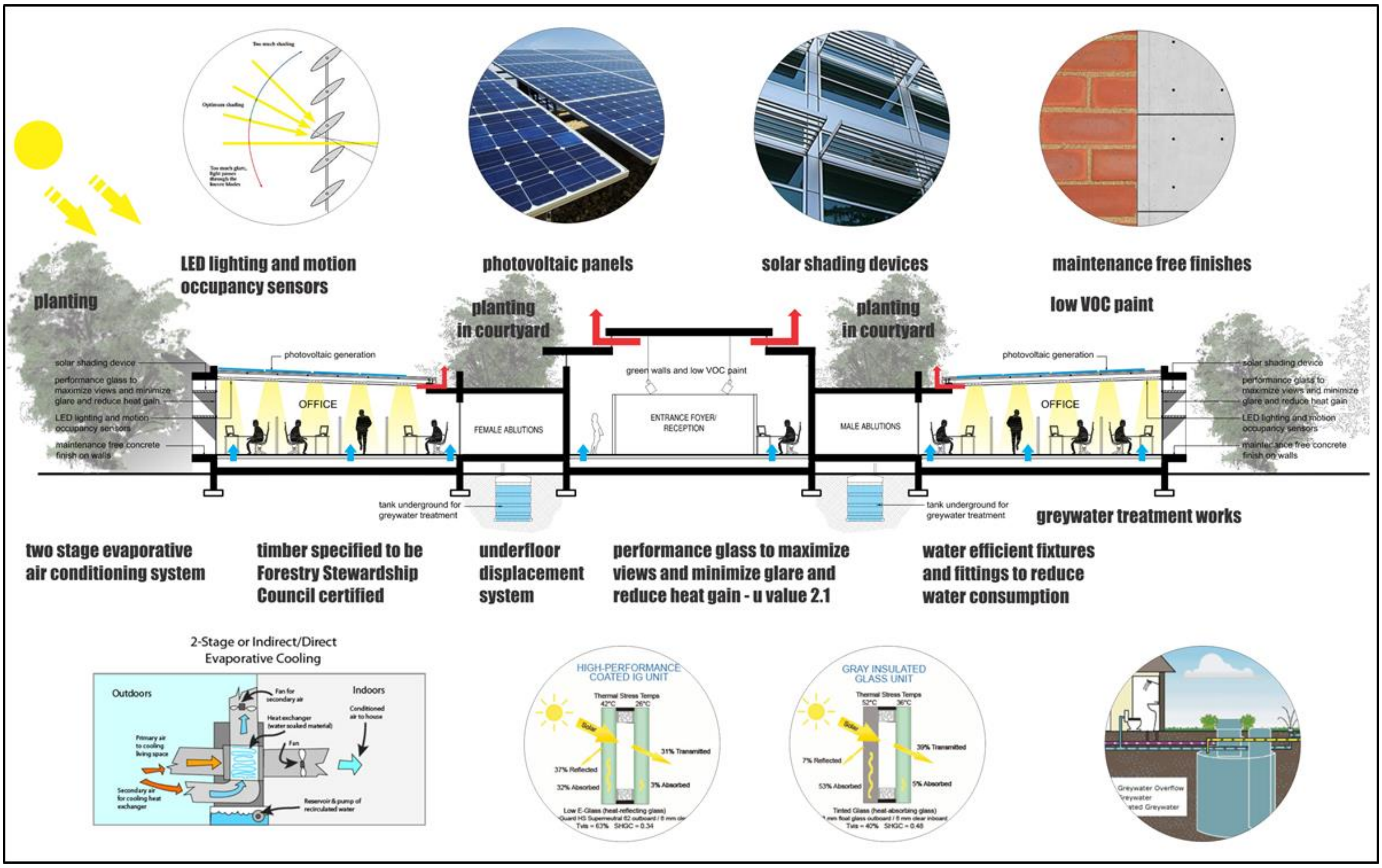


Figure 7 : **Section of Admin Building showing Green principles to be implemented**

12.20 STRUCTURAL DESIGN

12.20.1 General Design Philosophy

The purpose of the design is the achievement of acceptable probabilities, as defined in the relevant SANS Codes of Practice that the structures being designed will not become unfit for the use for which it is intended. Two limit states of design are considered; the Ultimate Limit State, and the Serviceability Limit State. The Ultimate Limit State (ULS) concerns safety, and considers the maximum load-carrying capacity of the structure. The Serviceability Limit State (SLS) design restricts excessive deformation or displacement, excessive local damage, excessive crack width, excessive vibration and corrosion of reinforcement in concrete.

The recommended design approach, which has been followed, is to design on the basis of the expected critical limit state and then to check that the remaining limit states will not be reached.

The analysis and design of the reinforced concrete, load bearing masonry and structural steel components of the works were carried out using the PROKON suite of programs, version W3.0.08, February 2016.

12.20.1.1 Blasting During Construction

The Contractor will generally be permitted to use explosives for breaking up rock and hard material during excavations, for demolishing existing structures and for such other purposes where they may normally be required. Blasting will be subject to the provisions in the Project Specifications.

To prevent damage to structures, whether completed or under construction, the Engineer shall specifically be authorized to prohibit the use of explosives in cases where, in his opinion, the risk of damage to adjoining structures is too high.

Where there is a reasonable possibility of damage to adjacent structures, the Contractor shall suitably adapt his method of blasting and the size of charges and shall use adequate protective measures, such as cover blasting, to limit the risk of damage as far as possible. The specific requirements relating to blasting in the Project Specifications must be adhered to.

Where blasting is to be performed close to structures susceptible to vibration damage, the Contractor must, before commencing blasting, employ the services of a specialist blasting consultant to prepare a method statement for approval by the Engineer, specifying in detail the requirements for all the activities related to blasting operations, to ensure that the vibration damage potential is controlled by keeping within the limiting criteria for vibration levels. These criteria shall be in accordance with acknowledged international standards, as approved by the Engineer, and shall relate to both peak particle velocity and wave frequency. The method statement shall be based on site-specific vibration characteristics determined by trial blasting as planned and monitored by the specialist-blasting consultant.

12.20.1.2 Concrete Cover to Reinforcement

The minimum concrete cover to the reinforcement for each type of structure is specified in the sections below. In accordance with BS 8007, a minimum cover of 50mm, suitable for severe and very severe exposure conditions, was specified. In those instances where the concrete is susceptible to chemical attack and the 50mm cover was deemed to be inadequate, coatings providing the required degree of chemical resistance were specified in the Project Specifications and on the drawings.

12.20.2 Liquid Retaining Structures

The term ‘liquid retaining structures’ includes structures designed to contain, or to exclude liquid, and include the tanks and reactors and similar vessels on the one hand and valve chambers, pump stations and the like on the other hand.

The critical limit state for the design of liquid retaining structures is the Serviceability Limit State, which considers the development of cracks in immature (early drying shrinkage) and mature concrete under service loads and temperature effects. The design entails element sizing and determining the amount of reinforcement required to limit crack widths to within the specified design limits. Once the reinforcement requirements have been established, compliance of the structure with the ultimate limit state requirements is checked.

The assessment of the foundation conditions at the site of the proposed works was based on the findings and recommendations contained in the Geotechnical Report Reference 5164/606 (Revision 1).

12.20.2.1 Joints in Liquid Retaining Structures

The design of liquid retaining structures against early thermal movement and shrinkage is closely related to the frequency and spacing of construction and expansion joints. All joint types and positions are therefore indicated and specified on the relevant concrete layout drawings.

12.20.2.2 Codes of Practice

i) Serviceability Limit State:

- BS 8007: Code of practice for design of concrete structures for retaining aqueous liquids.

ii) Ultimate Limit State:

- SANS 10100-Part 1: The structural use of concrete - Design
- SANS 10100-Part 2: The structural use of concrete - Materials and workmanship
- SANS 2001-CC1:2007: Concrete works (Structural)
- SANS 10144: Detailing of steel reinforcement for concrete
- SABS 920: Steel bars for concrete reinforcement
- SANS 10160-Parts 1 to 8 (as applicable): Basis of structural design and actions for buildings and industrial structures

12.20.2.3 Material Properties and Design Data

(i) Density of contained liquid: 11 kN/m^3
(ii) Density of concrete: 24 kN/m^3
(iii) Density of soil: 20 kN/m^3
(iv) Internal friction angle of soil: 30 degrees
(v) Concrete classes:
Structural concrete: Class 35/19 (35 MPa)

Benching: Class 20/19 (20 MPa)
Blinding: Class 15/19 (15 MPa)
(vi) Design crack width: 0,20mm (severe or very severe exposure)
(vii) Concrete cover to reinforcement: 50mm (minimum)

12.20.2.4 General Loading, Analysis and Design of Liquid Retaining Structures

In accordance with the relevant design codes, the liquid level inside the structures is taken as the top of the working top liquid level for the serviceability limit state design. For the ultimate limit state design, liquid levels were taken to the tops of walls, assuming that all liquid outlets are blocked.

Allowance has been made for the effects of adverse soil pressure on walls due to compaction and surcharge. The beneficial effect of external soil pressures on the liquid retaining structures in the filled condition was ignored.

In non-cylindrical structures, an assessment was made of the pressures to be resisted by horizontal and vertical bending moments in the walls. Allowance was also made for the effects of direct tension in walls induced by flexural action in adjacent walls.

The maximum hoop tension in the walls of cylindrical structures was determined assuming a pinned connection between the wall and the base. The maximum negative vertical bending moments in the walls of cylindrical structures were determined by considering a fixed connection at the wall/base interface. For the determination of positive midspan bending moments in the walls, a pinned connection was assumed.

As a rule, the floor slabs in both cylindrical and non-cylindrical structures were not monolithic with the wall foundations. The floors were divided into panels separated by sealed expansion joints, and either fibre-reinforced, or reinforced with high tensile steel reinforcement, as specified on the drawings.

The partial load factor for retained liquids and external soil pressure for the ultimate limit state was taken as 1.35.

For the design of the digesters, a maximum operational liquid temperature of 400 centigrade was considered.

12.20.3 Earth Retaining Structures

A substantial number of earth retaining structures/retaining walls are required to accommodate the change in grade of the natural ground level over the site of the proposed works, and to create the required elevations for the various components of the works. Primarily, use is made of reinforced concrete retaining walls and, where required or allowed by the topography of the site, concrete block retaining structures. The reinforced concrete retaining walls are pure cantilever retaining walls, with heights varying from 2.7m to a maximum height of approximately 8.5m.

12.20.3.1 Design Philosophy

The lateral earth pressures behind the walls were determined by considering the internal angle of friction of the retained soil (which will generally be specified to be a granular material), the surcharge at the top of the fill behind the wall, as well as the direction and magnitude of movement the retaining structure is expected to undergo. The latter is required to ensure that the correct soil pressure coefficient is used. The at-rest pressure coefficient assumes no lateral movement of the wall while the active pressure develops when lateral movement of the wall takes place. Friction between the back of the concrete wall and the soil backfill was ignored, this is a conservative approach. The friction coefficient between the underside of the base and the foundation material was taken as 0,50.

The allowance for the build-up of water behind the retaining wall was eliminated by designing and specifying suitable sub-soil drainage systems for the walls. This eliminates the hydrostatic pressure and improves the stability of the material behind the wall.

The factor of safety of the wall against sliding and overturning was taken as 1,5 under service loads. The partial load factors for dead loads (1,2), soil loads (1,4) and imposed loads (1,6) used are in accordance with the requirements of SANS 10160. The factorised loads were used for the Ultimate Limit State design of the wall, including wall thickness and reinforcement requirements.

12.20.3.2 Codes of Practice

- SANS 10100-Part 1: The structural use of concrete - Design
- SANS 10100-Part 2: The structural use of concrete - Materials and workmanship
- SANS 2001-CC1:2007: Concrete works (Structural)
- SANS 10144: Detailing of steel reinforcement for concrete
- SABS 920: Steel bars for concrete reinforcement
- SANS 10160-Parts 1 to 8 (as applicable): Basis of structural design and actions for buildings and industrial structures

12.20.3.3 Material Properties and Design Data

(i) Density of contained liquid: 11 kN/m^3
(ii) Density of concrete: 24 kN/m^3

(iii) Density of soil: 20 kN/m^3
(iv) Internal friction angle of soil: 30 degrees
(v) Concrete classes:
(vi) Structural concrete: Class 35/19 (35 MPa)
(vii) Benching: Class 20/19 (20 MPa)
(viii) Blinding: Class 15/19 (15 MPa)
(ix) Concrete cover to reinforcement: 50mm (minimum)

12.20.4 Buildings

12.20.4.1 Design Philosophy

The administration buildings will be built to house the treatment plant offices and consist mainly of concrete curved, cast in-situ wall panels, supporting the concrete roofs. The buildings have a number of glass façades. There is also a control building at the entrance with a similar design philosophy to be followed.

The administration buildings will be built as administration or office buildings, made up of concrete foundations, walls and roof. There are sheeted flat roofs which will drain off onto the concrete roofs. The concrete walls consist of cast in-situ concrete wall panels.

The administration buildings have been designed to adhere to meeting the ULS and SLS design criteria for buildings as per the design codes (SANS 10160 Parts 1 to 8). Additionally, the buildings have been designed to also withstand wind loadings.

The other buildings considered have been the pump station structures which also have crane loadings that were taken into consideration. The buildings consist of concrete slabs, supported by columns founded on concrete foundations. These buildings also have a number of retaining walls designed to meet the relevant design criteria for worst soil loadings.

12.20.4.2 Codes of Practice

- SANS 10160-Parts 1 to 8 (as applicable): Basis of structural design and actions for buildings and industrial structures
- SANS 10100-Part 1: The structural use of concrete - Design
- SANS 10100-Part 2: The structural use of concrete - Materials and workmanship
- SANS 2001-CC1:2007: Concrete works (Structural)
- SANS 10144: Detailing of steel reinforcement for concrete
- SABS 920: Steel bars for concrete reinforcement
- SANS 10162-Part 1: The structural use of steel –Design (Hot rolled steelwork)
- SANS 10164-Part 1: The structural use of masonry (Unreinforced)

12.20.4.3 Material Properties and Design Data

The following material properties are applicable to the buildings:

(i) Density of concrete: 24 kN/m^3
(ii) Concrete classes:
(iii) Structural concrete: Class 35/19 (35 MPa)
(iv) Benching: Class 20/19 (20 MPa)
(v) Blinding: Class 15/19 (15 MPa)
(vi) Concrete cover to reinforcement: 30mm (minimum)
(vii) Reinforcement: High yield bars (f_y=450 N/mm^2) and Mild steel bars (f_y=250 N/mm^2)
(viii) All Steelwork to be Grade 355JR and hot-rolled steelwork will be used for the steelwork on the project
(ix) Density of steel: 7850 kg/m^3
(x) Load-bearing masonry to be from masonry claybrick units – NFX/NFP with mortar class II

The following design data was considered in the designs for the buildings:

(i) All floor slabs (except for roofs) was taken as for offices (2.5kN/m^2) for the administration buildings and as industrial (5kN/m^2) for the pump station buildings.
(ii) The wind loading has been taken into account for the structures and a factor of 1.2 has been used for ULS designs and 1.3 (uplift) and 0.9 for SLS.
(iii) The retaining walls for the pump stations have been designed to take into account a vehicle imposed loading of 10kPa.
(iv) No seismic or accidental loads have been taken into account for the designs and these will be done in the detailed designs.

12.20.5 CONSTRUCTABILITY

The processes to construct the proposed waste water treatment works have been reviewed during the preliminary design phase. The design and layout of the structural components of the works have been done in such a way as to ensure ease of construction, considering the requirements of the completed works. Particular attention has been given to the following with regards to the design, drawings, specifications and construction of the components of the proposed works:

(i) That the Specifications and drawings accurately reflecting project requirements
(ii) The practicality of details
(iii) The Contractor’s ability to meet the specified tolerances

13 OUTFALL SEWER

The management, design and implementation of the Bulk Outfall Sewer is being implemented as a separate project within JW. However, the JW Project Managers and the professional teams on the Works project and the Outfall Sewer project have established an overall project liaison committee to ensure co-ordination between the two projects. The key areas of co-ordination between the two projects are:

- the implementation programmes of both projects, to ensure that the completion of construction is carefully co-ordinated. Whilst the nature of each of the projects and the expected construction durations are completely different, the projects are integrally linked, and the ideal scenario would see both projects being completed at around the same time. It is, however expected that the Outfall Sewer will be completed approximately one year in advance of the completion of the Works.
- the interface point where the Outfall Sewer will discharge into the Head of Works of the Lanseria WwTW, to ensure hydraulic connectivity.

Two key studies have been undertaken by JW with regard to the Outfall Sewer, as follows:

- Ndodana, Becker & Associates was commissioned in 1997 by the Technical Services: Wastewater Division of the then Greater Johannesburg Metropolitan Municipality to undertake a study to identify suitable sites for the construction of a new wastewater treatment works to service the northern drainage basin. This was a result of a previous study undertaken by the same consultants for the Water and Sanitation Strategic Development Plan which resolved that Northern Works does not have sufficient capacity to treat increased flows from the Lower Klein Jukskei catchment, nor the rest of the Northern Drainage Basin. It was recommended that a new wastewater treatment facility be constructed in the aforementioned basin. The study also investigated four routes for an outfall sewer with four viable drainage points to the area where a new wastewater treatment facility may be positioned.
- Master Plan – “Network Analysis: Future Lanseria Drainage Basin (Updated Report, June 2016)”, prepared by GLS Consulting, with the following summary conclusions:
    - The future Peak Daily Dry weather flows (PDDWF’s) are estimated at 117.7Mℓ/d and 172Mℓ/d for the medium and ultimate development scenarios respectively.
    - These flow volumes include contributions of 31.4Mℓ/d and 66.3Mℓ/d from the upstream Diepsloot Pumped and WKJ Pumped basins respectively.
    - The report assumes that the new Lanseria WWTW will be constructed at Northern Farm, phased as 3 x 50 Mℓ/d units.
    - The analysis indicates that the PDDWF from the catchment (including the area located outside the current UDB (urban development boundary)) may exceed the treatment potential of the Northern Farm site (> 150 Mℓ/d).

It is understood that the current design of the Outfall Sewer is based on the investigations and recommendations if the second report described above (i.e. the Master Plan).

14 ENERGY NEUTRALITY

Electricity consumption makes up between 20 and 30% of the operational costs of an activated sludge wastewater treatment works, the balance of the operational cost being spent on maintenance, staffing, chemicals, sludge disposal, transport and administration. Therefore, a reduction in the electricity consumption can present a significant operational cost saving for the owner of the treatment facility.

The objective is therefore to design the new Lanseria WwTW with energy neutrality in mind. The best-practice method of organics, nitrogen and phosphorus removal in wastewater treatment is by implementing the activated sludge process, and this is also prescribed by the Johannesburg Water Guideline for the Design of Wastewater Processes 2015. The activated sludge process is also able to reliably treat the wastewater to produce an effluent that consistently complies with South Africa's relatively strict discharge standards. However, the activated sludge process is by nature an energy intensive process, with the aeration process being the single largest consumer of electricity (aeration accounts for between 45 % and 60 % of the total activated sludge process electricity consumption).

In South Africa, the electricity price has increased significantly at a rate above inflation in the last few years. Considering the current economic climate as well as Eskom's ambitious capacity upgrades, it is expected that the electricity price will continue to increase over the next few years. Johannesburg Water measures their works electricity consumption as kWh per Mℓ of wastewater treated per day. Currently, on average over the six existing Johannesburg Water WwTW works, 394 kWh / Mℓ is consumed, against which the Lanseria wastewater treatment works can be benchmarked as the latest, state-of-the-art design for wastewater treatment.

Using a similar benchmark number, the power requirements for the proposed Lanseria works, without including any energy saving or energy recovery initiatives, is expected to be within the range of 3000 KW to 3500 kW, or 3.0 MW to 3.5 MW for the full 150 Mℓ/d works. A preliminary estimate for the total installed power as well as the actual power drawn was calculated for the Lanseria WwTW at ultimate 150 Mℓ/d capacity, as per the preliminary design of the WwTW. The estimated total installed power is calculated at 5.5 MW, and the estimated total utilised power at 2.5 MW. Fine bubble aeration has been assumed in these estimates. Even though the values may change as the detail process, mechanical and electrical designs progress, they present a baseline as to the expected electricity demand of the works at ultimate capacity.

Energy efficiency is a factor that will be incorporated into the design of the Lanseria Wastewater Treatment Works (WwTW) as a matter of course:

- The layout of the works is designed so that gravity flow is utilised for the liquid stream wherever possible to minimise and preferably eliminate pumping of the bulk liquid between process units;
- Diluted sludge streams are gravitated where the process, plant and site layouts allow. Thickened sludge streams are however always pumped, as gravitating thickened sludge streams can be problematic in terms of blocking of pipework;
- Provision of up to date power factor correction control system on the main incoming power supply from the electricity provider's substation,
- Selection of high-efficiency motors with high power factors, and ensuring that motors are not over-sized for their application.
- Implementation of variable speed drives (VSD) technologies where appropriate. (Note: JW prefers not to install VSD's unless absolutely unavoidable, and therefore this preference will be taken into account during the detailed design of the Lanseria WwTW).
- Implementation of soft-starter technology for larger electrical motors; (Note: JW prefers not to install soft-starters unless absolutely unavoidable, and therefore this preference will be taken into account during the detailed design of the Lanseria WwTW).
- Ensure correct selection of gearboxes (e.g. for mixers) that minimise losses through the gearbox;
- Selection of efficient pumping technology and ensuring the pump flows and the pump are matched correctly;
- Selecting energy efficient mechanical equipment, where applicable and appropriate;
- Introducing an energy monitoring systems;
- Providing low wattage lighting (e.g. LEDs) for site lighting as well as building lighting;
- Where possible automation of process units of the works will be installed.

The drive towards energy efficiency will not only receive due cognisance during the design stage of the Lanseria WwTW, it will also carry over to the mechanical and electrical procurement process to ensure that the equipment suppliers supply and install appropriate and energy efficient equipment.

14.1 Power Saving by Selection of Aeration Type

Five out of the six existing Johannesburg Water WwTW are fitted with mechanical surface aeration to aerate the aerobic zones of the bioreactors, while one is fitted with a fine bubble diffused aeration system. Surface aeration is commonly used and often preferred in South Africa due to its lower initial capital costs, simplicity of operation and ease of maintenance, however fine bubble diffused aeration is a significantly more efficient process with significantly lower electricity consumption for the same amount of oxygen transferred to the bulk liquid. By installing fine bubble diffused aeration system instead of mechanical surface aeration for the new Lanseria WwTW provides an average power saving of approximately 800KW, or approximately 45% less power than that required for a mechanical surface aeration installation. By installing a mechanical surface aeration system instead of a fine bubble diffused aeration system, the installed power calculated in Section 4 above increases from 5.5 MW to 6.3 MW, and the total utilised power increases from 2.5 MW to 3.3 MW. There is therefore a 32% increase in the projected overall actual power consumption of the Lanseria WwTW if mechanical surface aeration is implemented instead of fine bubble diffused aeration.

14.2 Renewable Energy

Sources of renewable energy available on WwTW are:

- Utilising bio solids as a form of renewable energy;
- Hydropower (Micro Hydropower);
- Solar energy; (JW prefers not to install solar panels due to the high rate of theft experienced with previous installations).
- Wind energy.

14.2.1 Biosolids

The most commonly implemented method of utilising bio solids as a form of renewable energy is by utilising the biogas to fuel a combined heat and power (CHP) installation. A CHP installation does not form part of the scope of work of this project, however sufficient space will be left on the sludge handling and treatment layout for a future CHP installation.

14.2.2 Hydropower

Hydropower can only be implemented for gravity flow where sufficient hydraulic head exists to generate power. A WwTW is generally laid out and designed in such a way that the bulk liquid gravitates through all the process units, thereby minimising the need for pumping the bulk liquid. Depending on the site topography, a significant portion of the available head is utilised to ensure the bulk liquid gravitates through the process train, as well as through the mechanical equipment (e.g. coarse and fine screens), leaving little head for hydropower applications. The topography of the Lanseria WwTW site is such that very little hydraulic head remains by the time the treated effluent is discharged to the river. This will however be confirmed during detail design, and should a case for micro hydropower exist on the treated effluent discharge, a recommendation for its implementation will be made.

Installing micro hydropower within the head of works or between process units is not recommended, not only due to the associated head loss, but also due to the fact that floatables and other material that is not screened at the head of works may get caught in the hydropower infrastructure and significantly predispose the plant to frequent blockages at the hydropower installation points. High pressure (pumped) pipelines at the Lanseria WwTW are mainly implemented for sludge applications, and installing micro hydropower in sludge lines is not recommended.

14.2.3 Solar power

Solar energy can be utilised in two ways to produce electrical power:

- Photovoltaic
- Concentrated solar power (CSP)

CSP, which uses lenses or mirrors to focus a large area of sunlight into a small beam, is mainly used in large scale applications by electricity utilities to generate large amounts of power. The power is not produced directly; the concentrated beam is used to heat water to steam, which drives a conventional steam turbine. Photovoltaic (PV) cells on the other hand directly convert light to electrical energy, and are therefore suitable for smaller to medium sized applications. PV systems use solar panels, either on rooftops or in ground-mounted solar farms, converting sunlight directly into electric power. This Section will concentrate on the use of PV cells to produce power for local consumption.

South Africa has a relatively sunny climate, which favours PV installations. It should however be noted that a PV installation will only provide electricity during the day, at night no electricity will be produced. Even though PV installations have become cheaper, they still require significant capital investment (R 30 000 to R 60 000 per kW). They also require large areas of land (PV area of 10 m2 / kW is required) to accommodate the PV panels.

Large scale solar installations to provide sufficient power to run the Lanseria WwTW are not feasible, as their capital costs are significant and their operation and maintenance falls far outside the core business of Johannesburg Water. However, PV installations on a smaller scale to produce electricity for the small power and lighting requirements within buildings (e.g. the administration block, laboratory, workshop, stores and ablution facilities) present a viable option. The PV panels can be mounted on the roofs of the buildings and can supply sufficient electricity to cover the small power and lighting demand of each respective building, excluding hot water geysers. Cognisance must however be taken that small PV installations are targeted by criminals, and the placement of these installations should be such that they are not easily accessible to criminals.

All buildings that require hot water must be fitted with solar geysers as a matter of course. Power storage banks can be provided to ensure power supply overnight, or the electricity supply can automatically be switched over to grid electricity at night time. Even though the small and lighting electricity demand of the buildings is insignificant compared to the WwTW electricity demand, powering them from a renewable energy source will showcase

Johannesburg Waters continued commitment to renewable energy. This will however not shift the Lanseria WwTW significantly closer to energy neutrality.

14.2.4 Wind energy

Wind power is the use of airflow (wind) through wind turbines that mechanically power generators to produce electricity. Wind turbines are available in a range of sizes, from micro wind turbines (50 W to 10 kW generation capacities) to full scale large wind turbines (up to 5 MW generation capacities). Electricity providers usually construct wind farms, which consist of a number of wind turbines in one installation to produced electrical power that feeds into the electricity distribution network.

As was the case for large scale solar power installation, wind farms are not considered feasible as a renewable energy source to power the Lanseria WwTW. Micro wind turbines could be supplied to generate electricity for the smalls power and lighting for the buildings on site, however for the Lanseria WwTW PV panels represent a more reliable source of renewable energy than micro wind turbines.

14.2.5 Energy neutrality and the Lanseria WwTW

By implementing the measures discussed above and assuming a CHP installation will be provided in future, the power demand of the 150 Mℓ/d Lanseria WwTW can be reduced from 3300 kW (mechanical surface aeration, no future CHP) to 900 kW (fine bubble diffused aeration, future CHP with sludge pre-treatment provided), which represents a significant saving in electricity and therefore operational cost. This does not shift the Lanseria WwTW to 100% energy neutrality; however, it brings it significantly closer at 73% towards energy neutrality.

The balance of the power demand of the Lanseria WwTW could be made up by renewable energy sources such as micro hydropower, solar power and wind energy. The site topography of the Lanseria WwTW site does not lend itself to micro hydropower, because most of the available hydraulic head is used to ensure that the bulk liquid gravitates through all process streams. There may be an opportunity to install a micro hydropower unit on the final treated effluent stream to the river, however this will be confirmed during detail design.

The provision of large scale solar power or wind farms to produce electricity for onsite consumption is not feasible, as the capital costs and land requirements are significant. Furthermore, electricity generation via solar or wind power falls too far outside the Johannesburg Water mandate of treating wastewater. However, to showcase Johannesburg Water’s continued commitment to renewable energy, it is recommended to equip all buildings (admin buildings, workshops, stores and ablution facilities) with solar panels sized to generate sufficient power to cover each buildings smalls power and lighting requirements, excluding hot water geysers. It is recommended to provide solar geysers for all buildings that require hot water.

Overall, it is expected that 100% energy neutrality will not be achievable for the Lanseria WwTW, however an overall reduction of external power demand of approximately 70% can be achieved.

15 ENVIRONMENTAL AUTHORISATION

The development of a WwTW is subject to the following pieces of legislation and regulations, amongst others:

- National Environmental Management Act, 107 of 1998, as amended (NEMA)
- Environmental Impact Assessment Regulations: GN 982-685 of 4 December 2014 (EIA regulations of 2014)
- National Environmental Management: Waste Act, 59 of 2008, as amended (NEMWA)
- National Water Act, 36 of 1998 and regulations (NWA)
- National Environmental Management: Air Quality Act, 39 of 2004 (NEMAQA)
- National Heritage Resources Act, 25 of 1999 (NHRA)
- National Environmental Management: Biodiversity Act, 10 of 2004 (NEMBA)
- National Environmental Management: Protected Areas Act, 57 of 2003 (NEMPAA)

Nemai was appointed by JW, via the Zitholele Consortium, as the independent Environmental Assessment Practitioner (EAP), to undertake the Environmental Authorisation processes for the new wastewater treatment works. The Draft Scoping Report as compiled by Nemai may be consulted for a more detailed approach to this process. The reports highlight the activities completed to date, challenges encountered and the overall timelines that will need to be met.

Gauteng Department of Agriculture and Rural Development (GDARD) is the competent authority who is responsible for issuing an Environmental Authorisation for this project. During a pre-consultation meeting with GDARD, they advised that an alternative site will need to be considered, as the likelihood of an objection/appeal being raised is very high if this is not done. The project team complied with this recommendation, and a full assessment of the preferred site as well as the alternative site was undertaken. This included all specialist studies as well as a technical evaluation of both sites.

Once the specialist studies were concluded, a masterplan of the study area was developed which delineated the undevelopable areas of the site (from an environmental sensitivity point of view). The undevelopable areas of the site formed a significant percentage of the overall site area, which was exacerbated by the electrical servitudes on site that had to be avoided. This stifled the flexibility that could have been incorporated in the layout of the works. The Works layout was developed around these site constraints. This is discussed further in Section 7 of this report.

The EAP has incorporated the technical aspects of the development of the Works into documents that will support the authorisation application, which will culminate in the submission of an Environmental Impact Report (EIR) to GDARD. The outcome of the authorisation process will be based on the information that will be submitted in the EIR.

A key component of the assessment is the Public Participation process, which has commenced. Comments are currently being received by the EAP and are being circulated to the relevant project team members for responses. A Draft Scoping Report is also being compiled which is expected to be issued to GDARD towards the end of September 2016.

The Environmental Authorisation is expected by August 2017.

Due to the proximity of the project to the Jukskei River, and several other tributaries that drain to it, a Water Use Licence Application (WULA) is also required. Zitholele Consulting was appointed to undertake this task. The application will be made on the preferred site only. Further to the specialist studies that were undertaken as part of the EIA, a groundwater study was required, to inform this application. Intrusive work on site is required for the groundwater study and due to its proximity to the aforementioned water courses, a General Authorisation is required. The competent authority for this process, and for issuing of a Water Use Licence, is the Department of Water and Sanitation (DWS). The General Authorisation application was submitted to DWS at the end of July 2016 and an approval is expected by mid-September 2016.

The WULA is scheduled to be submitted to DWS in January 2017. The Regulations that govern WULA's do not prescribe a timeframe for the assessment of the application, which poses a significant risk to the project, as this may cause a delay to the start of construction.

The project team will monitor this and liaise constantly with the competent authority to ensure a prompt approval process.

16 RISK MANAGEMENT

Every project has an element of risk, but the impact of these risks on the project at large is ultimately determined by the manner in which these risks are identified and managed.

A Risk Register has been compiled at the onset of the project in order to identify, monitor and mitigate risks on the project. The Risk Register showing the current status of identified risks is given in Appendix D.

The current major risks associated with this project are as follows:

- Project funding – the uncertainty of securing the full project budget for this long term project may decide on whether this project will proceed as programmed, or not. The project team is managing this risk by issuing updated budgets and cash flows to the infrastructure planning division of JW.

- Environmental Authorisation – there are two key risks associated with the authorisation process:
    - Alternative site - the environmental authorisation process required an alternative site for the works to be considered, in addition to the identified site. There is a risk that the alternative site may be authorised rather than the identified (preferred site). The EAP is liaising with GDARD to ensure that this process is managed.
    - Delay in issuing an Environmental Authorisation, or an appeal being lodged by an Interested and Affected Party (I&AP) – authorisation is currently expected in the last quarter of 2017, and construction may only commence once final authorisation has been received (after the expiry of the appeal period). The start of construction will be delayed if there are any delays in the authorisation process.
- Water Use License – the timeframe for DWS to issue a water use licence is currently not legislated, and construction may only commence after the license has been issued. The team is in discussion with DWS to ensure that the issuing of the license is expedited once the application has been submitted. The WULA is expected to be submitted in the first quarter of 2017.
- DWS Discharge Standards – a stringent discharge standard is currently proposed for the wastewater treatment works. However, the stringent limitations set in these discharge standards have an insignificant impact on the receiving watercourse. In order to meet the stringent standards, infrastructure in addition to JW's conventional treatment processes will be required. Apart from the additional capital costs for this infrastructure, the operating costs will be exorbitant. A cost benefit analysis shows that there is insignificant gain to the environment, apart from meeting the stringent standards, if these stringent standards are targetted. JW intends meeting with the relevant authority to motivate for the previous discharge standards that were issued for the other wastewater treatment works in the drainage basin.
- Outfall Sewer – The implementation of the outfall sewer that drains to the new wastewater treatment works is outside the scope of this project. It is being undertaken by a different section within JW Capex. If the outfall sewer is not commissioned prior to the completion of the new wastewater treatment works, the new works will not be able to be commissioned. The project team for the outfall sewer has been appointed and is planning to have the project implemented by November 2019. However, the Environmental Authorisation process has just commenced so the risks associated with it has not been identified as yet. The project teams on both projects have established a forum to ensure co-ordination between the two projects.

17 CONTRACTING STRATEGY

JW is a state-owned municipal entity which is governed by the Municipal Finance Management Act (MFMA), and the Preferential Procurement Policy Framework Act (PPPFA) of the Republic of South Africa. Therefore, this project, due to its size, will be subject to a competitive bidding process, and the appointment of contractors will need to comply with the aforementioned regulations. These regulations also require JW to set aside a certain amount of work on the project for previously marginalised enterprises, SMME's and local labour.

Two broad contracting strategies may be appropriate for the execution of this project, viz. "Design by Employer" or "Management Contractor".

In either scenario, the General Conditions of Contract can be used as the basis of the contract, and is recommended for the construction phase of this project.

17.1 Design by Employer

In this type of contract, a contractor undertakes only construction on the basis of full designs issued by JW (or JW's agent, which in this case is the Zitholele Consortium).

Thus the Zitholele Consortium will prepare and administer as many contracts as are required for the construction and commissioning of the works, through a competitive bidding process. The Consortium, acting as the Engineer, will also be expected to manage the overall programme of the construction activities, the interfaces between contracts, and the risks that develop as a result of those interfaces.

The scope of work of the project can broadly be broken up into the following four disciplines:

- Civil and Structural,
- Mechanical,
- Electrical,
- Control and Instrumentation

Thus, contracts could be prepared as follows:

17.1.1 Enabling Works

One contract for:

- Main Access Road
- Potable water and borehole on site
- Fencing around the site

17.1.2 Liquid Treatment Process Stream

Three contracts for:

- Civil Engineering Works
- Mechanical Engineering Works
- Electrical and Control and Instrumentation Engineering

17.1.3 Sludge Treatment Process Stream

Three contracts for:

- Civil Engineering Works
- Mechanical Engineering Works
- Electrical and Control and Instrumentation Engineering

Thus JW would potentially enter into a contractual relationship with seven contractors.

17.2 Management Contractor

In this type of contract, a contractor is responsible for planning and managing all post-contract activities, including the design of the works (if required), and for the performance of the whole of the contract.

The contractor would then appoint sub-contractors to undertake the work associated with each of the disciplines required (the management contractor could act as a “sub-contractor” as well). Whilst the Zitholele Consortium will still perform the functions of the Engineer, the contractor would be responsible to manage the overall programme of the construction activities, the interfaces between contracts, and risks that develop as a result of those interfaces. Since the Zitholele Consortium has undertaken the design, the contractor would not be required to undertake any design of the works.

JW, in the structuring of the management contract, can further specify the nature of the anticipated sub-contracts, sub-contractor CIDB grading, sub-contract participation goals, etc.

Thus, management contracts could be prepared as follows:

17.2.1 Enabling Works

One management contract for the Enabling Works:

- Subcontract 1 - Main Access Road

- Subcontract 2 - Potable water and borehole on site
- Subcontract 3 - Fencing around the site

17.2.2 Liquid Treatment Process Stream

One management contract for the Liquid Treatment Process Stream:

- Subcontract 1 - Civil Engineering Works
- Subcontract 2 - Mechanical Engineering Works
- Subcontract 3 - Electrical and Control and Instrumentation Engineering

17.2.3 Sludge Treatment Process Stream

One management contract for the Liquid Treatment Process Stream:

- Subcontract 1 - Civil Engineering Works
- Subcontract 2 - Mechanical Engineering Works
- Subcontract 3 - Electrical and Control and Instrumentation Engineering

Thus JW would potentially enter into a contractual relationship with three contractors.

The Management Contractor approach has certain distinct advantages over the Design by Employer approach, particularly in the number of contractual relationships that JW would enter into, and the number of interfaces that would need to be managed. This type of approach is particularly suited to the implementation of large contracts, and it is recommended that this option be considered further, during the Tender and Procurement phase.

The project contract strategy will further be dependent on the following key factors:

- Annual budget available to the project
- Programme for completion
- JW's Contract Participation Goals

18 OCCUPATIONAL HEALTH AND SAFETY

The Occupational Health and Safety Act (No. 85 of 1993), and the latest Amendment, requires that an Employer *provide for the health and safety of persons at work and for the health and safety of persons in connection with the use of plant and machinery; the protection of persons other than persons at work against hazards to health and safety arising out of or in connection with the activities of persons at work; to establish an advisory council for occupational health and safety; and to provide for matters connected therewith*. In terms of the foregoing, JW is in essence the Employer on all the envisaged contracts during implementation however will not have control of the site. It is therefore JW's responsibility to ensure that the appointed contractors comply fully with the Act with no provisions for exemptions or concessions.

The first step to ensuring compliance is to write a comprehensive Health and Safety specification for the compilation of an acceptable Health and Safety Plan by the tendering contractor. The Safety Plan should be subject to assessment during the Technical Evaluation stage of tender adjudication. Submission of a Safety Plan should be one of the gatekeepers for compliance which should result in disqualification of tenderers who do not submit a Safety Plan.

If Contractors are required to comply with the Safety Act at their own cost, they will not allocate dedicated personnel for this task. Primarily for this reason, the Bill of Quantities in the Tender Documents should make provision to pay the Contractor for, inter alia, the following:

- Compilation of a Health and Safety Plan;
- Maintenance of the Safety Plan to ensure that it is updated with changes to personnel;
- A suitably qualified full-time Safety Officer on site

Regardless of the Contractors commitment to Health and Safety on site, JW should monitor his compliance with the Health and Safety Act. The Zitholele Consortium has been tasked with the role of Safety Agent on the project. One of the roles of this appointment is to carry out monthly audits on site to ensure compliance. This will be conducted in a structured manner using a checklist of criteria contained in the Safety Plan. The contractor will be scored against this and scores lower than a prescribed value will render the Contractor non-compliant. This may result in the Contractor being asked to stop work immediately until the non-conformance is remediated. It is obviously in the Contractor's best interest to ensure that he is not found in non-compliance as any standing time will be at his own costs.

The Contractor will also be obliged to carry out safety induction on any person, apart from his staff, that is required to be on site. He should also ensure that the minimum Personal Protective Equipment (PPE) be kept on site for the use by visitors to site.

The Contractor will also need to inform the Department of Labour in writing of the dates he expects construction to start and end. This will be required before construction commences. The Department will make ad-hoc visits to site during construction to ensure compliance with the Safety Act.

19 PROGRAMME

A project schedule, in the form of a Gantt chart, was compiled at the onset of the project in order to track progress and identify the critical path tasks. The summary is shown in Table 37 below:

Table 37: Summary of Project Progress

STAGE	DESCRIPTION	DUE DATE	% DONE
1	Stage 1 – Project Initiation	19 June 2015	100%
2	Stage 2 – Reporting Stage	08 July 2016	99%
3	Stage 3 – Concept and Viability	31 Mar 2017	95%
4	Stage 4 – Design Development	29 Sep 2017	11%
5	Stage 5 – Documentation and Procurement	31 Jan 2018	0%
6	Stage 6 – Construction /Installation /Commissioning	18 Aug 2022	0%
7	Stage 7 – Project Close-Out	02 Feb 2022	0%
	Overall Progress		**44%**

The Reporting Stage of the Project is essentially complete with final comments on the remaining reports to be incorporated. This is envisaged to be concluded with comments received on the Preliminary Design Report (PDR, this report). The PDR commenced as soon as the major items of contention were resolved at the Reporting Stage such that both phases will be concluded simultaneously.

Thus far the project is on schedule. However, the following programme risks should be noted:

- Delay in issuing a General Authorisation by DWS in order to do intrusive work for environmental specialist studies which will inform the EIA and WUL;
- Delay in issuing a Water Use Licence, apart from the delays mentioned above, which will mean that construction cannot commence
- Delay in the issue of an Environmental Authorisation which will mean that construction cannot commence
- Delay in commissioning the feeding Outfall Sewer which will mean that Commissioning of the Works cannot commence

All of the above potential delays are outside the control of the project team and they have been captured in the Risk Register and will be monitored closely by the project team.

20 PROJECT INVESTMENT

A detailed estimate of the expected construction value of the project was compiled. This estimate is based on the following:

- A Bill of Quantities was developed for the project
- Quantities for the major construction items were extracted, which includes:
    - Bulk earthworks, including cut and fill
    - Rock excavation
    - Restricted excavation for structures on terraces
    - Concrete
    - Reinforcement
    - Formwork
    - Joints
    - Structural Steelwork
    - Interconnecting Pipework
- Rates were extracted from recently completed, similar projects, and were escalated to current rates.
- Rates for the major items such as ready-mix concrete, reinforcing and earthworks including blasting of rock were sourced from suppliers and contractors as budget prices.
- Re-use of crushed blasted rock was considered in the costs by including for a crushing plant on site. This posed as a significant cost savings in lieu of importation of backfill material from commercial sources.

A summary of the Bill of Quantities is shown in **Table 38** below.

Table 38: Summary of Capital Cost Estimate

Description		**Total (excl. VAT)**
Civil Engineering Works (Liquid Stream)	R	508,955,000.00
Civil Engineering Works (Sludge Stream)	R	227,580,000.00
Electrical and Control & Instrumentation	R	106,500,000.00
Mechanical Engineering (Liquid Stream)	R	79,653,000.00
Mechanical Engineering (Sludge Stream)	R	75,499,000.00
Preliminary & General Items	R	199,638,000.00
Total (excl. VAT)	**R**	**1,197,825,000.00**

A detailed cost breakdown per structure is given in the appendices.

21 LOCAL LABOUR OPPORTUNITIES

JW and the City of Johannesburg have initiated several programmes successfully in the recent past that will need to be researched in order to inform the utilisation of local labour in any of the proposed contracts within the project. This includes involvement of unskilled local labour employed directly by the contractors or local Small, Medium and Micro-sized Enterprises (SMME's) sub-contracting to the main contractor. The relevant stakeholders need to be identified within JW that will inform the contracts of the relevant participation goals that will need to be met. The professional team will highlight the tasks that may be completed only by local labour which becomes a contractual requirement on the contracts. The tender documents will be compiled accordingly.

The intent of using local labour needs to be well articulated in the contract documents such that the objective of such an initiative is not only met on paper but in substance as well.

Predominant participation of local labour is envisaged for the following tasks:

- Buildings (administration building, workshop, pump stations and electrical control buildings)
- Internal roads and paved areas
- Main access road which is proposed to be constructed by labour intensive means.
- Landscaping
- Excavation of trenches for pipelines and electrical cables
- Stone pitching for erosion protection
- Filling and placement of gabion baskets and reno mattresses
- Rubbing down of off-shutter concrete structures
- Erection of site fencing

It would be expected that the Contractors train the labour prior to them engaging on the above, or other, tasks on site. Certificates of participation should also be considered to be issued to these individuals in order to put them in good standing for future employment.

Sourcing local labour is a sensitive transaction and the proper protocols should be observed when doing so. JW should identify the correct ward that the project is within, identify the ward councillor for that ward and all communication should flow via this channel.

22 SKILLS TRANSFER

Members of Zitholele Consortium have a Commitment and Undertaking with the Engineering Council of South Africa (ECSA) and their professional engineers are registered as mentors with the Council. All training under the mentorship of these individuals is fully accredited by

ECSA and will ensure a seamless registration process for the earmarked candidates. However, the onus will be on these candidates to ensure that the Training and Experience Reports are completed by them and signed off by the relevant mentor before leaving the training programme.

The transfer of knowledge will take place throughout the project and will feature in every project stage. The specific events and actions which will contribute to knowledge transfer are summarised below for each of the project stages.

22.1 Stage 1 – Project Inception

Development of a knowledge and know-how transfer strategy and scheduling of specific events and actions. This step is complete and involved the identification of JW Staff to be seconded to the design offices during the following stages of the project.

22.2 Stage 2 – Project Concept and Viability

A JW staff member was seconded to the Consortium to be part of the Design Team. He was fully involved with design and detailing of structures at a level relevant to this stage of the project. His involvement will continue to the detailed design phase were a higher degree of detail will be required on his initial work. A second JW staff member is earmarked to join the team when we engage with the Detailed Design Stage.

22.3 Stage 3 – Design Development

Hazop workshops covering each of the functional areas of the wastewater treatment and sludge handling plant will be conducted. We will properly conduct these Hazop workshops over 10 day period to allow adequate discussion of each functional area.

As indicated previously, we have confirmed that two JW candidate engineers will join the Consortium design team for the duration of Stage 3. These candidate engineers have been nominated by JW and we have the capacity to provide experience and training in all engineering disciplines as reflected in the project.

22.4 Stage 4 – Documentation and Procurement

No specific workshop events are scheduled or planned as part of Stage 4.

22.5 Stage 5 – Contract Administration and Inspection

Skills transfer during this stage will be for both the construction team and the design team. This section covers only the design team and construction related skills transfer will be covered in Section 0 – Contracting Strategy.

We propose to create assistant Resident Engineer positions for designated JW candidate engineers and technicians. These candidate engineers/technicians will assist with the QA/QC on earthworks, civils, building, mechanical, electrical, control and instrumentation aspects of the project execution. This will allow these JW candidate engineers to proceed towards their professional registration.

22.6 Stage 6 – Project Close-out

Support to the operations and maintenance staff of the future Lanseria Works during the 12 months Defects Liability Period will be carried out by the professional design team. This will include compiling an Operating and Maintenance Manual as a training guideline. We propose to conduct monthly operations and maintenance review site visits and meetings to achieve this goal.

Skills transfer during this stage will be highly dependent on the individuals earmarked for the different positions applicable to the operation of the works. These individuals should be identified by JW prior to commissioning of the plant.

23 WAY FORWARD

The Preliminary Design that has been undertaken for the Lanseria WwTW has been documented in this report. The Preliminary Design phase overlapped the Feasibility and Investigation phase, during which numerous technical design review workshops were held with JW's Planning, Capital Investment and Operational teams. The outcomes of these two phases and the technical design reviews have been documented in a series of reports, which has culminated in the preparation and submission of this Preliminary Design Report.

Approval of this report is required in order for the Zitholele Consortium to commence with the next stage of the project, viz. Detailed Design. The approval of this report will be facilitated through a presentation of the report to the relevant stakeholders within JW, followed by a clarification meeting to resolve queries for the finalisation of the report.

Appendix A : Scope of Works

Item	Description	Deliverables	Current	Item
12	Filtrate treatment and thickening of dewatering liquors: indicative treatment train being considered by JW being lime addition, flocculation and aeration tanks and thickeners.			
13	Filtrate storage: 8 Mℓ		1	1
14	Wet weather storm management: 8,200 m^3storage dam.		1	1
15	Stormwater channel through site		2	2
15	Ferric Chloride storage and dosing system		1	1
16	Calcium Hyphochlorite storage and dosing system		1	1
17	Biogas to energy: 50m x 50m (2,500m^2 area provided) **NOT PART OF THE BRIEF**		0	1
18	Roads and stormwater reticulation		1	1
19	Access road: approximately 7.5km - Gravel to paved		1	1
20	Odour control facilities at screenings and fermentation areas		1	1
21	Fencing on the site		1	1
22	Sight lighting		1	1
23	Office block, workshop, laboratory, various process controller offices, gatehouse etc.		1	1
24	Potable water supply and reticulation: 5km, 160mm diameter		1	1
25	Effluent reticulation: various pumpstations		1	1
26	Electrical power supply and reticulation: 6MVA connections from Eskom		1	1
27	Environmental monitoringfacilities - groundwater quality, air quality		1	1
28	Moveable assets : front - end loaders, sludge turning machines, tipper turcks and skid-steer loaders.		1	1
29	Obtaining all relevant permits to construct and operate the new Works.		1	1

Item	Description	Deliverables	Current	Ultimate
1	Head of Works comprising 4 screening and grit removal units with associated infrastructure	Raw sewage influent screens	2	4
		Screenings collection and dewatering system	2	2
		Vortex type degritting system	2	4
		Screenings / grit storage area	1	1
		Storm overflow tank and holding dam	1	1
2	Primary Sedimentation: 6 x 35m diameter tanks, 2 per 50mℓ/d module	Primary Sedimentation tanks	2	6
3	In the flow balancing: total tank capacity of 30 000 m³ compartments	Flow / load balancing tank	1	1
4	BNR activated sludge reactors and clarifiers: 3 x 50Mℓ modules with blower house and air header pipelines , each module consisting of a 50mℓ/d reactor suitable for diffused air, each with 3 x 25m diameter clarifiers	Biological reactor	1	3
		Blower installation	2	4
		Clarifiers	3	9
5	Disinfected contact tank and plant wash water pump station	Ferric Chloride storage and dosing system	1	3
		Calcium hypochlorite storage and dosing system	2	4
		Chlorine contact channel	1	3
6	Primary Sludge fermentation and elutriation. Comprising 2 tanks and related pump stations	Primary Sludge fermentation tank	1	2
7	Waste activated sludge (WAS) thickening tanks: 2 tanks and related pump stations	Waste activated sludge thickening tank	1	2
8	Anaerobic Digesters and Gas Holders: 3 x 5, 000 m³ digesters and 2 x 2,500 m³ gas holders.	Mesophillic sludge digester	1	3
		Electrokinetic cell lysis system	1	3
		Biogas holder	1	2
9	Digested sludge holding tank.	Digested sludge holding tank	1	1
10	Sludge dewatering and belt presses: 5 belt presses (4 duty, 1 standby)	Filter belt press installation complete	2	5
		Dewatering sludge filtrate treatment system	1	1
11	Solar sludge drying and composting / curing: 30, 000m² of drying and curing area and storm setting pond	Concrete sludge solar drying bed	1	1

Appendix B : Project Programme

JW13045R : NEW LANSERIA WASTEWATER TREATMENT WORKS
PROJECT SCHEDULE REV 21 02 SEPTEMBER 2016

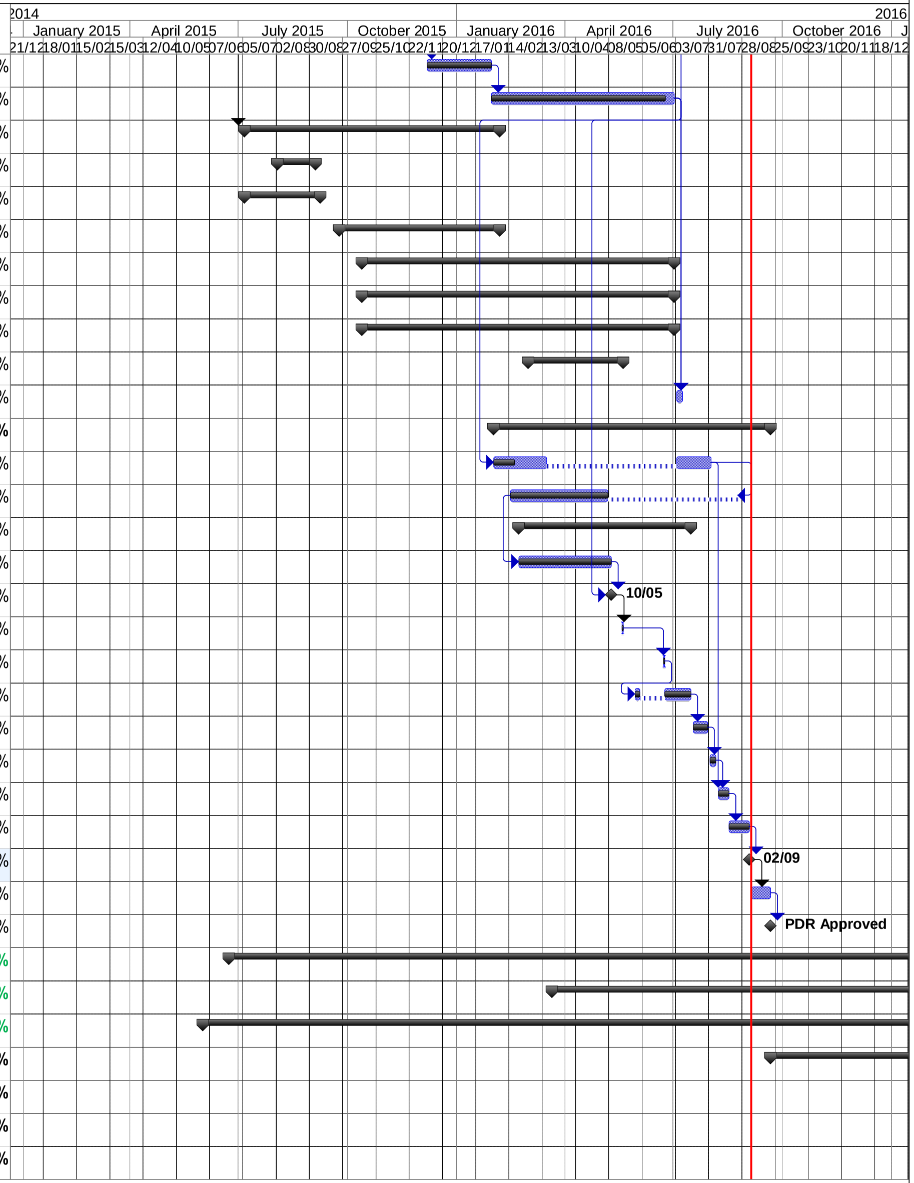
ID	Task Name	Duration	Start	Finish	% Complete
1	**LANSERIA WASTE WATER TREATMENT WORKS**	**1754 days**	**Mon 22/12/14**	**Tue 29/03/22**	**35%**
2	**1. PROJECT INCEPTION**	**115 days**	**Mon 22/12/14**	**Fri 19/06/15**	**100%**
3	Letter of Appointment	0 days	Mon 22/12/14	Mon 22/12/14	100%
4	Project Initiation Meeting	0 days	Fri 30/01/15	Fri 30/01/15	100%
5	Determine availability of existing information and source	7 days	Fri 30/01/15	Mon 09/02/15	100%
6	Inspect Site and Determine Surveys/Investigations Required	5 days	Tue 10/02/15	Mon 16/02/15	100%
7	Determine Conceptual Programme for Implementation	5 days	Fri 30/01/15	Thu 05/02/15	100%
8	Prepare Project Inception Report	11 days	Tue 10/02/15	Tue 24/02/15	100%
9	**PROJECT PUT ON HOLD**	**32 days**	**Wed 25/02/15**	**Thu 09/04/15**	**100%**
10	Completion and Submission of Inception Report	19 days	Fri 10/04/15	Wed 06/05/15	100%
11	Review and Comments	32 days	Thu 07/05/15	Fri 19/06/15	100%
12	Final Approval	0 days	Fri 19/06/15	Fri 19/06/15	100%
13	**2. REPORTING STAGE**	**254 days**	**Mon 22/06/15**	**Fri 08/07/16**	**92%**
14	Basis of design	81 days	Mon 22/06/15	Mon 12/10/15	100%
24	Preliminary process model development and process design (base case)	14 days	Tue 18/08/15	Fri 04/09/15	100%
29	Treatment technology options identification, evaluation and recommendations for selection.	194 days	Mon 07/09/15	Fri 01/07/16	98%
30	Identification and selection of treatment technology options to be investigated	105 days	Mon 07/09/15	Mon 29/02/16	100%
31	Technical evaluation of alternative technologies	5 days	Tue 01/03/16	Mon 07/03/16	100%
32	Financial evaluation of the alternative technologies	3 days	Tue 08/03/16	Thu 10/03/16	100%
33	Life cycle cost	3 days	Fri 11/03/16	Tue 15/03/16	100%
34	Environmental evaluation of alternative technologies with specific reference to energy consumption, greenhouse gas emissions, chemicals usage, waste production etc.	3 days	Wed 16/03/16	Fri 18/03/16	100%
35	Integrated evaluation of alternative treatment technologies	3 days	Mon 21/03/16	Wed 23/03/16	100%
36	Selection of the best and most appropriate treatment technologies	72 days	Thu 24/03/16	Fri 01/07/16	95%
37	Treatment Plant Layout	229 days	Mon 20/07/15	Fri 01/07/16	97%
38	Review and interpretation of the topographic survey and features of the site	3 days	Mon 20/07/15	Wed 22/07/15	100%
39	Review and interpretation of site hydrological data	2 days	Mon 20/07/15	Tue 21/07/15	100%
40	Consultation with the environmental authorisation team	5 days	Mon 20/07/15	Fri 24/07/15	100%
41	Preparation of a number of alternative wastewater treatment plant layouts	20 days	Mon 07/09/15	Fri 02/10/15	100%
42	Evaluation of alternative plant layouts using a multi-criteria methodology	45 days	Mon 05/10/15	Fri 04/12/15	100%

JW13045 ZC13082 Lanseria WWTW

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Critical
Split	External Tasks	Inactive Summary	Manual Summary	Critical Split
Milestone	External MileTask	Manual Task	Start-only	Progress
Summary	Inactive Task	Duration-only	Finish-only	Split

JW13045R : NEW LANSERIA WASTEWATER TREATMENT WORKS
PROJECT SCHEDULE REV 21 02 SEPTEMBER 2016

ID	Task Name	Duration	Start	Finish	% Complete
43	Select the best wastewater treatment works layout	19 days	Mon 07/12/15	Fri 29/01/16	100%
44	Plant layout approved	110 days	Fri 29/01/16	Fri 01/07/16	95%
45	Bulk Services	134 days	Mon 06/07/15	Fri 05/02/16	100%
46	Roads	24 days	Mon 03/08/15	Thu 03/09/15	100%
54	Power Supply	46 days	Mon 06/07/15	Mon 07/09/15	100%
60	Potable Water Supply	76 days	Thu 24/09/15	Fri 05/02/16	100%
65	Value addition aspects	168 days	Tue 13/10/15	Fri 01/07/16	80%
66	Energy	168 days	Tue 13/10/15	Fri 01/07/16	97%
71	Nutrient recovery (Sludge Liquor Treatment)	168 days	Tue 13/10/15	Fri 01/07/16	96%
77	Water reclamation and reuse	58 days	Tue 01/03/16	Thu 19/05/16	0%
86	Prefeasibility report	5 days	Mon 04/07/16	Fri 08/07/16	0%
87	**3. CONCEPT AND VIABILITY (PRELIMINARY DESIGN)**	**167 days**	**Mon 01/02/16**	**Tue 20/09/16**	**72%**
88	Additional surveys, investigations, studies and tests	131 days	Mon 01/02/16	Mon 01/08/16	25%
89	Review data and information	137.5 days	Mon 15/02/16	Wed 24/08/16	100%
90	Prepare Conceptual Designs and Drawings	105 days	Mon 22/02/16	Fri 15/07/16	99%
91	Conceptual design of individual structures	56 days	Mon 22/02/16	Mon 09/05/16	100%
92	Adopt approved Works layout	1 day	Tue 10/05/16	Mon 04/07/16	100%
93	Design Review Workshop 1	1 day	Thu 19/05/16	Thu 19/05/16	100%
94	Design Review Workshop 2	1 day	Thu 23/06/16	Thu 23/06/16	100%
95	Finalise Preliminary Design drawings	20 days	Mon 30/05/16	Fri 15/07/16	100%
96	Prepare Construction Cost Estimates	10 days	Mon 18/07/16	Fri 29/07/16	100%
97	Value Engineering Workshop and Option Selection	5 days	Mon 01/08/16	Fri 05/08/16	100%
98	Update preliminary design to comments and additional investigations	7 days	Mon 08/08/16	Tue 16/08/16	100%
99	Compile Prelim Design Report (PDR)	13 days	Wed 17/08/16	Fri 02/09/16	100%
100	Issue and Present PDR to JW	0 days	Fri 02/09/16	Fri 02/09/16	100%
101	Review and Approval of PDR by JW	12 days	Mon 05/09/16	Tue 20/09/16	0%
102	PDR Approved	0 days	Tue 20/09/16	Tue 20/09/16	0%
103	**4. Environmental Authorisation**	**530 days**	**Tue 23/06/15**	**Thu 24/08/17**	**72%**
182	**5. Water Use License**	**271.9 days**	**Mon 21/03/16**	**Thu 27/04/17**	**34%**
227	**6. New Outfall Sewer**	**971 days**	**Mon 01/06/15**	**Mon 27/05/19**	**2%**
233	**7. DESIGN DEVELOPMENT**	**86 days**	**Wed 21/09/16**	**Fri 10/02/17**	**0%**
246	**8. DOCUMENTATION AND PROCUREMENT**	**105 days**	**Mon 23/01/17**	**Fri 16/06/17**	**0%**
260	**9. CONTRACT ADMINISTRATION AND INSPECTION**	**1127 days**	**Mon 19/06/17**	**Tue 15/02/22**	**0%**
273	**10. CLOSE OUT**	**30 days**	**Wed 16/02/22**	**Tue 29/03/22**	**0%**



JW13045 ZC13082 Lanseria WWTW

Task		Project Summary		Inactive Milestone		Manual Summary Rollup		Critical	
Split		External Tasks		Inactive Summary		Manual Summary		Critical Split	
Milestone		External MileTask		Manual Task		Start-only		Progress	
Summary		Inactive Task		Duration-only		Finish-only		Split	

Appendix C : Drawing Register

LANSERIA WASTE WATER TREATMENT WORKS

DRAWING NUMBER	DRAWING TITLE
SECTION 01 - SITE LAYOUTS	
13082-73-01-001	DRAWING LIST
13082-73-01-101	LOCALITY MAP
13082-73-01-102	LAYOUT OF EXISTING SERVICES
13082-73-01-103	EXISTING SERVICES TO BE RELOCATED
13082-73-01-201	LAYOUT OF PROPOSED NEW STRUCTURES
SECTION 02 - TERRACING	
13082-73-02-101	TERRACING LAYOUT
13082-73-02-201	GROUND PROFILES - SHEET 1 OF 3
13082-73-02-202	GROUND PROFILES - SHEET 2 OF 3
SECTION 03 - RETAINING WALLS	
13082-73-03-101	RETAINING WALLS - GENERAL ARRANGEMENT
13082-73-03-201	RETAINING WALLS - HEAD OF WORKS
13082-73-03-202	RETAINING WALLS - PRIMARY TREATMENT
13082-73-03-203	RETAINING WALLS - FLOW BALANCING
13082-73-03-204	RETAINING WALLS - BIOLOGICAL REACTOR
13082-73-03-205	RETAINING WALLS - SECONDARY TREATMENT
13082-73-03-206	RETAINING WALLS - DISINFECTION
SECTION 04 - ACCESS ROADS AND STORMWATER	
13082-73-04-101	LAYOUT OF ACCESS ROADS AND STORMWATER
13082-73-04-201	ROADS LONGITUDINAL SECTIONS - SHEET 1 OF 3
13082-73-04-202	ROADS LONGITUDINAL SECTIONS - SHEET 2 OF 3
13082-73-04-203	ROADS LONGITUDINAL SECTIONS - SHEET 3 OF 3
13082-73-04-204	STORMWATER LONGITUDINAL SECTIONS AND TYPICAL DETAILS - SHEET 1 OF 2
13082-73-04-205	STORMWATER LONGITUDINAL SECTIONS AND TYPICAL DETAILS - SHEET 2 OF 2
13082-73-04-206	TYPICAL CULVERT DETAILS
SECTION 05 - HEAD OF WORKS	
13082-73-05-101	GENERAL ARRANGEMENT
13082-73-05-201	HEAD OF WORKS - 3D VIEWS - SHEET 1 OF 3
13082-73-05-202	HEAD OF WORKS - 3D VIEWS - SHEET 2 OF 3
13082-73-05-203	HEAD OF WORKS - 3D VIEWS - SHEET 3 OF 3
13082-73-05-211	HEAD OF WORKS - GENERAL ARRANGEMENT
13082-73-05-212	HEAD OF WORKS - MAIN INLET CHANNEL - LAYOUT, SECTIONS AND DETAILS
13082-73-05-213	HEAD OF WORKS - PRIMARY SCREENING CHANNEL - PART A - SHEET 1 OF 2
13082-73-05-214	HEAD OF WORKS - PRIMARY SCREENING CHANNEL - PART A - SHEET 2 OF 2
13082-73-05-215	HEAD OF WORKS - VORTEX DEGRITTERS - LAYOUT AND SECTIONS, SHEET 1 OF 2
13082-73-05-216	HEAD OF WORKS - VORTEX DEGRITTERS - LAYOUT AND SECTIONS, SHEET 1 OF 2
13082-73-05-217	HEAD OF WORKS - PRIMARY SCREENING CHANNEL - PART B - LAYOUT
13082-73-05-218	HEAD OF WORKS - PRIMARY SCREENING CHANNEL - PART B - SECTIONS AND DETAILS
13082-73-05-219	HEAD OF WORKS - FINE SCREENING CHANNEL - PART B - LAYOUT, SECTIONS AND DETAILS
13082-73-05-220	HEAD OF WORKS - LAYOUT OF CONCRETE ROOFS
13082-73-05-301	COMBINED BLOWER AND CONTROL BUILDING - 3D VIEWS
13082-73-05-311	COMBINED BLOWER AND CONTROL BUILDING - LAYOUT
13082-73-05-312	COMBINED BLOWER AND CONTROL BUILDING - ELEVATIONS
13082-73-05-313	COMBINED BLOWER AND CONTROL BUILDING - SECTIONS
13082-73-05-401	3D - EMERGENCY GRIT DRYING BED
13082-73-05-411	EMERGENCY GRIT DRYING BED
13082-73-05-501	PIPEWORK LAYOUT
SECTION 06 - PRIMARY TREATMENT	
13082-73-06-101	GENERAL ARRANGEMENT
13082-73-06-201	3D - FLOW DIVISION STRUCTURE
13082-73-06-211	FLOW DIVISION STRUCTURE
13082-73-06-301	3D - PRIMARY SEDIMENTATION TANK
13082-73-06-311	PRIMARY SEDIMENTATION TANK
13082-73-06-312	PRIMARY SEDIMENTATION TANK
13082-73-06-401	3D - PRIMARY SLUDGE PUMP STATION
13082-73-06-411	PRIMARY SLUDGE PUMP STATION
13082-73-06-412	PRIMARY SLUDGE PUMP STATION
13082-73-06-413	PRIMARY SLUDGE PUMP STATION
13082-73-06-501	PIPEWORK LAYOUT
SECTION 07 - FLOW BALANCING	
13082-73-07-101	GENERAL ARRANGEMENT
13082-73-07-201	3D - FLOW DIVISION STRUCTURE
13082-73-07-211	FLOW DIVISION STRUCTURE
13082-73-07-301	3D - BALANCING TANK
13082-73-07-302	3D - BALANCING TANK
13082-73-07-310	BALANCING TANK
13082-73-07-311	BALANCING TANK
13082-73-07-312	BALANCING TANK
13082-73-07-313	BALANCING TANK
13082-73-07-314	BALANCING TANK
13082-73-07-315	BALANCING TANK
13082-73-07-401	3D - FLOW BALANCING CONTROL BOX
13082-73-07-411	FLOW BALANCING CONTROL BOX
13082-73-07-501	PIPEWORK LAYOUT
SECTION 08 - BIOLOGICAL REACTOR	
13082-73-08-101	GENERAL ARRANGEMENT
13082-73-08-201	3D - FLOW DIVISION STRUCTURE
13082-73-08-211	FLOW DIVISION STRUCTURE
13082-73-08-301	3D - BIOLOGICAL REACTOR
13082-73-08-302	3D - BIOLOGICAL REACTOR
13082-73-08-303	3D - BIOLOGICAL REACTOR
13082-73-08-311	BIOLOGICAL REACTOR
13082-73-08-312	BIOLOGICAL REACTOR
13082-73-08-313	BIOLOGICAL REACTOR
13082-73-08-314	BIOLOGICAL REACTOR
13082-73-08-315	BIOLOGICAL REACTOR
13082-73-08-316	BIOLOGICAL REACTOR
13082-73-08-317	BIOLOGICAL REACTOR
13082-73-08-318	BIOLOGICAL REACTOR
13082-73-08-401	3D - RAS PUMP STATION
13082-73-08-411	RAS PUMP STATION
13082-73-08-501	3D - BLOWER BUILDING AND CONTROL BUILDING
13082-73-08-502	3D - BLOWER BUILDING AND CONTROL BUILDING
13082-73-08-511	BLOWER BUILDING AND CONTROL BUILDING
13082-73-08-512	BLOWER BUILDING AND CONTROL BUILDING
13082-73-08-601	3D VIEWS - FERRIC DOSING INSTALLATION
13082-73-08-611	FERRIC DOSING INSTALLATION - LAYOUT AND SECTIONS
13082-73-08-701	PIPEWORK LAYOUT
SECTION 09 - SECONDARY TREATMENT	
13082-73-09-101	GENERAL ARRANGEMENT
13082-73-09-201	3D - FLOW DIVISION STRUCTURE
13082-73-09-211	FLOW DIVISION STRUCTURE
13082-73-09-301	3D - FINAL CLARIFIER
13082-73-09-311	FINAL CLARIFIER
13082-73-09-312	FINAL CLARIFIER
13082-73-09-501	3D - WAS PUMP STATION
13082-73-09-502	3D - WAS PUMP STATION
13082-73-09-511	WAS PUMP STATION
13082-73-09-512	WAS PUMP STATION
13082-73-09-513	WAS PUMP STATION
13082-73-09-601	PIPEWORK LAYOUT
SECTION 10 - DISINFECTION AND FINAL EFFLUENT	
13082-73-10-101	GENERAL ARRANGEMENT
13082-73-10-201	3D - WASH WATER PUMP STATION
13082-73-10-202	3D - WASH WATER PUMP STATION
13082-73-10-211	WASH WATER PUMP STATION
13082-73-10-212	WASH WATER PUMP STATION
13082-73-10-301	3D - DISINFECTION CONTACT CHANNELS
13082-73-10-311	DISINFECTION CONTACT CHANNELS
13082-73-10-312	DISINFECTION CONTACT CHANNELS
13082-73-10-411	FINAL EFFLUENT OUTLET BOX
13082-73-10-501	3D - CHLORINE DOSING INSTALLATION
13082-73-10-511	CHLORINE DOSING INSTALLATION
13082-73-10-601	PIPEWORK LAYOUT

SECTION 11 - STORM FLOW DAM	
13082-73-11-101	GENERAL ARRANGEMENT
13082-73-11-102	SETTING OUT DETAILS
13082-73-11-103	CONCRETE LINING LAYOUT
13082-73-11-104	SUB-SOIL AND LEACHATE COLLECTION LAYOUT
13082-73-11-211	INLET STRUCTURE
13082-73-11-311	DAM SUB-SOIL DRAINAGE DETAILS
13082-73-11-312	DAM TYPICAL DETAILS
13082-73-11-313	TYPICAL GUARD RAIL DETAILS
13082-73-11-411	ACCESS RAMP
13082-73-11-511	EMERGENCY OVERFLOW STRUCTURE
13082-73-11-611	DRAW-OFF STRUCTURE
13082-73-11-701	3D - STORM FLOW DAM RETURN PUMP STATION
13082-73-11-702	3D - STORM FLOW DAM RETURN PUMP STATION
13082-73-11-711	STORM FLOW DAM RETURN PUMP STATION
13082-73-11-712	STORM FLOW DAM RETURN PUMP STATION
13082-73-11-801	PIPEWORK LAYOUT
SECTION 12 - FERMENTER AREA	
13082-73-12-101	GENERAL ARRANGEMENT
13082-73-12-201	3D - FLOW DIVISION STRUCTURE
13082-73-12-211	FLOW DIVISION STRUCTURE
13082-73-12-301	3D - FERMENTER TANK
13082-73-12-311	FERMENTER TANK
13082-73-12-312	FERMENTER TANK
13082-73-12-401	3D - FERMENTED SLUDGE PUMP STATION
13082-73-12-411	FERMENTED SLUDGE PUMP STATION
13082-73-12-412	FERMENTED SLUDGE PUMP STATION
13082-73-12-413	FERMENTED SLUDGE PUMP STATION
13082-73-12-501	PIPEWORK LAYOUT
SECTION 13 - SLUDGE HANDLING	
13082-73-13-101	LAYOUT AND SETTING OUT DETAILS
13082-73-13-102	LAYOUT AND SETTING OUT DETAILS
13082-73-13-201	ANAEROBIC DIGESTER CLUSTER
13082-73-13-202	ANAEROBIC DIGESTER CLUSTER
13082-73-13-203	ANAEROBIC DIGESTER CLUSTER
13082-73-13-204	ANAEROBIC DIGESTER CLUSTER
13082-73-13-205	ANAEROBIC DIGESTER CLUSTER
13082-73-13-301	ANAEROBIC DIGESTER DISTIBUTION BOX
13082-73-13-302	ANAEROBIC DIGESTER DISTIBUTION BOX
13082-73-13-303	ANAEROBIC DIGESTER DISTIBUTION BOX
13082-73-13-304	ANAEROBIC DIGESTER DISTIBUTION BOX
13082-73-13-401	ANAEROBIC DIGESTER
13082-73-13-402	ANAEROBIC DIGESTER
13082-73-13-403	ANAEROBIC DIGESTER
13082-73-13-501	BIOGAS HOLDER
13082-73-13-502	BIOGAS HOLDER
13082-73-13-601	BOILER HOUSE
13082-73-13-602	BOILER HOUSE
13082-73-13-603	BOILER HOUSE
13082-73-13-604	BOILER HOUSE
13082-73-13-605	BOILER HOUSE
13082-73-13-701	HEAT EXCHANGER
13082-73-13-801	WAS GRAVITY THICKENER CLUSTER
13082-73-13-802	WAS GRAVITY THICKENER CLUSTER
13082-73-13-803	WAS GRAVITY THICKENER CLUSTER
13082-73-13-901	WAS GRAVITY THICKENER DISTRIBUTION BOX
13082-73-13-902	WAS GRAVITY THICKENER DISTRIBUTION BOX
13082-73-13-1001	WAS GRAVITY THICKENER
13082-73-13-1002	WAS GRAVITY THICKENER
13082-73-13-1003	WAS GRAVITY THICKENER
13082-73-13-1101	GBT & FBP BUILDING
13082-73-13-1102	GBT & FBP BUILDING
13082-73-13-1103	GBT & FBP BUILDING
13082-73-13-1104	GBT & FBP BUILDING
13082-73-13-1105	GBT & FBP BUILDING
13082-73-13-1106	GBT & FBP BUILDING
13082-73-13-1107	GBT & FBP BUILDING
13082-73-13-1108	GBT & FBP BUILDING
13082-73-13-1109	GBT & FBP BUILDING
13082-73-13-1110	GBT & FBP BUILDING
13082-73-13-1111	GBT & FBP BUILDING
13082-73-13-1112	GBT & FBP BUILDING
13082-73-13-1113	GBT & FBP BUILDING
13082-73-13-1114	GBT & FBP BUILDING
13082-73-13-1115	GBT & FBP BUILDING
13082-73-13-1116	GBT & FBP BUILDING
13082-73-13-1117	GBT & FBP BUILDING
13082-73-13-1118	GBT & FBP BUILDING
13082-73-13-1119	GBT & FBP BUILDING
13082-73-13-1120	GBT & FBP BUILDING
13082-73-13-1121	GBT & FBP BUILDING
13082-73-13-1122	GBT & FBP BUILDING
13082-73-13-1123	GBT & FBP BUILDING
13082-73-13-1201	WAS MANHOLE CLUSTER
13082-73-13-1202	WAS MANHOLE CLUSTER
13082-73-13-1301	LIME MAKE-UP CLUSTER
13082-73-13-1302	LIME MAKE-UP CLUSTER
13082-73-13-1303	LIME MAKE-UP CLUSTER
13082-73-13-1304	LIME MAKE-UP CLUSTER
13082-73-13-1305	LIME MAKE-UP CLUSTER
13082-73-13-1401	LIME REACTION TANK
13082-73-13-1402	LIME REACTION TANK
13082-73-13-1403	LIME REACTION TANK
13082-73-13-1404	LIME REACTION TANK
13082-73-13-1501	LIME CLARIFIER
13082-73-13-1502	LIME CLARIFIER
13082-73-13-1503	LIME CLARIFIER
13082-73-13-1601	SOLAR SLUDGE DRYER HOUSE
13082-73-13-1602	SOLAR SLUDGE DRYER HOUSE
13082-73-13-1603	SOLAR SLUDGE DRYER HOUSE
13082-73-13-1701	SCUM, SLUDGE AND FILTRATE RETURN PUMP STATION
13082-73-13-1702	SCUM, SLUDGE AND FILTRATE RETURN PUMP STATION
13082-73-13-1703	SCUM, SLUDGE AND FILTRATE RETURN PUMP STATION
13082-73-13-1704	SCUM, SLUDGE AND FILTRATE RETURN PUMP STATION
13082-73-13-1705	SCUM, SLUDGE AND FILTRATE RETURN PUMP STATION
13082-73-13-1706	SCUM, SLUDGE AND FILTRATE RETURN PUMP STATION
13082-73-13-1801	STOCKPILING AREA
13082-73-13-1802	STOCKPILING AREA
13082-73-13-1803	STOCKPILING AREA
13082-73-13-1804	STOCKPILING AREA
13082-73-13-1805	STOCKPILING AREA
13082-73-13-1901	OUTLOADING STATION
13082-73-13-1902	OUTLOADING STATION
13082-73-13-1903	OUTLOADING STATION
13082-73-13-1904	OUTLOADING STATION
13082-73-13-1905	OUTLOADING STATION
13082-73-13-2001	GRIT DRYING BEDS
13082-73-13-2002	GRIT DRYING BEDS
13082-73-13-2201	Lime Pump Station
13082-73-13-2202	Lime Pump Station
13082-73-13-2203	Lime Pump Station
13082-73-13-2301	Conveyor from GBT Building to Outloading station
13082-73-13-2302	Conveyor from GBT Building to Outloading station

SECTION 14 - ANCILLARY WORKS	
13082-73-14-101	BOUNDARY FENCE LAYOUT
13082-73-14-102	PALISADE FENCE DETAILS
13082-73-14-103	STANDARD HANDRAIL DETAILS
13082-73-14-201	WATER NETWORK - WASH WATER NETWORK
13082-73-14-202	WATER NETWORK - SMALL SERVICES
13082-73-14-203	WATER NETWORK - SMALL SERVICES
13082-73-14-204	WATER NETWORK - SMALL SERVICES
13082-73-14-301	GENERAL ARRANGEMENT: NORTHERN WORKS RESERVOIR TO LANSERIA WWTW
13082-73-14-302	LONGITUDINAL SECTIONS
SECTION 15 - ARCHITECTURAL	
13082-73-15-501	NEW ADMINISTRATION BUILDING
13082-73-15-502	NEW ADMINISTRATION BUILDING
13082-73-15-503	GUARD HOUSE
13082-73-15-504	3D VIEWS OF WORKSHOP AND STORAGE BUILDING
13082-73-15-505	WORKSHOP AND STORAGE BUILDING
13082-73-15-506	WORKSHOP AND STORAGE BUILDING
13082-73-15-507	3D VIEWS OF MONITORING BUILDING
13082-73-15-508	MONITORING BUILDING
13082-73-15-509	MONITORING BUILDING
13082-73-15-510	3D VIEWS OF ABLUTION FACILITY
13082-73-15-511	ABLUTION FACILITY
13082-73-15-512	ABLUTION FACILITY
SECTION 16 - HYDRAULIC PROFILES	
13082-73-16-101	HEAD OF WORKS
13082-73-16-102	PRIMARY TREATMENT
13082-73-16-103	FLOW BALANCING
13082-73-16-104	BIOLOGICAL REACTOR
13082-73-16-105	SECONDARY TREATMENT
13082-73-16-106	DISINFECTION AND FINAL EFFLUENT
SECTION 17 - OVERALL FLOW DIAGRAMS	
13082-72-4-PFD-22	LIQUID STREAM
13082-72-4-PFD-23	SLUDGE STREAM

DEPARTMENT	APPROVED	DESIGNATION	DATE

NOT FOR CONSTRUCTION

CONSULTING ENGINEERS

ZITHOLELE CONSORTIUM
P.O. BOX 6002
HALFWAY HOUSE
1685

TEL: (011) 207 2060
FAX: (086) 674 6121
EMAIL: mail@zitholele.co.za

SURVEYED	WIMBERLEY
DESIGNED	JHS
DRAWN	BVV
CHECKED	SP
SERVICES CHECKED	JHS
GEOTECHNICAL INVESTIGATION	HH
SERVITUDES	CK
APPROVED	
Pr. Eng. No.	
DATE	

JOHANNESBURG WATER (SOC) LTD

Johannesburg Water

17 HARRISON STREET
MARSHALLTOWN
2107

TEL: (011) 688-1400
FAX: (011) 688-1529

CITY OF JOHANNESBURG

LANSERIA WASTEWATER TREATMENT WORKS

DRAWING LIST

CIVIL

DESIGN MANAGER	SCALE	AMENDMENTS		APPROVED	DATE
		P10	ISSUED WITH FOR	JHS	02.09.2016
DATE	N.T.S.				

DRAWING No.
JW NUMBER: JW13045R
CONSULTANT'S NUMBER: 13082-73-01-001
FILE No: BWW1000
P 1 0

Z:\Projects\13082 – Lanseria WWTW\7 Drawings\73 Civil\00 Drawing List and PDF's\13082-73-01-001-P01 – DRAWING LIST.dwg Sep 05, 2016 – 10:11am

Appendix D : Risk Register

Contract Name :	New Waste Water Treatment Works at Lanseria	
Project / Contract No.	BWW1000 / JW13045R	
ZC Project Reference	13208-16-Risk-001 Risk Register	
Rev	10	18-Aug-16

SEVERITY : *The severity of the implication if it is realised*

PROBABILITY : *The probability of the implication being realised*

RISK NO	DATE	IDENTIFIED RISK	IMPLICATION	MITIGATION MEASURE	STATUS	DATE RESOLVED	COMMENTS	SEVERITY	PROBABILITY
005	Dec-13	Impact of project program on budget availability; funding required over a longer period.	Not having adequate budget to complete Module 1 construction	Ensure that budget funding is available over full duration of project, estimated currently to be into financial year 2021/2022.	Active		Budget to be confirmed every financial year up to and including commissioning stage	High	Medium
006	Dec-13	The legal ownership of the proposed site is not proven.	Environmental Authorisation cannot commence prior to authority given by landowner and construction cannot commence prior to land procurement and transfer	Ensure that JW's ownership and/or use of the site is proven and documented.	Resolved	Jun-14	Done. Legitimate use by JW now proven.	Medium	Medium
007	Dec-13	Getting an engineering consultant who is not sufficiently or appropriately experienced.	Inadequate design or design is not in accordance with JW operational philosophy	Using an appropriate tendering procedure. Obtaining independent legal advice on such procedure and tender document.	Resolved	Dec-14	Project design advertised on open tender and evaluation based on price and functionality	Medium	Medium
008	Dec-13	Cannot use name 'Lanseria' for the new wastewater treatment works, as a 'Lanseria' wastewater treatment works currently exists at Lanseria Airport.	Confusion by stakeholders on duplicate naming	Rename the WwTW to avoid confusion with others in close proximity	Resolved	Jun-14	Management to decide. "Lanseria" has been adopted as the name.	Low	Low
009	Dec-13	Objections raised by Lanseria Airport authorities to risks associated with birds attracted to the new wastewater treatment works.	Birds flying over the runway at Lanseria Airport pose a high safety risk to flights taking off and landing at the airport	To be addressed during Environmental Impact Assessment. Project team of opinion that the 1500 metres horizontal distance from boundary of new Works and boundary of Lanseria Airport, is sufficient to significantly mitigate the risk.	Resolved		Environmental specialist (Avi faunal) has been appointed, and to advise on flight patterns of bird species and proximity to airport. The Avifauna final report outcome is that the preferred site will have less impact that the alternative site has on the flight paths from Lanseria Airport.	Medium	Low
010	Jan-15	Late appointment of Environmental Assessment Practitioner	Environmental Authorisation not issued prior to construction	EAP to be appointed as soon as possible	Resolved	Sep-15	Appointment of EAP is imminent. EAP to be appointed as sub-consultant to ZC	High	High
011	Jan-15	Stringent discharge standards imposed by the Department of Water and Sanitation	Design must cater for higher discharge standard which will increase capital and operating costs	Arrange meeting with authorities to discuss possible site specific discharge standard	Active		Meeting to be held on 18 September 2015. Report to DWS by 30.10.15. JW has submitted report to DWS. RM and RV have met with DWS and have submitted an updated report (March 2016) - await further comment from DWS. NR to arrange a meeting with the case officer for the WULA to discuss teh discharge standards.	Medium	High
012	Jan-15	Land ownership of a portion of the site could be owned by City of Tshwane	Environmental Authorisation and construction cannot commence until permission has been sought from the relevant land owner	Confirm land ownership and procure if necessary	Resolved	Jul-15	Land was confirmed as being owned by City of Johannesburg	Medium	Medium

Contract Name :	New Waste Water Treatment Works at Lanseria		
Project / Contract No.	BWW1000 / JW13045R		
ZC Project Reference	13208-16-Risk-001 Risk Register		
Rev	10	18-Aug-16	

SEVERITY : *The severity of the implication if it is realised* *PROBABILITY :* *The probability of the implication being realised*

RISK NO	DATE	IDENTIFIED RISK	IMPLICATION	MITIGATION MEASURE	STATUS	DATE RESOLVED	COMMENTS	SEVERITY	PROBABILITY
013	Jan-15	Delayed implementation of the outfall sewer draining to Lanseria WwTW	Delayed or postponed commissioning of Lanseria WwTW	Engage with the relevant authorities and design engineers for the planning and implementation of the proposed outfall sewer	Active		Meeting with outfall sewer design team held. Still uncertainty regarding the timeframe for implementation. JW Planning to takeover implementation. JW has included this in their 2016/17 financial year. A consultant has been identified but will be appointed in July 2016. JW have confirmed that UWP have been appointed (March 2016). UWP has made contact with ZC - await meeting with UWP. Meeting held with UWP. Awaiting appointment of an Environmental Assessment Practitioner to commence with the EIA	High	Low
014	Aug-15	Portion of proposed access road within land owned by City of Tshwane	CoT to be consulted on road design and approval sought from them prior to construction	Confirm land ownership. If confirmed CoT property, engage with CoT for road design guidelines and takeover for maintenance post construction	Resolved		Liaise with appropriate authority for design guidelines and maintenance post construction. Also check feasibility of keeping to CoJ property. Preferred route to be "ground truthed". Motivation letter to be sent to RD. Surveyor appointed and survey completed (March 2016). ZC setting out new road reserve. The proposed road has been kept to within the CoJ boundary.	Medium	Medium
015	Sep-15	Dual electrical supply from different electrical networks are not available	No electrical back-up is available from another network and power failures may result in plant downtime	Provide dual supply now from same network and change one over to different network when available	Active		Liaise with Eskom. Two sources have been applied for to supply 100% power each. Two sources of supply will be provided, although from the same network. ZC to implement emergency power according to JW Design Guidance. Await confirmation from Eskom	Medium	Medium

Joburg a world class African city / Johannesburg Water	Contract Name :	New Waste Water Treatment Works at Lanseria	ZITHOLELE CONSORTIUM
	Project / Contract No.	BWW1000 / JW13045R	
	ZC Project Reference	13208-16-Risk-001 Risk Register	
	Rev	10	18-Aug-16

SEVERITY : *The severity of the implication if it is realised* *PROBABILITY :* *The probability of the implication being realised*

RISK NO	DATE	IDENTIFIED RISK	IMPLICATION	MITIGATION MEASURE	STATUS	DATE RESOLVED	COMMENTS	SEVERITY	PROBABILITY
016	Mar-16	Site alternatives for EIA. During the planning phase of the project, site alternatives were not considered, as there were no suitable sites that could be identified within the CoJ's boundaries. Nemai, after discussion with GDARD and the I&AP's, has advised that GDARD has requested that a site alternative be considered, so as not to compromise the EIA process.	The project may not get an Environmental Authorisation if an I&AP lodges an appeal via the EA process. The completion of the EIA will be delayed by approximately 2 months, so that specialist studies can be undertaken on the alternative site.	W2, s site identified in 1998 via a feasibility study commissioned by JW, will be used as the alternative site. All relevant studies to be done on this site.	Resolved	Mar-16	Nemai have been given the go-ahead to source quotes for specialist studies to be done on site W2 in order to inform the EIA. W2 has been confirmed as the alternative site, and will be assessed as part of the Environmental Assessment process.	High	High
017	Apr-16	Property Impact Assessment	A PIA will not be submitted as part of the EA application. A site alternative has been identified (W2), and the PIA would then have to be done on both sites. DEA has difficulty in comparing PIA's over 2 sites.	The exclusion of the PIA to be captured in the Scoping Report. DEA would then advise if it is still required.	Active		Exclusion of the PIA to be captured in the Scoping Report. This will be deferred to a later stage.	High	Medium
018	May-16	Lindley WWTW - Alternative Site	The site alternative that is being considered as part of the Lindley authorization process, is that same as the one that is being considered as part of the Lanseria project (i.e. W2). This could be problematic should the Lindley EA application be lodged before the Lanseria EA application.	The landowner of W2 is to be consulted immediately, and the PP documentation is to be updated to reflect W2 as the site alternative	Resolved	Aug-16	Consult landowner and update PP documentation. EIA has not yet commenced on the Lindley site.	High	Medium
019	08-Jun-16	WULA-Engineers expect to commence construction in early 2017.	The WULA process takes approximately 300 days. Construction can only commence after the WUL is received. The Final EIR is only planned for submission in March 2017. Any construction taking place prior to the Water use License and Environmental Authorisation being granted will be in non-compliance with legislation. Should the WULA be submitted by 30 November, the anticipated date of receipt of the WULA and EA would be at the end of September 2017.	The overall project programme must take cognisance of the required licensing and authorisation periods.	Active			High	High

Contract Name :	New Waste Water Treatment Works at Lanseria		
Project / Contract No.	BWW1000 / JW13045R		
ZC Project Reference	13208-16-Risk-001 Risk Register		
Rev	10	18-Aug-16	

SEVERITY : *The severity of the implication if it is realised* *PROBABILITY :* *The probability of the implication being realised*

RISK NO	DATE	IDENTIFIED RISK	IMPLICATION	MITIGATION MEASURE	STATUS	DATE RESOLVED	COMMENTS	SEVERITY	PROBABILITY
020	08-Jun-16	WULA submission with DEIR for public review	Possible delay in WUL being issued.	During the pre-application meeting, the DWS confirmed that the WULA does not have to go out for Public review and it is not necessary to be appended to the DEIR. Separate project schedules for the EIA and WULA should be implemented so as to avoid delays in the process.	Resolved	Jul-16	Joyce to confirm that this will be communicated to Nemai.	Medium	High
021	08-Jun-16	WULA-Impact methodology in specialist reports are different for EIA and WULA. Zitholele has requested that the WULA specialists utilise Nemai's impact rating methodology. Nemai has indicated that this is not permitted.	Nemai has undertaken most of the specialist studies during the EIA process. Specialists appointed by Nemai used Nemai's impact ratings methodology to compile their reports. This differs from Zitholele's methodology. Therefore, translating the information over to Zitholele methodology may result in inaccuracy of the data.	It will be best to use Nemai's methodology for the 2 specialists appointed for the WULA so that the ratings within the EIA align with that of the WULA report. However, if Nemai refuse to allow this, the specialist ratings will need to be transferred to Zitholele methodology and this will require that the specialist sign off.	Resolved	Jul-16	Joyce to confirm that this will be communicated to Nemai.	Medium	Medium
022	23-Jun-16	Main Access Road - impact of alignment on Northern Farm	Proposed alignment of Main Access Road may interfere with the operations of Northern Farm, and may affect some of the existing services on the farm.	Consult with the manager / operator of Northern Farm to ensure that the operations of the farm are not negatively affected by the proposed alignment of the main access road.	Active		ZC met with Johan de Jager (JW) to discuss concerns. Further discussions to ensure that all concerns are addressed / mitigated CoT prefers the route that does not impact on the farms and this will most likely be chosen.	Low	Medium
022	23-Jun-16	Main Access Road - impact of alignment on Northern Farm	Proposed alignment of Main Access Road may interfere with the operations of Northern Farm, and may affect some of the existing services on the farm.	Consult with the manager / operator of Northern Farm to ensure that the operations of the farm are not negatively affected by the proposed alignment of the main access road.	Active		ZC met with Johan de Jager (JW) to discuss concerns. Further discussions to ensure that all concerns are addressed / mitigated.	Low	Low
023	18-Aug-16	Second review required on EIA	Delay to issue of EA and resultant delay in start of construction	Request for possible ommission of the second review or an extended review period	Active		Nemai to advise on the requirement for this and the impact on the programme.	High	High

Appendix E : Detailed Cost Estimate

LANSERIA WASTE WATER TREATMENT PLANT

SUMMARY OF BILL OF QUANTITIES

	DESCRIPTION	AMOUNT R
1	BULK EARTHWORKS	131,186,256.00
2	RETAINING WALLS	27,423,046.00
3	ACCESS ROADS AND STORMWATER	30,617,970.00
4	HEAD OF WORKS	15,119,981.00
5	PRIMARY TREATMENT	18,562,620.00
6	FLOW BALANCING	20,201,076.00
7	BIOLOGICAL REACTOR	53,676,600.00
8	SECONDARY TREATMENT	21,718,110.00
9	DISINFECTION & FINAL EFFLUENT	13,813,643.00
10	EMERGENCY OVERFLOW DAM	15,000,000.00
11	FERMENTER AREA	9,104,407.00
12	ANCILLARY WORKS	5,605,130.00
13	BULK SERVICES	48,940,246.25
14	BUILDINGS	21,053,000.00
15	INTERCONNECTING PIPEWORK	61,932,568.60
16	MOBILE CRUSHING PLANT	15,000,000.00
SUB-TOTAL A (CIVIL COST)		**508,954,653.85**
ELECTRICAL AND C & I		**106,500,000.00**
MECHANICAL		**155,152,000.00**
SUB-TOTAL B		**770,606,653.85**
PRELIMINARY AND GENERAL		**199,638,000.00**
SUB-TOTAL C		**970,244,653.85**
ALLOW 10% FOR CONTINGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER		**97,024,465.39**
SUB-TOTAL D		**1,067,269,119.24**
ADD 14% VAT		**149,417,676.69**
FINAL ESTIMATED GRAND TOTAL		**1,216,686,795.93**

Project Cost Summary

Section	Total
1. Bulk Earthworks	R131,186,256.00
2. Retaining Walls	R27,423,046.00
3. Access Roads and Stormwater	R30,617,970.00
4. Head of Works	R15,119,981.00
5. Primary Treatment	R18,562,620.00
6. Flow Balancing	R20,201,076.00
7. Biological Reactor	R53,676,600.00
8. Secondary Treatment	R21,718,110.00
9. Disinfection & Final Effluent	R13,813,643.00
10. Emergency Overflow Dam	R15,000,000.00
11. Fermenter Area	R9,104,407.00
12. Ancillary Works	R5,605,130.00
13. Bulk Services	R48,940,246.25
14. Buildings	R21,053,000.00
15. Interconnecting Pipework	R61,932,568.60
16. Mobile Crushing Plant	R15,000,000.00
Total Civils Liquid (excl. VAT)	**R508,955,000.00**
Total Civils Sludge (excl. VAT)	**R227,580,000.00**
Electrical and C & I	**R106,500,000.00**
Mechanical (Liquid)	**R79,653,000.00**
Mechanical (Sludge)	**R75,499,000.00**
Preliminary & General	**R199,638,000.00**
Total (excl. VAT)	**R1,197,825,000.00**

ML

Master Rates

Concrete (per m^3)	R2,200.00
Formwork (per m^2)	R650.00
Reinforcement (per ton)	R13,600.00
Bulk Excavation (per m^3)	
Soft	R120.00
Intermediate	R250.00
Hard	R850.00
Restricted Excavation (per m^3)	
Soft	R180.00
Intermediate	R375.00
Hard	R1,020.00
Allowance for Mass Concrete	5%
Contingency by the Engineer	0%
Buildings Engineering (R/m²)	R6,500.00
Building Architectural (R/m²)	R10,000.00
Restricted Excavation	**100%**
Soft	20%
Intermediate	20%
Hard	60%
Bulk Excavation	**100%**
Soft	20%
Intermediate	20%
Hard	60%
Bulk Excavation & dispose (per m^3)	R120.00
Dispose	10%
Reuse	90%
Import G7 fill material	R175.00
80 mm Interlocking Paving Blocks (per m²)	R200.00
60 mm Interlocking Paving Blocks (per m²)	R150.00
150 mm C4 (per m³)	R250.00
150 mm rip and recompact (per m³)	R120.00
Precast kerbing units (per m)	R250.00
Manholes (per 1 no. off)	R6,500.00
Kerb Inlets (per 1 no. off)	R8,000.00
Grid Inlets (per m)	R2,000.00
Culverts (per 1 no. off)	R6,500.00
Emergency Dam (R/m³)	R750.00
P & G (%)	20%

Concrete Factors

RETAINING WALLS	1.00
ACCESS ROADS AND STORMWATER	1.00
HEAD OF WORKS	1.50
PRIMARY TREATMENT	1.30
FLOW BALANCING	1.13
BIOLOGICAL REACTOR	1.25
SECONDARY TREATMENT	1.30
DISINFECTION & FINAL EFFLUENT	1.20
STORM FLOW DAM	1.00
FERMENTER AREA	1.30
ANCILLARY WORKS	1.37
INTERCONNECTING PIPEWORK	1.37

Pipelines

	Description	Rate (R/m)
	Concrete Pipelines	
	Class 100D Diameter 500 Concrete Pipe	R1,100.00
	Class 100D Diameter 750 Concrete Pipe	R1,600.00
	Class 100D Diameter 900 Concrete Pipe	R2,100.00
	Class 100D Diameter 1000 Concrete Pipe	R3,000.00
	Class 100D Diameter 1200 Concrete Pipe	R4,000.00
	Class 100D Diameter 1500 Concrete Pipe	R5,750.00
100%	Class 100D Diameter 1800 Concrete Pipe	R8,000.00
	HDPE Pipelines	
	PN12.5 Diameter 160 HDPE Pipe	R450.00
	PN12.5 Diameter 500 HDPE Pipe	R1,500.00
	Stainless Steel Pipes	
	SS304 Diamter 200 Pipe	R1,200.00
	SS304 Diamter 500 Pipe	R6,000.00
	SS304 Diamter 900 Pipe	R10,000.00
	SS304 Diamter 1000 Pipe	R12,000.00
	uPVC Pipes	
	Diameter 200 Class 12	R300.00
	Weholite Pipes	
	Diameter 450	R1,288.00
	Diameter 1500	R10,640.00
	Diameter 1800	R15,528.00

BULK EARTHWORKS

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Bulk Earthworks					**R 110,746,256.00**
	Head of Works	3772	m^3		**R 2,202,848.00**
	Soft excavation	754	m^3	R 120.00	R 90,528.00
	Intermediate excavation	754	m^3	R 250.00	R 188,600.00
	Hard excavation	2263	m^3	R 850.00	R 1,923,720.00
	Dispose	0	m^3	R 120.00	R -
	Import fill G7 fill material from commercial sources	0	m^3	R 175.00	R -
	Primary Treatment	1083	m^3		**R 632,472.00**
	Soft excavation	217	m^3	R 120.00	R 25,992.00
	Intermediate excavation	217	m^3	R 250.00	R 54,150.00
	Hard excavation	650	m^3	R 850.00	R 552,330.00
	Dispose	0	m^3	R 120.00	R -
	Import fill G7 fill material from commercial sources	0	m^3	R 175.00	R -
	Balancing Tank	30124	m^3		**R 17,592,416.00**
	Soft excavation	6025	m^3	R 120.00	R 722,976.00
	Intermediate excavation	6025	m^3	R 250.00	R 1,506,200.00
	Hard excavation	18074	m^3	R 850.00	R 15,363,240.00
	Dispose	0	m^3	R 120.00	R -
	Import fill G7 fill material from commercial sources	0	m^3	R 175.00	R -
	Biological Reactor	82311	m^3		**R 48,069,624.00**
	Soft excavation	16462	m^3	R 120.00	R 1,975,464.00
	Intermediate excavation	16462	m^3	R 250.00	R 4,115,550.00
	Hard excavation	49387	m^3	R 850.00	R 41,978,610.00
	Dispose	0	m^3	R 120.00	R -
	Import fill G7 fill material from commercial sources	0	m^3	R 175.00	R -
	Secondary Treatment	59549	m^3		**R 34,776,616.00**
	Soft excavation	11910	m^3	R 120.00	R 1,429,176.00
	Intermediate excavation	11910	m^3	R 250.00	R 2,977,450.00
	Hard excavation	35729	m^3	R 850.00	R 30,369,990.00
	Dispose	0	m^3	R 120.00	R -
	Import fill G7 fill material from commercial sources	0	m^3	R 175.00	R -
	Disinfection Facility	12795	m^3		**R 7,472,280.00**
	Soft excavation	2559	m^3	R 120.00	R 307,080.00
	Intermediate excavation	2559	m^3	R 250.00	R 639,750.00
	Hard excavation	7677	m^3	R 850.00	R 6,525,450.00
	Dispose	0	m^3	R 120.00	R -
	Import fill G7 fill material from commercial sources	0	m^3	R 175.00	R -
	Terrace Layerworks				R 20,440,000.00
Layerworks	80 mm Interlocking Paving Blocks	80,000	m^2	R 200.00	R 16,000,000.00
	150 mm C4	12,000	m^3	R 250.00	R 3,000,000.00
	150 mm Rip and Recompact	12,000	m^3	R 120.00	R 1,440,000.00
SUB-TOTAL A					R 131,186,256.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 131,186,256.00
ADD 14% VAT					R 18,366,075.84
FINAL TOTAL FOR STRUCTURE					**R 149,552,331.84**

RETAINING WALLS

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**3928**	**m^3**	**R 2,200.00**	**R 8,641,600.00**
	Walls and Floors	3928	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**196.4**	**m^3**	**R 2,200.00**	**R 432,080.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**471.36**	**Ton**	**R 13,600.00**	**R 6,410,496.00**
Formwork	**Total Formwork**	**13985**	**m^2**	**R 650.00**	**R 9,090,250.00**
	Vertical	**13985**	**m^2**	**R 650.00**	**R 9,090,250.00**
	Walls	12865	m^2		
	Footings	1120	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
	Horizontal	**0**	**m^2**	**R 650.00**	**R -**
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**3940**	**m^3**		**R 2,848,620.00**
	Soft	788	m^3	R 180.00	R 141,840.00
	Intermediate	788	m^3	R 375.00	R 295,500.00
	Hard	2364	m^3	R 1,020.00	R 2,411,280.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 27,423,046.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 27,423,046.00
ADD 14% VAT					R 3,839,226.44
FINAL TOTAL FOR STRUCTURE					**R 31,262,272.44**

INTERNAL ACCESS ROADS AND STORMWATER

				Calculated By:	NG
				Checked By:	NR
Item	**Description**	**Total Quantity Regular**	**Unit**	**Rate**	**Amount**
ACCESS ROADS					**R 17,247,920.00**
Excavation	Soft	9,168	m^3	R 180.00	R 1,650,240.00
	Intermediate	4,584	m^3	R 375.00	R 1,719,000.00
	Hard	4,584	m^3	R 1,020.00	R 4,675,680.00
Fill Material	Fill	1,000	m^3	R 175.00	R 175,000.00
Layerworks	80 mm Interlocking Paving Blocks	20,000	m^2	R 200.00	R 4,000,000.00
	60 mm Interlocking Paving Blocks	4,500	m^3	R 150.00	R 675,000.00
	150 mm C4	3,600	m^3	R 250.00	R 900,000.00
	150 mm G7	4,000	m^3	R 175.00	R 700,000.00
	150 mm R&R	4,400	m^3	R 120.00	R 528,000.00
Kerbing	Precast kerbing units	7,500	m	R 250.00	R 1,875,000.00
Road Markings and Signage	Yellow/white lines, painted signs, sign boards	1	Sum	R 350,000.00	R 350,000.00
STORMWATER					**R 13,370,050.00**
Trench Excavation	Soft	4,300.00	m^3	R 180.00	R 774,000.00
	Intermediate	1,550.00	m^3	R 375.00	R 581,250.00
	Hard	2,050.00	m^3	R 1,020.00	R 2,091,000.00
Backfill	Fill	5,616.00	m^3	R 175.00	R 982,800.00
Stormwater Precast Elements	Dia. 450 mm	510.00	m	R 1,100.00	R 561,000.00
	Dia. 625 mm	120.00	m	R 1,600.00	R 192,000.00
	Dia. 1050 mm	350.00	m	R 3,000.00	R 1,050,000.00
	Discharging in to river	1.00	Sum	R 200,000.00	R 200,000.00
	Manholes	20.00	No.	R 6,500.00	R 130,000.00
	Kerb Inlets	7.00	No.	R 8,000.00	R 56,000.00
	Grid Inlets	1,350.00	m	R 2,000.00	R 2,700,000.00
	Culverts	150.00	No.	R 6,500.00	R 975,000.00
Earth Berm	Compacted and grassed	500.00	m	R 750.00	R 375,000.00
In-situ Concrete	Concrete slab for culverts (Top)	150.00	m^3	R 2,200.00	R 330,000.00
	Concrete base for culverts (bottom)	150.00	m^3	R 2,200.00	R 330,000.00
	Wingwalls for culverts	240.00	m^3	R 2,200.00	R 528,000.00
Reinforcement	For in-situ concrete for culverts	65.00	t	R 13,600.00	R 884,000.00
Formwork	For in-situ concrete for culverts	800.00	m^2	R 650.00	R 520,000.00
Blinding	For in-situ concrete for culverts	50.00	m^3	R 2,200.00	R 110,000.00
SUB-TOTAL A					R 30,617,970.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 30,617,970.00
ADD 14% VAT					R 4,286,515.80
FINAL TOTAL FOR STRUCTURE					**R 34,904,485.80**

R 13,312.16

2300
R 7,499.10

HEAD OF WORKS

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**1454**	**m^3**	**R 2,200.00**	**R 4,798,200.00**
	Walls and Floors	1454	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**72.7**	**m^3**	**R 2,200.00**	**R 159,940.00**
Reinforcing Steel	**Calculated at 140 kg/m^3 of Structural Concrete**	**204**	**Ton**	**R 13,600.00**	**R 2,768,416.00**
Formwork	**Total Formwork**	**5952**	**m^2**	**R 650.00**	**R 3,868,800.00**
	Vertical	**5539**	**m^2**	**R 650.00**	**R 3,600,350.00**
	Walls and Floors	5539	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
	Horizontal	**413**	**m^2**	**R 650.00**	**R 268,450.00**
	Soffit of roof slabs	137	m^2		
	Soffit of walkways and suspended floors	276	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**4875**	**m^3**		**R 3,524,625.00**
	Soft	975	m^3	R 180.00	R 175,500.00
	Intermediate	975	m^3	R 375.00	R 365,625.00
	Hard	2925	m^3	R 1,020.00	R 2,983,500.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 15,119,981.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 15,119,981.00
ADD 14% VAT					R 2,116,797.34
FINAL TOTAL FOR STRUCTURE					**R 17,236,778.34**

R 10,398.89

PRIMARY TREATMENT

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**782**	**m^3**	**R 2,200.00**	**R 2,236,520.00**
	Walls and floors	782	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**39.1**	**m^3**	**R 2,200.00**	**R 86,020.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**93.84**	**Ton**	**R 13,600.00**	**R 1,276,224.00**
Formwork	**Total Formwork**	**2586**	**m^2**	**R 650.00**	**R 1,680,900.00**
	Vertical	**2536**	**m^2**	**R 650.00**	**R 1,648,400.00**
	Walls	2096	m^2		
	Launder Walls	288	m^2		
	Floors	78	m^2		
	Columns	74	m^2		
			m^2		
			m^2		
	Horizontal	**50**	**m^2**	**R 650.00**	**R 32,500.00**
	Launder floor	42	m^2		
	Centre structure	8	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**18372**	**m^3**		**R 13,282,956.00**
	Soft	3674.4	m^3	R 180.00	R 661,392.00
	Intermediate	3674.4	m^3	R 375.00	R 1,377,900.00
	Hard	11023.2	m^3	R 1,020.00	R 11,243,664.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 18,562,620.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 18,562,620.00
ADD 14% VAT					R 2,598,766.80
FINAL TOTAL FOR STRUCTURE					**R 21,161,386.80**

FLOW BALANCING

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**1413**	**m^3**	**R 2,200.00**	**R 3,512,718.00**
	Walls and floors	1413	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**70.65**	**m^3**	**R 2,200.00**	**R 155,430.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**169.56**	**Ton**	**R 13,600.00**	**R 2,306,016.00**
Formwork	**Total Formwork**	**5154**	**m^2**	**R 650.00**	**R 3,350,100.00**
	Vertical	**5079**	**m^2**	**R 650.00**	**R 3,301,350.00**
	Walls	4450	m^2		
	Footings	306	m^2		
	Columns	323	m^2		
			m^2		
			m^2		
			m^2		
	Horizontal	**75**	**m^2**	**R 650.00**	**R 48,750.00**
	Soffits of walkways	75	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**15044**	**m^3**		**R 10,876,812.00**
	Soft	3008.8	m^3	R 180.00	R 541,584.00
	Intermediate	3008.8	m^3	R 375.00	R 1,128,300.00
	Hard	9026.4	m^3	R 1,020.00	R 9,206,928.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 20,201,076.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 20,201,076.00
ADD 14% VAT					R 2,828,150.64
FINAL TOTAL FOR STRUCTURE					**R 23,029,226.64**

BIOLOGICAL REACTOR

Item	Description	Total Quantity Regular	Unit	Rate		Amount	
			Calculated By:			NG	
			Checked By:			NR	
Concrete	**Total Structural Concrete**	**3950**	**m^3**	**R**	**2,200.00**	**R**	**10,862,500.00**
	Walls and floors	3950	m^3				
			m^3				
			m^3				
			m^3				
			m^3				
			m^3				
	Provisional: Mass Concrete	**197.5**	**m^3**	**R**	**2,200.00**	**R**	**434,500.00**
Reinforcing Steel	**Calculated at 100 kg/m^3 of Structural Concrete**	**395**	**Ton**	**R**	**13,600.00**	**R**	**5,372,000.00**
Formwork	**Total Formwork**	**15835**	**m^2**	**R**	**650.00**	**R**	**10,292,750.00**
	Vertical	**15525**	**m^2**	**R**	**650.00**	**R**	**10,091,250.00**
	Walls and floors	15525	m^2				
			m^2				
			m^2				
			m^2				
			m^2				
			m^2				
	Horizontal	**310**	**m^2**	**R**	**650.00**	**R**	**201,500.00**
	Soffits walkways	310	m^2				
			m^2				
			m^2				
			m^2				
			m^2				
			m^2				
Restricted Excavations		36950	**m^3**			**R**	**26,714,850.00**
	Soft	7390	m^3	R	180.00	R	1,330,200.00
	Intermediate	7390	m^3	R	375.00	R	2,771,250.00
	Hard	22170	m^3	R	1,020.00	R	22,613,400.00
						R	**-**
						R	**-**
						R	**-**
						R	**-**
SUB-TOTAL A						R	53,676,600.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER						R	-
SUB-TOTAL B						R	53,676,600.00
ADD 14% VAT						R	7,514,724.00
FINAL TOTAL FOR STRUCTURE						**R**	**61,191,324.00**

R 13,589.01

SECONDARY TREATMENT

Item	Description	Total Quantity Regular	Unit	Rate	Amount
			Calculated By:		NG
			Checked By:		NR
Concrete	**Total Structural Concrete**	**1227**	**m^3**	**R 2,200.00**	**R 3,509,220.00**
	Walls and floors	1227	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**61.35**	**m^3**	**R 2,200.00**	**R 134,970.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**147.24**	**Ton**	**R 13,600.00**	**R 2,002,464.00**
Formwork	**Total Formwork**	**4290**	**m^2**	**R 650.00**	**R 2,788,500.00**
	Vertical	**4215**	**m^2**	**R 650.00**	**R 2,739,750.00**
	Walls	3714	m^2		
	Launder walls	384	m^2		
	Floor	117	m^2		
			m^2		
			m^2		
			m^2		
	Horizontal	**75**	**m^2**	**R 650.00**	**R 48,750.00**
	Launder Floor	63	m^2		
	Center Structure	12	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**18372**	**m^3**		**R 13,282,956.00**
	Soft	3674.4	m^3	R 180.00	R 661,392.00
	Intermediate	3674.4	m^3	R 375.00	R 1,377,900.00
	Hard	11023.2	m^3	R 1,020.00	R 11,243,664.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 21,718,110.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 21,718,110.00
ADD 14% VAT					R 3,040,535.40
FINAL TOTAL FOR STRUCTURE					**R 24,758,645.40**

DISINFECTION & FINAL EFFLUENT

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**1497**	**m^3**	**R 2,200.00**	**R 3,952,080.00**
	Walls and floors	1497	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**74.85**	**m^3**	**R 2,200.00**	**R 164,670.00**
Reinforcing Steel	**Calculated at 100 kg/m^3 of Structural Concrete**	**149.7**	**Ton**	**R 13,600.00**	**R 2,035,920.00**
Formwork	**Total Formwork**	**3832**	**m^2**	**R 650.00**	**R 2,490,800.00**
	Vertical	**3780**	**m^2**	**R 650.00**	**R 2,457,000.00**
	Walls of contact channel	3606	m^2		
	Floor of contact channel	74	m^2		
	DBF bund	100	m^2		
			m^2		
			m^2		
			m^2		
	Horizontal	**52**	**m^2**	**R 650.00**	**R 33,800.00**
	Soffits of walkways	43	m^2		
	Soffit of scum baffle	9	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**7151**	**m^3**		**R 5,170,173.00**
	Soft	1430.2	m^3	R 180.00	R 257,436.00
	Intermediate	1430.2	m^3	R 375.00	R 536,325.00
	Hard	4290.6	m^3	R 1,020.00	R 4,376,412.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 13,813,643.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 13,813,643.00
ADD 14% VAT					R 1,933,910.02
FINAL TOTAL FOR STRUCTURE					**R 15,747,553.02**

EMERGENCY OVERFLOW DAM

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
	Capacity of Dam	**20000**	**m^3**	**R 750.00**	**R 15,000,000.00**
			m^3		
SUB-TOTAL A					R 15,000,000.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 15,000,000.00
ADD 14% VAT					R 2,100,000.00
FINAL TOTAL FOR STRUCTURE					**R 17,100,000.00**

FERMENTER AREA

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**632**	**m^3**	**R 2,200.00**	**R 1,807,520.00**
	Walls and floors	632	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**31.6**	**m^3**	**R 2,200.00**	**R 69,520.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**75.84**	**Ton**	**R 13,600.00**	**R 1,031,424.00**
Formwork	**Total Formwork**	**755**	**m^2**	**R 650.00**	**R 490,750.00**
	Vertical	**623**	**m^2**	**R 650.00**	**R 404,950.00**
	Tank walls	262	m^2		
	Launder walls	180	m^2		
	Floors	69	m^2		
	Columns	112	m^2		
			m^2		
			m^2		
	Horizontal	**132**	**m^2**	**R 650.00**	**R 85,800.00**
	Launder floor	128	m^2		
	Center structure	4	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**7891**	**m^3**		**R 5,705,193.00**
	Soft	1578.2	m^3	R 180.00	R 284,076.00
	Intermediate	1578.2	m^3	R 375.00	R 591,825.00
	Hard	4734.6	m^3	R 1,020.00	R 4,829,292.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 9,104,407.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 9,104,407.00
ADD 14% VAT					R 1,274,616.98
FINAL TOTAL FOR STRUCTURE					**R 10,379,023.98**

ANCILLARY WORKS

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**357**	**m^3**	**R 2,200.00**	**R 1,075,998.00**
	PST division box	192	m^3		
	Balancing tank division box	92	m^3		
	Final clarifier division box	55	m^3		
	Fermenter division box	18	m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**17.85**	**m^3**	**R 2,200.00**	**R 39,270.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**42.84**	**Ton**	**R 13,600.00**	**R 582,624.00**
Formwork	**Total Formwork**	**1444**	**m^2**	**R 650.00**	**R 938,600.00**
	Vertical	**1444**	**m^2**	**R 650.00**	**R 938,600.00**
	PST division box	559	m^2		
	Balancing tank division box	416	m^2		
	Final clarifier division box	323	m^2		
	Fermenter division box	146	m^2		
			m^2		
			m^2		
	Horizontal	**0**	**m^2**	**R 650.00**	**R -**
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**4106**	**m^3**		**R 2,968,638.00**
	Soft	821.2	m^3	R 180.00	R 147,816.00
	Intermediate	821.2	m^3	R 375.00	R 307,950.00
	Hard	2463.6	m^3	R 1,020.00	R 2,512,872.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 5,605,130.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 5,605,130.00
ADD 14% VAT					R 784,718.20
FINAL TOTAL FOR STRUCTURE					**R 6,389,848.20**

BULK SERVICES

				Calculated By:	NG
				Checked By:	NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Main Access Road	**Total Main Access Roads**				**R 42,940,246.25**
	Accomodation of traffic				R 2,341,265.00
	Clearing and grubbing				R 517,975.00
	Dayworks and hire of construction equipment				R 375,540.00
	Prefabricated culverts				R 370,840.00
	Mass earthworks				R 13,366,675.00
	Pavement layers of gravel material				R 6,172,000.00
	Stabilization				R 2,965,200.00
	Crushed stone base				R 3,645,000.00
	Prime coat				R 680,560.00
	Asphalt base and surfacing				R 6,829,800.00
	Treatment of an existing surface exhibiting certain defects				R 100,000.00
	Fencing				R 5,000,000.00
	Road signs				R 83,525.00
	Road markings				R 80,716.25
	Finishing the road and road reserve and treating old roads				R 111,150.00
	Testing materials and workmanship				R 300,000.00
Potable Water	**Bulk Potable Water Pipeline**		**Sum**		**R 6,000,000.00**
					R -
SUB-TOTAL A					R 48,940,246.25
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 48,940,246.25
ADD 14% VAT					R 6,851,634.48
FINAL TOTAL FOR STRUCTURE					**R 55,791,880.73**

BUILDINGS

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Buildings	**Architectural and Engineering Buildings**				**R 21,053,000.00**
	Combined Blower and Control Building	220	m^2	6500	1,430,000.00
	Primary Sludge Pump Station	186	m^2	6500	1,209,000.00
	Blower Building	367	m^2	6500	2,385,500.00
	WAS Pump Station	102	m^2	6500	663,000.00
	Wash Water and Sludge Pump Station	160	m^2	6500	1,040,000.00
	Emergency Overflow Dam Pump Station	120	m^2	6500	780,000.00
	Fermented Sludge Pump Station	98	m^2	6500	637,000.00
	Monitoring Building	36	m^2	6500	234,000.00
	Workshop and Storage Building	673	m^2	6500	4,374,500.00
	Electrical substations	200	m^2	6500	1,300,000.00
	Ablution Facility	100	m^2	10000	1,000,000.00
	Admin Building (incl. gatehouse and entrance)	600	m^2	10000	6,000,000.00
					R -
SUB-TOTAL A					R 21,053,000.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 21,053,000.00
ADD 14% VAT					R 2,947,420.00
FINAL TOTAL FOR STRUCTURE					**R 24,000,420.00**

INTERCONNECTING PIPEWORK

			Calculated By:			NG	
			Checked By:			NR	
Item	Description	Total Quantity Regular	Unit	Rate		Amount	
Pipelines	**Interconnecting Pipework**					**R**	**32,337,315.60**
	Concrete Pipelines					**R**	**9,745,800.00**
	Class 100D Diameter 500 Concrete Pipe	27	m	R	1,100.00	R	29,700.00
	Class 100D Diameter 750 Concrete Pipe	97	m	R	1,600.00	R	155,200.00
	Class 100D Diameter 900 Concrete Pipe	64	m	R	2,100.00	R	134,400.00
	Class 100D Diameter 1000 Concrete Pipe	230	m	R	3,000.00	R	690,000.00
	Class 100D Diameter 1200 Concrete Pipe	39	m	R	4,000.00	R	156,000.00
	Class 100D Diameter 1500 Concrete Pipe	382	m	R	5,750.00	R	2,196,500.00
	Class 100D Diameter 1800 Concrete Pipe	798	m	R	8,000.00	R	6,384,000.00
	HDPE Pipelines					**R**	**5,647,500.00**
	PN12.5 Diameter 160 HDPE Pipe	4915	m	R	450.00	R	2,211,750.00
	PN12.5 Diameter 160 HDPE Pipe	5415	m	R	450.00	R	2,436,750.00
	PN12.5 Diameter 500 HDPE Pipe	666	m	R	1,500.00	R	999,000.00
	Stainless Steel Pipes					**R**	**2,622,800.00**
	SS304 Diamter 200 Pipe	39	m	R	1,200.00	R	46,800.00
	SS304 Diamter 500 Pipe	46	m	R	6,000.00	R	276,000.00
	SS304 Diamter 900 Pipe	50	m	R	10,000.00	R	500,000.00
	SS304 Diamter 1000 Pipe	150	m	R	12,000.00	R	1,800,000.00
	uPVC Pipes					**R**	**1,005,900.00**
	Diameter 200 Class 12	3353	m	R	300.00	R	1,005,900.00
	Weoholite Pipes					**R**	**4,581,880.00**
	Diameter 450	348	m	R	1,288.00	R	448,224.00
	Diameter 1500	101	m	R	10,640.00	R	1,074,640.00
	Diameter 1800	197	m	R	15,528.00	R	3,059,016.00
Restricted Excavations		39761	**m^3**			**R**	**29,595,253.00**
	Soft	7952	m^3	R	180.00	R	1,431,396.00
	Intermediate	7952	m^3	R	375.00	R	2,982,075.00
	Hard	23857	m^3	R	1,020.00	R	24,333,732.00
	Import G7 material from commercial sources	4846	m^3	R	175.00	R	848,050.00
						R	**-**
						R	**-**
SUB-TOTAL A						R	61,932,568.60
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER						R	-
SUB-TOTAL B						R	61,932,568.60
ADD 14% VAT						R	8,670,559.60
FINAL TOTAL FOR STRUCTURE						**R**	**70,603,128.20**

Project Cost Summary (SLUDGE)

Section	Total
WAS THICKENER FEED BOX	426,415.00
WAS THICKENER	3,399,120.00
WAS MANHOLES & BOXES	2,648,660.00
ANAEROBIC DIGESTER INLET TOWER	1,990,575.00
ANAEROBIC DIGESTER	8,616,600.00
BOILER HOUSE	2,568,600.00
GAS HOLDER	4,393,060.00
FBP BUILDING	19,996,760.00
OUTLOADING STATION	6,870,600.00
SOLAR DRYING BEDS	21,668,160.00
SLUDGE STORAGE AREA	4,571,500.00
GRIT DRYING BEDS	1,897,680.00
RETURN PUMP STATION	3,097,740.00
LIME THICKENER	4,024,080.00
LIME REACTOR AND SILO BUND	1,725,600.00
LIME SLUDGE PUMP STATION	910,080.00
INTERCONNECTING PIPEWORK	12,086,541.53
RESTRICTED AND BULK EARTHWORKS	76,446,400.00
RETAINING WALLS	14,774,000.00
PRELIMINARY, GENERAL AND OVERHEADS (20 %)	35,467,634.31
Total Civils Sludge (excl. VAT)	**R227,579,805.84**
Electrical and C & I	**R0.00**
Mechanical	
Total (excl. VAT)	**R227,579,805.84**

Master Rates (SLUDGE)

Concrete (per m^3)	R2,200.00
Formwork (per m^2)	R650.00
Reinforcement (per ton)	R13,600.00
Bulk Excavation (per m^3)	
Soft	R120.00
Intermediate	R250.00
Hard	R850.00
Restricted Excavation (per m^3)	
Soft	R180.00
Intermediate	R375.00
Hard	R1,020.00
Allowance for Mass Concrete	5%
Contingency by the Engineer	0%
Buildings Engineering (R/m²)	R6,500.00
Building Architectural (R/m²)	R10,000.00
Restricted Excavation	**100%**
Soft	20%
Intermediate	20%
Hard	60%
Bulk Excavation	**100%**
Soft	20%
Intermediate	20%
Hard	60%
Bulk Excavation & dispose (per m^3)	R120.00
Dispose	10%
Reuse	90%
Import G7 fill material	R250.00
Emergency Dam (R/m³)	R750.00
P & G (%)	20%

100%

Between Floor Panels (incl. reargaurd)	R570.00
Between Wall Panels (incl. waterbar)	R570.00
Handrails with Kicker plates	R1,760.00
Grid Flooring (GRP) (per m^2)	R1,500.00
Grid Flooring (GMS) (per m^2)	R1,500.00
Brickwork (230, one plain one facebrick)	R750.00
Victorian Style Roof	R2,500.00
Portal Frame	R2,600.00
Cladding	R2,400.00

Concrete Factors (SLUDGE)

WAS THICKENER FEED BOX	1.10
WAS THICKENER	1.20
WAS MANHOLES & BOXES	1.40
ANAEROBIC DIGESTER INLET TOWER	1.50
ANAEROBIC DIGESTER	1.20
BOILER HOUSE	1.20
GAS HOLDER	1.40
FBP BUILDING	1.40
OUTLOADING STATION	1.10
SOLAR DRYING BEDS	1.20
SLUDGE STORAGE AREA	1.00
GRIT DRYING BEDS	1.20
RETURN PUMP STATION	1.20
LIME THICKENER	1.20
LIME REACTOR AND SILO BUND	1.20
LIME SLUDGE PUMP STATION	1.20
INTERCONNECTING PIPEWORK	1.20
RESTRICTED AND BULK EARTHWORKS	1.10
RETAINING WALLS	1.00

WAS THICKENER FEED BOX QUANTITIES

			Calculated by:	HJvR	29/07/2016
			Checked by:	JP	01/08/2016

Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**35.00**	**m^3**	**R 2,200.00**	**R 77,000.00**
	Floor slab of inlet tower sump	5.00	m^3		
	Floor slab of box	5.00	m^3		
	Walls of inlet tower sump	5.00	m^3		
	Walls of box	20.00	m^3		
	Provisional (5%): Mass Concrete	**2.00**	**m^3**	**R 2,200.00**	**R 4,400.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**5.00**	**Ton**	**R 13,600.00**	**R 68,000.00**
Formwork	**Total Formwork**	**165.00**	**m^2**		
	Vertical	**160.00**	**m^2**	**R 650.00**	**R 104,000.00**
	Sides of Floor slab of inlet tower sump	5.00	m^2		
	Sides of Floor slab of box	5.00	m^2		
	Sides of Walls of inlet tower sump	10.00	m^2		
	Sides of Walls of box	140.00	m^2		
	Horizontal	**5.00**	**m^2**	**R 650.00**	**R 3,250.00**
	Soffits of Box outs	5.00	m^2		
Joints	**Total Joints**	**100.00**	**m**		
	Between Floor Panels (incl. reargaurd)	50.00	m	R 570.00	R 28,500.00
	Between Wall Panels (incl. waterbar)	50.00	m	R 570.00	R 28,500.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates	25.00	m	R 1,760.00	R 44,000.00
	Grid Flooring	20.00	m^2	R 1,500.00	R 30,000.00
SUB-TOTAL A					R 387,650.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 38,765.00
FINAL TOTAL FOR STRUCTURE					R 426,415.00

WAS THICKENER QUANTITIES

			Calculated by:	HJvR	29/07/2016
			Checked by:	JP	01/08/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**340.00**	**m^3**	**R 2,200.00**	**R 748,000.00**
	Floor slab and footing of sludge hopper	10.00	m^3		
	Walls of sludge hopper	10.00	m^3		
	Footing of tank retaining walls	40.00	m^3		
	Floor slab of tank	60.00	m^3		
	Walls of tank	180.00	m^3		
	Floor Slabs of launders and boxes	10.00	m^3		
	Walls of launders and boxes	10.00	m^3		
	Centre column	20.00	m^3		
	Provisional (5%): Mass Concrete	**17.00**	**m^3**	**R 2,200.00**	**R 37,400.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**41.00**	**Ton**	**R 13,600.00**	**R 557,600.00**
Formwork	**Total Formwork**	**1570.00**	**m^2**		
	Vertical	**1510.00**	**m^2**	**R 650.00**	**R 981,500.00**
	Sides of Floor slab and footing of sludge hopper	10.00	m^2		
	Sides of Walls of sludge hopper	60.00	m^2		
	Sides of Footing of tank retaining walls	40.00	m^2		
	Sides of Walls of tank	1120.00	m^2		
	Sides of Floor Slabs of launders and boxes	40.00	m^2		
	Side of Walls of launders and boxes	80.00	m^2		
	Sides of Centre column	60.00	m^2		
	Sides of Pipe casings	100.00	m^2		
	Horizontal	**60.00**	**m^2**	**R 650.00**	**R 39,000.00**
	Soffits of Launders and boxes	60.00	m^2		
Joints	**Total Joints**	**250.00**	**m**		
	Between Floor Panels (incl. reargaurd)	240.00	m	R 570.00	R 136,800.00
	Between Wall Panels (incl. waterbar) (Provisional)	10.00	m	R 570.00	R 5,700.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates	160.00	m	R 1,760.00	R 281,600.00
	Grid Flooring	30.00	m^2	R 1,500.00	R 45,000.00
SUB-TOTAL A					R 2,832,600.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 566,520.00
FINAL TOTAL FOR STRUCTURE					R 3,399,120.00

WAS MANHOLES AND BOXES QUANTITIES

			Calculated by:	HJvR
			Checked by:	JP
Item	Description	Total Quantity Regular	Unit	Rate
Concrete	**Total Structural Concrete**	**290.00**	**m^3**	**R 2,200.00**
	Floor slab and footing of effluent manholes	40.00	m^3	
	Walls of Effluent manholes	40.00	m^3	
	Cover slab of effluent manholes	40.00	m^3	
	Floor slab and footing of scum manholes	40.00	m^3	
	Walls of Scum manholes	40.00	m^3	
	Cover slab of scum manholes	40.00	m^3	
	Floor slab of sludge valve boxes	20.00	m^3	
	Walls of sludge valve boxes	20.00	m^3	
	Roof slab of sludge valve boxes	10.00	m^3	
	Provisional (5%): Mass Concrete	**15.00**	**m^3**	**R 2,200.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**35.00**	**Ton**	**R 13,600.00**
Formwork	**Total Formwork**	**960.00**	**m^2**	
	Vertical	**920.00**	**m^2**	**R 650.00**
	Sides of Floor slab and footing of effluent manholes	40.00	m^2	
	Sides of Walls of Effluent manholes	320.00	m^2	
	Sides of Cover slab of effluent manholes	40.00	m^2	
	Sides of Floor slab and footing of scum manholes	40.00	m^2	
	Sides of Walls of Scum manholes	320.00	m^2	
	Sides of Cover slab of scum manholes	40.00	m^2	
	Sides of Floor slab of sludge valve boxes	10.00	m^2	
	Sides of Walls of sludge valve boxes	100.00	m^2	
	Sides of Roof slab of sludge valve boxes	10.00	m^2	
	Horizontal	**40.00**	**m^2**	**R 650.00**
	Soffit of Cover slab of effluent manholes	40.00	m^2	
	Soffit of Cover slab of scum manholes	40.00	m^2	
	Soffit of Roof slab of sludge valve boxes	20.00	m^2	
Joints	**Total Joints**	**80.00**	**m**	
	Between Floor Panels (incl. reargaurd) (Provisional)	20.00	m	R 570.00
	Between Wall Panels (incl. waterbar) (Provisional)	60.00	m	R 570.00
Structural Steelwork	**Items:**			
	Handrails with Kicker plates (Provisional)	30.00	m	R 1,760.00
	Grid Flooring (Provisional)	15.00	m^2	R 1,500.00
SUB-TOTAL A				
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED				
FINAL TOTAL FOR STRUCTURE				

29/07/2016
01/08/2016
Amount
R 638,000.00
R 33,000.00
R 476,000.00
R 598,000.00
R 26,000.00
R 11,400.00
R 34,200.00
R 52,800.00
R 22,500.00
R 1,891,900.00
R 756,760.00
R 2,648,660.00

ANAEROBIC DIGESTER INLET TOWER QUANTITIES

		Calculated by:		HB	28/07/2016
		Checked by:		JP	28/07/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**140.00**	**m^3**	**R 2,200.00**	**R 308,000.00**
	Pad foundations	30.00	m^3		
	Columns	30.00	m^3		
	Support beams between Columns	20.00	m^3		
	Elevated floor slab of tank	20.00	m^3		
	Walls of tank and Inlet tower	40.00	m^3		
	Provisional (5%): Mass Concrete	**7.00**	**m^3**	**R 2,200.00**	**R 15,400.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**17.00**	**Ton**	**R 13,600.00**	**R 231,200.00**
Formwork	**Total Formwork**	**525.00**	**m^2**		
	Vertical	**420.00**	**m^2**	**R 650.00**	**R 273,000.00**
	Sides of Pad foundations	40.00	m^2		
	Sides of Columns	150.00	m^2		
	Sides of Support beams between Columns	40.00	m^2		
	Sides of Elevated floor slab of tank	10.00	m^2		
	Sides of Walls of tank and Inlet tower	180.00	m^2		
	Horizontal	**105.00**	**m^2**	**R 650.00**	**R 68,250.00**
	Soffits of Support beams between Columns	60.00	m^2		
	Soffit of Elevated floor slab of tank	40.00	m^2		
	Soffits of Box outs	5.00	m^2		
Joints	**Total Joints**	**100.00**	**m**		
	Between Floor Panels (incl. reargaurd)	50.00	m	R 570.00	R 28,500.00
	Between Wall Panels (incl. waterbar)	50.00	m	R 570.00	R 28,500.00
Structural Steelwork	**Items:**				
	Handrails with Kicker Plates	170.00	m	R 1,760.00	R 299,200.00
	Grid Flooring	50.00	m^2	R 1,500.00	R 75,000.00
SUB-TOTAL A					R 1,327,050.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 663,525.00
FINAL TOTAL FOR STRUCTURE					R 1,990,575.00

ANAEROBIC DIGESTER QUANTITIES

			Calculated by:	HB	28/07/2016
			Checked by:	JP	28/07/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**1050.00**	**m^3**	**R 2,200.00**	**R 2,310,000.00**
	Floor slab and Footing	280.00	m^3		
	Walls	520.00	m^3		
	Roof slab	220.00	m^3		
	Scum box floor and walls	10.00	m^3		
	Overflow walls and walkway	20.00	m^3		
	Provisional (5%): Mass Concrete	**53.00**	**m^3**	**R 2,200.00**	**R 116,600.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**126.00**	**Ton**	**R 13,600.00**	**R 1,713,600.00**
Formwork	**Total Formwork**	**3510.00**	**m^2**		
	Vertical	**2950.00**	**m^2**	**R 650.00**	**R 1,917,500.00**
	Sides of Footing and Sump	100.00	m^2		
	Sides of Walls	2560.00	m^2		
	Sides of Roof slab	120.00	m^2		
	Sides of Roof slab stairs and risers	10.00	m^2		
	Sides of Scum box floor and walls	60.00	m^2		
	Sides of Overflow walls and walkway	100.00	m^2		
	Horizontal	**560.00**	**m^2**	**R 650.00**	**R 364,000.00**
	Soffits of Roof slab	520.00	m^2		
	Soffit of Scum box floor	20.00	m^2		
	Soffit of Overflow walkway	20.00	m^2		
Joints	**Total Joints**	**600.00**	**m**		
	Between Floor Panels (incl. reargaurd)	300.00	m	R 570.00	R 171,000.00
	Between Wall Panels (incl. waterbar)	300.00	m	R 570.00	R 171,000.00
Structural Steelwork	**Items:**				
	Handrails with Kicker Plates	230.00	m	R 1,760.00	R 404,800.00
	Grid Flooring	8.00	m^2	R 1,500.00	R 12,000.00
SUB-TOTAL A					R 7,180,500.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 1,436,100.00
FINAL TOTAL FOR STRUCTURE					R 8,616,600.00

BOILER HOUSE QUANTITIES

		Calculated by:		HB	28/07/2016
		Checked by:		JP	29/07/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**270.00**	**m^3**	**R 2,200.00**	**R 594,000.00**
	Pad foundations	40.00	m^3		
	Strip footings	40.00	m^3		
	Columns	20.00	m^3		
	Beams	40.00	m^3		
	Floor slabs of trenchs	40.00	m^3		
	Floor slabs	60.00	m^3		
	Bund walls	10.00	m^3		
	Plinths	10.00	m^3		
	Ramps	10.00	m^3		
	Provisional (5%): Mass Concrete	**14.00**	**m^3**	**R 2,200**	**R 30,800.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**33.00**	**Ton**	**R 13,600**	**R 448,800.00**
Formwork	**Total Formwork**	**850.00**	**m^2**		
	Vertical	**790.00**	**m^2**	**R 650.00**	**R 513,500.00**
	Sides of Pad foundations	80.00	m^2		
	Sides of Strip footings	100.00	m^2		
	Sides of Columns	200.00	m^2		
	Sides of Beams	180.00	m^2		
	Sides of Floor slabs of trenchs	40.00	m^2		
	Sides of Floor slabs	60.00	m^2		
	Sides of Bund Walls	80.00	m^2		
	Sides of Plinths	40.00	m^2		
	Sides of Ramps	10.00	m^2		
	Horizontal	**60.00**	**m^2**	**R 650.00**	**R 39,000.00**
	Soffits of Beams	60.00	m^2		
Brickwork	**All Wall Thicknesses**	**680.00**	**m^2**	**R 0**	**R 0.00**
Joints	**Total Joints**	**200.00**	**m**		
	Between Floor Panels (incl. reargaurd)	100.00	m	R 570.00	R 57,000.00
	Between Wall Panels (incl. waterbar)	100.00	m	R 570.00	R 57,000.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates (Provisional)	40.00	m	1760	R 70,400.00
	Grid Flooring (Provisional)	220.00	m^2	1500	R 330,000.00
Roofing	**Items:**				
	Trusses, Purlins, Grids and Bracing	420.00	m^2	R 2,500.00	R 1,050,000.00
SUB-TOTAL A					R 2,140,500.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 428,100.00
FINAL TOTAL FOR STRUCTURE					R 2,568,600.00

GAS HOLDER QUANTITIES

		Calculated by:		HB	05/09/2016
		Checked by:		JP	31/08/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**380.00**	**m^3**	**R 2,200.00**	**R 836,000.00**
	Foundation	360.00	m^3		
	Plinths	10.00	m^3		
	Inlet valve box	10.00	m^3		
	Provisional (5%): Mass Concrete	**19.00**	**m^3**	**R 2,200.00**	**R 41,800.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**46.00**	**Ton**	**R 13,600.00**	**R 625,600.00**
Formwork	**Total Formwork**	**200.00**	**m^2**		
	Vertical	**200.00**	**m^2**	**R 650.00**	**R 130,000.00**
	Sides of Foundation	80.00	m^2		
	Sides of Plinths	40.00	m^2		
	Sides of Inlet valve box	80.00	m^2		
Joints	**Total Joints**	**250.00**	**m**		
	Between Floor Panels (incl. reargaurd)	100.00	m	R 570.00	R 57,000.00
	Between Wall Panels (incl. waterbar)	150.00	m	R 570.00	R 85,500.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates (Provisional)	450.00	m	R 1,760.00	R 792,000.00
	Grid Flooring (Provisional)	380.00	m^2	R 1,500.00	R 570,000.00
SUB-TOTAL A					R 3,137,900.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 1,255,160.00
FINAL TOTAL FOR STRUCTURE					R 4,393,060.00

FBP BUILDING QUANTITIES

Item	Description	Total Quantity Regular	Unit	Rate
			Calculated by:	JE
			Checked by:	NS
Concrete	**Total Structural Concrete**	**2070.00**	**m^3**	**R 2,200.00**
	Floor slab of wet well, basement, ground floor and first floor	1050.00	m^3	
	Walls wet well, beams and columns of building	700.00	m^3	
	Walls of sumps, basement floor and cable trenches	110.00	m^3	
	Wet well platforms, walkways and columns	110.00	m^3	
	Plinths and stairs	100.00	m^3	
	Provisional (5%): Mass Concrete	**104.00**	**m^3**	**R 2,200.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**249.00**	**Ton**	**R 13,600.00**
Formwork	**Total Formwork**	**8330.00**	**m^2**	
	Vertical	**6980.00**	**m^2**	**R 650.00**
	Sides of Floor slab of wet well, basement, ground floor and first floor	320.00	m^2	
	Sides of Walls of wet well, beams and columns of building	3290.00	m^2	
	Sides of Walls of sumps, basement floor and cable trenches	2780.00	m^2	
	Sides of Wet well platforms, walkways and columns	340.00	m^2	
	Sides of Plinths and stairs	250.00	m^2	
	Horizontal	**1350.00**	**m^2**	**R 650.00**
	Soffits of slabs, walkways and stairs	1350.00	m^2	
Brickwork	**All Wall of Various Thicknesses**	**1650.00**	**m^2**	**R 0.00**
Joints	**Total Joints**	**200.00**	**m**	
	Between Floor Panels (incl. reargaurd) (Provisional)	100.00	m	R 570.00
	Between Wall Panels (incl. waterbar) (Provisional)	100.00	m	R 570.00
Structural Steelwork	**Items:**			
	Handrails with Kicker plates (Provisional)	320.00	m	R 1,760.00
	Grid Flooring (Provisional)	15.00	m^2	R 1,500.00
Roofing	**Items:**			
	Portal Frame: Bolts, Cleats, Plates, Mild Steel Trusses, Mild Steel Columns, Mild Steel Beams, Purlins, Grids and Bracing	1150.00	m^2	R 2,600.00
	Clading	1150.00	m^2	R 2,400.00
SUB-TOTAL A				
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED				
FINAL TOTAL FOR STRUCTURE				

25/08/2016
31/08/2016
Amount
R 4,554,000.00
R 228,800.00
R 3,386,400.00
R 4,537,000.00
R 877,500.00
R 0.00
R 57,000.00
R 57,000.00
R 563,200.00
R 22,500.00
R 2,990,000.00
R 2,760,000.00
R 14,283,400.00
R 5,713,360.00
R 19,996,760.00

OUTLOADING STATION QUANTITIES

Item	Description	Total Quantity Regular	Unit	Rate	Amount
			Calculated by:	HJvR	01/08/2016
			Checked by:	JP	02/08/2016
Concrete	**Total Structural Concrete**	**360.00**	**m^3**	**R 2,200.00**	**R 792,000.00**
	Floor slab	150.00	m^3		
	Retaining walls and footing	210.00	m^3		
	Provisional (5%): Mass Concrete	**18.00**	**m^3**	**R 2,200.00**	**R 39,600.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**44.00**	**Ton**	**R 13,600.00**	**R 598,400.00**
Formwork	**Total Formwork**	**740.00**	**m^2**		
	Vertical	**740.00**	**m^2**	**R 650.00**	**R 481,000.00**
	Sides of Floor slab	10.00	m^2		
	Sides of Retaining walls and footing	730.00	m^2		
Joints	**Total Joints**	**500.00**	**m**		
	Between Floor Panels (incl. reargaurd)	430.00	m	R 570.00	R 245,100.00
	Between Wall Panels (incl. waterbar)	70.00	m	R 570.00	R 39,900.00
Roofing	**Items:**				
				2500.00	
	Portal Frame: Bolts, Cleats, Plates, Mild Steel Trusses, Mild Steel Columns, Mild Steel Beams, Purlins, Grids and Bracing	810.00	m^2	R 2,600.00	R 2,106,000.00
	Clading	810.00	m^2	R 2,400.00	R 1,944,000.00
SUB-TOTAL A					R 6,246,000.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 624,600.00
FINAL TOTAL FOR STRUCTURE					R 6,870,600.00

SOLAR DRYING BEDS

		Calculated by:		JE	26/08/2016
		Checked by:		IS	31/08/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**860.00**	**m^3**	**R 2,200.00**	**R 1,892,000.00**
	Floor slab & walls	640.00	m^3		
	Retaining walls and footing	220.00	m^3		
	Provisional (5%): Mass Concrete	**43.00**	**m^3**	**R 2,200.00**	**R 94,600.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**104.00**	**Ton**	**R 13,600.00**	**R 1,414,400.00**
Formwork	**Total Formwork**	**1240.00**	**m^2**		
	Vertical	**1240.00**	**m^2**	**R 650.00**	**R 806,000.00**
	Sides of Floor slab	200.00	m^2		
	Sides of Retaining walls, footing & walls	1040.00	m^2		
Brickwork	**All Wall of Various Thicknesses**	**60.00**	**m^2**	**R 0.00**	**R 0.00**
Joints	**Total Joints**	**1140.00**	**m**		
	Between Floor Panels (incl. reargaurd) PROV	1100.00	m	R 570.00	R 627,000.00
	Between Wall Panels (incl. waterbar) PROV	40.00	m	R 570.00	R 22,800.00
Roofing	**Items:**				
	Portal Frame: Bolts, Cleats, Plates, Mild Steel Trusses, Mild Steel Columns, Mild Steel Beams, Purlins, Grids and Bracing	2880.00	m^2	R 2,600.00	R 7,488,000.00
	Clading	2380.00	m^2	R 2,400.00	R 5,712,000.00
SUB-TOTAL A					R 18,056,800.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 3,611,360.00
FINAL TOTAL FOR STRUCTURE					R 21,668,160.00

SLUDGE STORAGE AREA

			Calculated by:	JE	26/08/2016
			Checked by:	IS	31/08/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**705.00**	**m^3**	**R 2,200.00**	**R 1,551,000.00**
	Floor slab & walls	700.00	m^3		
	Retaining walls and footing (Incl. kerbs)	5.00	m^3		
	Provisional (5%): Mass Concrete	**36.00**	**m^3**	**R 2,200.00**	**R 79,200.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**85.00**	**Ton**	**R 13,600.00**	**R 1,156,000.00**
Formwork	**Total Formwork**	**870.00**	**m^2**		
	Vertical	**870.00**	**m^2**	**R 650.00**	**R 565,500.00**
	Sides of Floor slab	400.00	m^2		
	Sides of Retaining walls, footing & walls	470.00	m^2		
Joints	**Total Joints**	**2140.00**	**m**		
	Between Floor Panels (incl. reargaurd)	2080.00	m	R 570.00	R 1,185,600.00
	Between Wall Panels (incl. waterbar)	60.00	m	R 570.00	R 34,200.00
SUB-TOTAL A					R 4,571,500.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 0.00
FINAL TOTAL FOR STRUCTURE					R 4,571,500.00

GRIT DRYING BEDS QUANTITIES

		Calculated by:		HJvR	01/08/2016
		Checked by:		JP	02/08/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**260.00**	**m^3**	**R 2,200.00**	**R 572,000.00**
	Floor slab of beds and ramps	180.00	m^3		
	Floor slab of channels	20.00	m^3		
	Walls of beds	20.00	m^3		
	Walls of channels	40.00	m^3		
	Provisional (5%): Mass Concrete	**13.00**	**m^3**	**R 2,200.00**	**R 28,600.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**32.00**	**Ton**	**R 13,600.00**	**R 435,200.00**
Formwork	**Total Formwork**	**550.00**	**m^2**		
	Vertical	**550.00**	**m^2**	**R 650.00**	**R 357,500.00**
	Sides of Floor slab of beds and ramps	40.00	m^2		
	Sides of Floor slab of channels	40.00	m^2		
	Sides of Walls of beds	120.00	m^2		
	Sides of of channels	350.00	m^2		
Joints	**Total Joints**	**330.00**	**m**		
	Between Floor Panels (incl. reargaurd)	320.00	m	R 570.00	R 182,400.00
	Between Wall Panels (incl. waterbar)	10.00	m	R 570.00	R 5,700.00
SUB-TOTAL A					R 1,581,400.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 316,280.00
FINAL TOTAL FOR STRUCTURE					R 1,897,680.00

RETURN PUMP STATION QUANTITIES

Item	Description	Total Quantity Regular	Unit	Rate	Amount
			Calculated by:	HJvR	01/08/2016
			Checked by:	JP	01/08/2016
Concrete	**Total Structural Concrete**	**285.00**	**m^3**	**R 2,200.00**	**R 627,000.00**
	Floor slab of dry well, sumps and wet wells	100.00	m^3		
	Walls Slab dry well, sumps and wet wells	140.00	m^3		
	Cover slabs and walkways	30.00	m^3		
	Beams	5.00	m^3		
	Plinths	5.00	m^3		
	Ramps	5.00	m^3		
	Provisional (5%): Mass Concrete	**15.00**	**m^3**	**R 2,200.00**	**R 33,000.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**35.00**	**Ton**	**R 13,600.00**	**R 476,000.00**
Formwork	**Total Formwork**	**1085.00**	**m^2**		
	Vertical	**1015.00**	**m^2**	**R 650.00**	**R 659,750.00**
	Sides of Floor slab of dry well, sumps and wet wells	50.00	m^2		
	Sides of Walls Slab dry well, sumps and wet wells	900.00	m^2		
	Sides of Cover slabs and walkways	30.00	m^2		
	Sides of Beams	10.00	m^2		
	Sides of Plinths	20.00	m^2		
	Sides of Ramps	5.00	m^2		
	Horizontal	**70.00**	**m^2**	**R 650.00**	**R 45,500.00**
	Soffits of Cover slabs and walkways	70.00	m^2		
Brickwork	**All Wall of Various Thicknesses**	**117.83**	**m^2**	**R 0.00**	**R 0.00**
Joints	**Total Joints**	**200.00**	**m**		
	Between Floor Panels (incl. reargaurd) (Provisional)	130.00	m	R 570.00	R 74,100.00
	Between Wall Panels (incl. waterbar) (Provisional)	70.00	m	R 570.00	R 39,900.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates (Provisional)	120.00	m	R 1,760.00	R 211,200.00
	Grid Flooring (Provisional)	10.00	m^2	R 1,500.00	R 15,000.00
Roofing	**Items:**				
	Trusses, Purlins, Grids and Bracing	160.00	m^2	R 2,500.00	R 400,000.00
SUB-TOTAL A					R 2,581,450.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 516,290.00
FINAL TOTAL FOR STRUCTURE					R 3,097,740.00

LIME THICKENER QUANTITIES

Item	Description	Total Quantity Regular	Unit	Rate	Amount
			Calculated by:	JP	25/08/2016
			Checked by:	DB	31/08/2016
Concrete	**Total Structural Concrete**	**430.00**	**m^3**	**R 2,200.00**	**R 946,000.00**
	Floor slab and footing of sludge hopper	10.00	m^3		
	Walls of sludge hopper	10.00	m^3		
	Footing of tank retaining walls	40.00	m^3		
	Floor slab of tank	100.00	m^3		
	Walls of tank	220.00	m^3		
	Floor Slabs of launders and boxes	20.00	m^3		
	Walls of launders and boxes	10.00	m^3		
	Centre column	20.00	m^3		
	Provisional (5%): Mass Concrete	**22.00**	**m^3**	**R 2,200.00**	**R 48,400.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**52.00**	**Ton**	**R 13,600.00**	**R 707,200.00**
Formwork	**Total Formwork**	**1830.00**	**m^2**		
	Vertical	**1770.00**	**m^2**	**R 650.00**	**R 1,150,500.00**
	Sides of Floor slab and footing of sludge hopper	10.00	m^2		
	Sides of Walls of sludge hopper	60.00	m^2		
	Sides of Footing of tank retaining walls	60.00	m^2		
	Sides of Walls of tank	1380.00	m^2		
	Sides of Floor Slabs of launders and boxes	40.00	m^2		
	Side of Walls of launders and boxes	120.00	m^2		
	Sides of Centre column	60.00	m^2		
	Sides of Pipe casings (Provisional)	40.00	m^2		
	Horizontal	**60.00**	**m^2**	**R 650.00**	**R 39,000.00**
	Soffits of Launders and boxes	60.00	m^2		
Joints	**Total Joints**	**230.00**	**m**		
	Between Floor Panels (incl. reargaurd)	220.00	m	R 570.00	R 125,400.00
	Between Wall Panels (incl. waterbar) (Provisional)	10.00	m	R 570.00	R 5,700.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates	120.00	m	R 1,760.00	R 211,200.00
	Grid Flooring	80.00	m^2	R 1,500.00	R 120,000.00
SUB-TOTAL A					R 3,353,400.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 670,680.00
FINAL TOTAL FOR STRUCTURE					R 4,024,080.00

LIME REACTOR AND SILO BUND QUANTITIES

Item	Description	Total Quantity Regular	Unit	Rate	Amount
		Calculated by:		JP	25/08/2016
		Checked by:		DB	31/08/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**210.00**	**m^3**	**R 2,200.00**	**R 462,000.00**
	Floor slab	60.00	m^3		
	Floor slab of platforms, launders and boxes	10.00	m^3		
	Walls and columns	100.00	m^3		
	Walls of launders and boxes	5.00	m^3		
	Stairs	5.00	m^3		
	Silo bund	30.00	m^3		
	Provisional (5%): Mass Concrete	**11.00**	**m^3**	**R 2,200.00**	**R 24,200.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**26.00**	**Ton**	**R 13,600.00**	**R 353,600.00**
Formwork	**Total Formwork**	**620.00**	**m^2**		
	Vertical	**560.00**	**m^2**	**R 650.00**	**R 364,000.00**
	Sides of Floor slab	30.00	m^2		
	Sides of Floor slab of platforms, launders and boxes	20.00	m^2		
	Sides of Walls and columns	450.00	m^2		
	Sides of Walls of launders, boxes and stairs	30.00	m^2		
	Sides of Silo bund	30.00	m^2		
	Horizontal	**60.00**	**m^2**	**R 650.00**	**R 39,000.00**
	Soffits of Platforms, launders, boxes and stairs	60.00	m^2		
Joints	**Total Joints**	**100.00**	**m**		
	Between Floor Panels (incl. reargaurd)	80.00	m	R 570.00	R 45,600.00
	Between Wall Panels (incl. waterbar)	20.00	m	R 570.00	R 11,400.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates	70.00	m	R 1,760.00	R 123,200.00
	Grid Flooring	10.00	m^2	R 1,500.00	R 15,000.00
SUB-TOTAL A					R 1,438,000.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 287,600.00
FINAL TOTAL FOR STRUCTURE					R 1,725,600.00

LIME SLUDGE PUMP STATION QUANTIT

		Calculated by:		JP
		Checked by:		DB
Item	Description	Total Quantity Regular	Unit	Rate
Concrete	**Total Structural Concrete**	**80.00**	**m^3**	**R 2,200.00**
	Floor slab of dry well, sumps and wet wells	20.00	m^3	
	Walls Slab dry well, sumps and wet wells	30.00	m^3	
	Walkways and stairs	10.00	m^3	
	Beams	5.00	m^3	
	Plinths and ramps	5.00	m^3	
	Roof Slab	10.00	m^3	
	Provisional (5%): Mass Concrete	**4.00**	**m^3**	**R 2,200.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**10.00**	**Ton**	**R 13,600.00**
Formwork	**Total Formwork**	**380.00**	**m^2**	
	Vertical	**290.00**	**m^2**	**R 650.00**
	Sides of Floor slab of dry well, sumps and wet wells	10.00	m^2	
	Sides of Walls Slab dry well, sumps and wet wells	230.00	m^2	
	Sides of Walkways and stairs	20.00	m^2	
	Sides of Beams	5.00	m^2	
	Sides of Plinths and ramps	5.00	m^2	
	Sides of Roof Slab	20.00	m^2	
	Horizontal	**90.00**	**m^2**	**R 650.00**
	Soffits of Roof slab, walkways and stairs	90.00	m^2	
Brickwork	**All Wall of Various Thicknesses**	**90.00**	**m^2**	**R 0.00**
Joints	**Total Joints**	**220.00**	**m**	
	Between Floor Panels (incl. reargaurd) (Provisional)	200.00	m	R 570.00
	Between Wall Panels (incl. waterbar) (Provisional)	20.00	m	R 570.00
Structural Steelwork	**Items:**			
	Handrails with Kicker plates (Provisional)	20.00	m	R 1,760.00
	Grid Flooring (Provisional)	20.00	m^2	R 1,500.00
SUB-TOTAL A				
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED				
FINAL TOTAL FOR STRUCTURE				

TIES

25/08/2016
31/08/2016
Amount
R 176,000.00
R 8,800.00
R 136,000.00
R 188,500.00
R 58,500.00
R 0.00
R 114,000.00
R 11,400.00
R 35,200.00
R 30,000.00
R 758,400.00
R 151,680.00
R 910,080.00

INTERCONNECTING PIPEWORK QUANTITIES

							Calculated by:		DJB	05/09/2016
							Checked by:		IS	
Item	**PFD**	**Liquid**	**Diameter (mm)**	**Material**	**From**	**To**	**Total Quantity Regular**	**Unit**	**Rate**	**Amount**
Pipe Runs and Handling Fees	12	WAS	200	uPVC	Flow Diversion Structure	WAS Gravity Thickeners	80	m	R 130.00	R 10,400.00
	12	Scum	200	uPVC	WAS Gravity Thickeners	Scum Sump	270	m	R 130.00	R 35,100.00
	12	Thickener Overflow	200	uPVC	WAS Gravity Thickeners	Filtrate Sump	310	m	R 130.00	R 40,300.00
	12	Thickener Underflow	300	uPVC	WAS Gravity Thickeners	GBT	170	m	R 250.00	R 42,500.00
	13	WF Sludge	200	uPVC	Sludge Fermenters	GBT Tickened Sludge Storage Sump	145	m	R 130.00	R 18,850.00
	13	Primary Scum	200	uPVC	Primary Sedimentation Tanks	GBT Tickened Sludge Storage Sump	145	m	R 130.00	R 18,850.00
	14	Thickened Sludge	200	uPVC	GBT Building	Distribution Tower	200	m	R 130.00	R 26,000.00
	14	Thickened Sludge	200	Steel	Distribution Tower	Anaerobic Digesters (6 off)	110	m	R 1,300.00	R 143,000.00
	14	Grit & Sludge	200	uPVC	Anaerobic Digesters	Grit Drying Beds	210	m	R 130.00	R 27,300.00
	14	Digested Sludge	200	uPVC	Anaerobic Digesters (Drain)	Digested Sludge Storage Tanks	565	m	R 130.00	R 73,450.00
	14	Digester Overflow	200	uPVC	Anaerobic Digesters	Struvite Reactors	335	m	R 130.00	R 43,550.00
	14	Grit Decant	200	uPVC	Grit Drying Beds	Filtrate Sump (?)	105	m	R 130.00	R 13,650.00
	14	Gas	400	Steel	Boiler Houses	Gas Holding Tanks	200	m	R 4,000.00	R 800,000.00
	15	Lime Underflow	200	uPVC	Lime Clarifier	Digested Sludge Storage Tanks	65	m	R 130.00	R 8,450.00
	16	Gas	400	Steel	Anaerobic Digesters	Boiler Houses	300	m	R 4,000.00	R 1,200,080.00
	16	Gas	400	Steel	Boiler Houses	Heat Exchangers	100	m	R 4,000.00	R 400,000.00
	19	Stormwater Run-Off	500	Concrete	Sludge Stockpiling Area	Stormflow Dam	800	m	R 800.00	R 640,000.00
	20	BFP & GBT Filtrate	200	uPVC	BFP Building	Lime Reaction Tanks	35	m	R 130.00	R 4,550.00
	20	Lime Make-Up	200	uPVC	Lime Make-Up Tanks	Lime Reaction Tanks	25	m	R 130.00	R 3,250.00
	20	Lime Overflow	200	uPVC	Lime Clarifier	Filtrate Sump	45	m	R 130.00	R 5,905.90
	20	Lime Scum	200	uPVC	Lime Clarifier	Scum Sump	80	m	R 130.00	R 10,423.40
	20	Filtrate	200	uPVC	Filtrate Sump	Head of Works	1200	m	R 130.00	R 156,000.00
								m		R 0.00
Pipe Bends and Handling Fees			200	uPVC	45° Bend		35	No.	R 600.00	R 21,000.00
			200	uPVC	90° Bend		70	No.	R 600.00	R 42,000.00
			300	uPVC	45° Bend		10	No.	R 2,100.00	R 21,000.00
			300	uPVC	90° Bend		10	No.	R 2,100.00	R 21,000.00
			400	Steel	45° Bend		15	No.	R 10,000.00	R 150,000.00
			400	Steel	90° Bend		2	No.	R 10,000.00	R 20,000.00
			500	Concrete	45° Bend		2	No.	R 15,000.00	R 30,000.00
			500	Concrete	90° Bend		5	No.	R 15,000.00	R 75,000.00
Pipe Tees and Handling Fees			200	uPVC			20	No.	R 600.00	R 12,000.00
			400	Steel			8	No.	R 15,000.00	R 120,000.00
Estimated Pipe Excavations					**Over 0mm up to 500mm Diameter for Depths:**					
					0 m- 2m		2580	m^3	R 450.00	R 1,161,000.00
					2 m- 4m		2211	m^3	R 900.00	R 1,989,900.00
					Extra Over Items for :					
					Excavation in Hard Rock (Assumed 20 %)		959	m^3	R 1,000.00	R 959,000.00
					Excavation in Unsuitable Material from Bottom of Trench (Assumed 10 %)		480	m^3	R 100.00	R 48,000.00
					Excavation and Backfill by Hand in Restricted Areas (Assumed 10 %)		480	m^3	R 150.00	R 72,000.00
					Shoring of Trenches where Instructed by Engineer (Assumed 5 %)		240	m^3	R 250.00	R 60,000.00
Test, Supply, Handle, Lay, Bed Class C					Over 0mm upto 500mm Diameter for Depths:		4786	m	R 250.00	R 1,196,402.50
Bedding Pipes					**From Trench Excavations**					
			200		Bedding		406	m^3	R 200.00	R 81,260.13
					Blanket		1355	m^3	R 200.00	R 270,945.60
			300		Bedding		22	m^3	R 200.00	R 4,348.60
					Blanket		73	m^3	R 200.00	R 14,667.60
			500		Bedding		146	m^3	R 200.00	R 29,120.00
					Blanket		489	m^3	R 200.00	R 97,856.00
			200, 300, 500		Backfill		2301	m^3	R 200.00	R 460,200.00
SUB-TOTAL A: REFER TO CALCULATIONS FOR BREAKDOWN										R 10,072,117.53
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED										R 2,014,424.00
FINAL TOTAL FOR STRUCTURE										R 12,086,541.53

RESTRICTED AND BULK EARTHWORKS

Item	Description	Total Quantity Regular	Unit	Rate	Amount
	Calculated by:			JE / LM	01/09/2016
	Checked by:				
Bulk Earthworks	**Clear & Grub**	**84400.00**	**m^2**	**R 3.00**	**R 253,200.00**
	Bulk Excavation	**92560.00**	m^3		
	0 - 2m	57040.00	m^3	R 120.00	R 6,844,800.00
	2 - 4m	27360.00	m^3	R 850.00	R 23,256,000.00
	4 - 6m	7180.00	m^3	R 850.00	R 6,103,000.00
	6 - 8m	980.00	m^3	R 850.00	R 833,000.00
	8 - 10m	0.00	m^3	R 850.00	R 0.00
	10 - 12m	0.00	m^3	R 850.00	R 0.00
	Bulk Fill	**48790.00**	**m^3**		
	Re-useable Material (incl.)	45630.00	m^3	R 0.00	R 0.00
	Imported from Commercial Sources	3160.00	m^3	R 250.00	R 790,000.00
	Blasting	**29210.00**	**m^3**		
	Blasting in Hard Rock (incl.)	29210.00	**m^3**	R 0.00	R 0.00
Restricted Excavation	**Anaerobic Digester Cluster**	**11450.00**	**m^3**		
	0 - 2m	5190.00	m^3	R 1,020.00	R 5,293,800.00
	2 - 4m	4550.00	m^3	R 1,020.00	R 4,641,000.00
	4 - 6m	1710.00	m^3	R 1,020.00	R 1,744,200.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	WAS Thickener Cluster	**360.00**	**m^3**		
	0 - 2m	320.00	m^3	R 1,020.00	R 326,400.00
	2 - 4m	40.00	m^3	R 1,020.00	R 40,800.00
	4 - 6m	0.00	m^3	R 1,020.00	R 0.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	Gas Holder	**360.00**	**m^3**		
	0 - 2m	340.00	m^3	R 1,020.00	R 346,800.00
	2 - 4m	20.00	m^3	R 1,020.00	R 20,400.00
	4 - 6m	0.00	m^3	R 1,020.00	R 0.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	GBT & FBP Building	**3680.00**	**m^3**		
	0 - 2m	3420.00	m^3	R 1,020.00	R 3,488,400.00
	2 - 4m	150.00	m^3	R 1,020.00	R 153,000.00
	4 - 6m	110.00	m^3	R 1,020.00	R 112,200.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	Grit Drying Beds	**770.00**	**m^3**		
	0 - 2m	**770.00**	m^3	R 1,020.00	R 785,400.00
	2 - 4m	**0.00**	m^3	R 1,020.00	R 0.00
	4 - 6m	**0.00**	m^3	R 1,020.00	R 0.00
	6 - 8m	**0.00**	m^3	R 1,020.00	R 0.00
	Lime Cluster	**5070.00**	**m^3**		
	0 - 2m	2240.00	m^3	R 1,020.00	R 2,284,800.00
	2 - 4m	1920.00	m^3	R 1,020.00	R 1,958,400.00
	4 - 6m	880.00	m^3	R 1,020.00	R 897,600.00
	6 - 8m	30.00	m^3	R 1,020.00	R 30,600.00
	Return Pump Station	**1600.00**	**m^3**		
	0 - 2m	950.00	m^3	R 1,020.00	R 969,000.00
	2 - 4m	540.00	m^3	R 1,020.00	R 550,800.00
	4 - 6m	110.00	m^3	R 1,020.00	R 112,200.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	Solar Drying Beds	**5860.00**	**m^3**		
	0 - 2m	**5860.00**	m^3	R 1,020.00	R 5,977,200.00
	2 - 4m	**0.00**	m^3	R 1,020.00	R 0.00
	4 - 6m	**0.00**	m^3	R 1,020.00	R 0.00
	6 - 8m	**0.00**	m^3	R 1,020.00	R 0.00
	Outloading Station	**570.00**	**m^3**		

Item	Description	Total Quantity Regular	Unit	Rate	Amount
	0 - 2m	570.00	m^3	R 1,020.00	R 581,400.00
	2 - 4m	0.00	m^3	R 1,020.00	R 0.00
	4 - 6m	0.00	m^3	R 1,020.00	R 0.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	Sludge Stockpiling Area	**3080.00**	**m^3**		
	0 - 2m	3080.00	m^3	R 1,020.00	R 3,141,600.00
	2 - 4m	0.00	m^3	R 1,020.00	R 0.00
	4 - 6m	0.00	m^3	R 1,020.00	R 0.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	Excavate and Dispose of Unsuitbale Material and Hard rock	**40920.00**	**m^3**	**R 120.00**	**R 4,910,400.00**
SUB-TOTAL A					R 76,446,400.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 0.00
FINAL TOTAL FOR STRUCTURE					R 76,446,400.00

RESTRICTED AND BULK EARTHWORKS

Item	Description	Total Quantity Regular	Unit	Rate	Amount
			Calculated by:	TD	01/09/2016
			Checked by:		
Concrete	**Total Structural Concrete**	**2360.00**	**m^3**	**R 2,200.00**	**R 5,192,000.00**
	Walls and Floors	2360.00	m^3		
	Provisional: Mass Concrete	**118.00**	**m^3**	**R 2,200.00**	**R 259,600.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**284.00**	**Ton**	**R 13,600.00**	**R 3,862,400.00**
Formwork	**Total Formwork**	**8400.00**	**m^2**		
	Vertical	**8400.00**	**m^2**	**R 650.00**	**R 5,460,000.00**
	Walls	7720.00	m^2		
	Footings	680.00	m^2		
SUB-TOTAL A					R 14,774,000.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 0.00
FINAL TOTAL FOR STRUCTURE					R 14,774,000.00

		0 to 2m	2 to 4m	4 to 6m	6 to 8m	TOTAL
Lime clarifier	m^3	3365.49	226.03	0	0	3591.52
Digester	m^3	6445.71	2018.68	146.34	0	8610.73
Was thickener	m^3	1154.5	13.73	0	0	1168.23
Grit Drying Bed	m^3	0.32	0	0	0	0.32
Sludge Drying Bed	m^3	22715.76	13269.91	5753.55	981.1	42720.32
Sludge Stockpiling Area	m^3	9138.88	5233.13	1280.41	0	15652.42
Belt Press building	m^3	1056.22	284.58	0	0	1340.8
	TOTAL	**43876.88**	**21046.06**	**7180.3**	**981.1**	
ADJUSTED (30% MORE)	**TOTAL**	**57039.94**	**27359.88**	**9334.39**	**1275.43**	

	Blasting(m^3)	+ 30%
Lime clarifier	226.03	293.839
Digester	2165.02	2814.526
Was thickener	13.73	17.849
Grit Drying Bed	0	0
Sludge Drying Bed	20004.56	26005.93
Sludge Stockpiling Area	6513.54	8467.602
Belt Press building	284.58	369.954

	FILL	+ 30%
Lime clarifier	1081.47	1405.911
Digester	22624.86	29412.32
Was thickener	7100.79	9231.027
Grit Drying Bed	5040.28	6552.364
Sludge Drying Bed	1630.6	2119.78
Sludge Stockpiling Area	53.68	69.784
Belt Press building	0	0
TOTAL		**48791.18**
TOTAL RE-USABLE		45631.96

CLEAR & GRUB	48468	m^2
+ 30%	**63008.4**	

TOTAL + 30%		Total
4668.976	Lime clarifier	3591.52
11193.949	Digester	8610.73
1518.699	Was thickener	1168.23
0.416	Grit Drying Bed	0.32
55536.416	Sludge Drying Bed	42720.32
20348.146	Sludge Stockpiling Area	15652.42
1743.04	Belt Press building	1340.8
	TOTAL ROCK	

From 2m	From 4m	From 6m	From 8m	2D Area	Fill
226.03	0	0	0	4592.59	1081.47
2165.02	146.34	0	0	14877.33	22624.86
13.73	0	0	0	4283.83	7100.79
0	0	0	0	2319.22	5040.28
20004.56	6734.65	981.1	0	15869.24	1630.6
6513.54	1280.41	0	0	5843.59	53.68
284.58				682.2	0
29207.46					

Anaerobic Digester Cluster

Digester					no of		
0 - 2m	756.82			756.82	6	4540.92	
2 - 4m	756.82			756.82	6	4540.92	
4 - 6m	270.56315	13.35		283.9132	6	1703.479	
Boiler House							
0 - 2m	259.2384	11.7312		270.9696	2	541.9392	Assumed F
2 - 4m				0	2	0	
4 - 6m				0	2	0	
Division Tower							
0 - 2m	103.8251507			103.8252	1	103.8252	
2 - 4m				0	1	0	Assumed F
4 - 6m				0	1	0	

WAS Thickener Cluster

0 - 2m	36.50812	32.53	8.758	77.79612	4	311.1845	Feed Box e
2 - 4m	1.31	7.1725		8.4825	4	33.93	
4 - 6m				0	4	0	

Gas Holder

0 - 2m	295.677	40.28		335.957	1	335.957	Assumed F
2 - 4m		13.3931		13.3931	1	13.3931	
4 - 6m				0	1	0	

GBT & FBP Building (incl conveyor cut)

0 - 2m	3377.4129	42.27	506.1033	3925.786	1	3925.786	Assumed F
2 - 4m	149.95			149.95	1	149.95	
4 - 6m	108.62			108.62	1	108.62	

Grit Drying Beds

0 - 2m	581.80278	91.767	91.1872	764.757	1	764.757	Assumed F
2 - 4m					1	0	
4 - 6m					1	0	

Lime Cluster (incl Lime dosing)

0 - 2m	830.96			830.96	2	1661.92	2 Clarifiers
2 - 4m	830.96			830.96	2	1661.92	
4 - 6m	361.4676	77		438.4676	2	876.9352	

6 - 8m	13.9675		13.9675	2	27.935	
Dosing & Pump Station						
0 - 2m	29.028	204	233.028	1	233.028	
2 - 4m		51	51	1	51	
4 - 6m		0.8125	0.8125	1	0.8125	
6 - 8m			0	1	0	
Lime Reator						
0 - 2m	344.43		344.43	1	344.43	
2 - 4m	198.04725		198.0473	1	198.0473	
4 - 6m			0	1	0	
6 - 8m			0	1	0	

Return PS

0 - 2m	943.85		943.85	1	943.85	Assumed N
2 - 4m	259.55875	276.8993	536.458	1	536.458	
4 - 6m	0.88	105.0308	105.9108	1	105.9108	

Solar Drying Beds

0 - 2m	509.5278	467.0672	976.595	6	5859.57	Assumed N
2 - 4m			0	1	0	
4 - 6m			0	1	0	

Outloading Station

0 - 2m	477.48	89.23845	566.7185	1	566.7185	Assumed N
2 - 4m			0	1	0	
4 - 6m			0	1	0	

Sludge Storage Bunker

0 - 2m	3029.91085	41.5616	3071.472	1	3071.472	Assumed N
2 - 4m			0	1	0	
4 - 6m			0	1	0	

Totals

Anaerobic Digester Cluster

0 - 2m	5186.684
2 - 4m	4540.92
4 - 6m	1703.479

GL to be 100mm below door

GL 500mm above concrete footing

xcluded, Manholes Excluded (floating)

Anaerobic Digester Cluster

0 - 2m	311.1845
2 - 4m	33.93
4 - 6m	0

GL is 50mm below concrete footing

Gas Holder

0 - 2m	335.957
2 - 4m	13.3931
4 - 6m	0

GL is 50mm below concrete footing

GBT & FBP Building

0 - 2m	3925.786
2 - 4m	149.95
4 - 6m	108.62

GL is 50mm below TOC

Grit Drying Beds

0 - 2m	764.757
2 - 4m	0
4 - 6m	0

Lime Cluster

0 - 2m	2239.378
2 - 4m	1910.967

4 - 6m	877.7477
6 - 8m	27.935

GL is 50mm below TOC

Return PS	
0 - 2m	943.85
2 - 4m	536.458
4 - 6m	105.9108

GL is 50mm below TOC of Footing/Floor

Solar Drying Beds	
0 - 2m	5859.57
2 - 4m	0
4 - 6m	0

GL is 50mm below TOC of Floor

Solar Drying Beds	
0 - 2m	566.7185
2 - 4m	0
4 - 6m	0

GL is 100mm below TOC of Kerb

Solar Drying Beds	
0 - 2m	3071.472
2 - 4m	0
4 - 6m	0

RETAINING WALLS

		Calculated by:		JE / LM	01/09/2016
		Checked by:			
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Retaining Walls	**Sub Total For Retaining Walls**	**2730.00**	**m**		
	0 - 2m Sub Total	**1500.00**	**m**	**R 0.00**	**R 0.00**
	2 - 4m Sub Total	**765.00**	**m**	**R 0.00**	**R 0.00**
	4 - 6m Sub Total	**355.00**	**m**	**R 0.00**	**R 0.00**
	6 - 8m Sub Total	**110.00**	**m**	**R 0.00**	**R 0.00**
	Lime Cluster Terrace (1286.00m)				
	0 - 2m	195.00	m		
	2 - 4m	40.00	m		
	4 - 6m	0.00	m		
	6 - 8m	0.00	m		
	Anaerobobic Digester Cluster (1289.00m)				
	0 - 2m	330.00	m		
	2 - 4m	190.00	m		
	4 - 6m	40.00	m		
	6 - 8m	0.00	m		
	WAS Thickener Cluster (1291.34m)				
	0 - 2m	120.00	m		
	2 - 4m	60.00	m		
	4 - 6m	10.00	m		
	6 - 8m	0.00	m		
	Grit Drying Beds (1289.00m)				
	0 - 2m	85.00	m		
	2 - 4m	35.00	m		
	4 - 6m	0.00	m		
	6 - 8m	0.00	m		
	Solar Drying Beds (1293.40m)				
	0 - 2m	495.00	m		
	2 - 4m	245.00	m		
	4 - 6m	185.00	m		
	6 - 8m	110.00	m		
	Sludge Stockpiling Area (1293.40m)				
	0 - 2m	215.00	m		
	2 - 4m	165.00	m		
	4 - 6m	115.00	m		
	6 - 8m	0.00	m		
	GBT & FBP Building (1288.85m)				
	0 - 2m	60.00	m		
	2 - 4m	30.00	m		
	4 - 6m	5.00	m		
	6 - 8m	0.00	m		
SUB-TOTAL A					R 0.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 0.00
FINAL TOTAL FOR STRUCTURE					R 0.00

SECTION 1 : MECHANICAL EQUIPMENT FOR THE HEAD OF WORKS

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
1.1	**Design, Manufacture, Delivery, Installation and Commissioning of Clamshell Bucket Stone removal equipment**				
1.1.1	500 liter Clamshell buckets	No	1	81,880.00	81,880.00
1.1.2	Steel A-frame with crawl beam including trolley, electric hoist	No	1	75,000.00	75,000.00
1.2	**Design, Manufacture, Delivery, Installation and Commissioning of Coarse Screening equipment**				
1.2.1	Complete Mechanically front raked Screen for a 1500mm wide channel with 12mm bar spacing	No	2	480,000.00	960,000.00
1.3	**Design, Manufacture, Delivery, Installation and Commissioning of Coarse Screenings handling Equipment**				
1.3.1	Hydraulic Screenings conveyor complete in	No	1	220,000.00	220,000.00
1.3.2	Screenings press / compactor complete in	No	2	625,000.00	1,250,000.00
1.4	**Design, Manufacture, Delivery, Installation and Commisioning of electrically/manually operated penstocks**				
1.4.1	Manual Operated channel penstocks dimensions 2000mm wide x 2000mm deep	No	4	215,000.00	860,000.00
1.4.2	Electrically Actuated channel penstocks dimensions 1500mm wide x 2000mm deep	No	2	194,000.00	388,000.00
1.4.3	Electrically Actuated channel penstocks dimensions 1500mm wide x 1900mm deep	No	2	194,000.00	388,000.00
1.4.4	Electrically Actuated channel gates complete 1300mm wide x 1900mm deep	No	2	160,000.00	320,000.00
1.4.5	Electrically Actuated channel gates complete 1300mm wide x 2000mm deep	No	2	160,000.00	320,000.00
1.4.6	Electrically Actuated channel gates complete 2600mm wide x 2450mm deep	No	2	248,000.00	496,000.00
1.4.7	Electrically Actuated channel gates complete 2600mm wide x 2950mm deep	No	2	261,000.00	522,000.00
1.4.8	Manual Operated wall penstocks 1800mm wide x 1800mm deep	No	2	194,000.00	388,000.00
1	**Total**				**6,268,880.00**

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
BROUGHT FORWARD					6,268,880.00
1.5	**Design, Manufacture, Delivery, Installation and Commissioning of the Grit handling Equipment**				
1.5.1	Internal pipework for each vortex degritter including - washwater, compressed air, air blower and grit	No	2	80,293.53	160,587.07
1.5.2	Complete Airlift system	No	2	350,000.00	700,000.00
1.5.3	Grit classifiers complete with feed troughs and hand stops including air lift pipework from each vortex chamber to the grit classifiers.	No	2	200,000.00	400,000.00
1.5.4	Washwater strorage tank, 2 pumps, pipework, valves and supports for each vortex chamber to connect to the pipework priced under item 2.4.1	sum	2	97,422.82	194,845.64
1.6	**Design, Manufacture, Delivery, Installation and Commissioning of Fine Screening equipment**				
1.6.1	Complete Mechanically Drum Type Screen for a 2600mm wide channel with 6mm openings	No	2	2,180,000.00	4,360,000.00
1.7	**Design, Manufacture, Delivery, Installation and Commissioning of Fine Screenings handling Equipment**				
1.7.1	Hydraulic Screenings conveyor complete at Fine Screens	No	1	220,000.00	220,000.00
1.7.2	Screenings press / compactor complete at Fine Screens	No	1	625,000.00	625,000.00
1.8	**Design, Manufacture, Delivery, Installation and Commissioning of Miscelaneous equipment**				
1.8.1	Skips	No	6	35,000.00	210,000.00
1.8.2	Manual Screen	No	3	50,000.00	150,000.00
1	**Total Section 1**				**13,289,312.71**

SECTION 2 : MECHANICAL EQUIPMENT FOR THE PST's

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
2.1	**Design, Manufacture, Delivery, Installation and Commissioning of**				
2.1.1	Complete mechanical equipment for 34m PST including single peripheral drive bridge, floor scraper, scum scraper, scum baffle, weir plate and scum trough	No	2	978,912.01	1,957,824.02
2.1.2	200mm Diameter electrically operated knife gate valves as specified	No	4	67,955.09	271,820.38
2.1.3	Launder covers	m^2	125.92	500.00	62,957.52
2.1.4	Manual Operated wall penstocks 900mm wide x 900mm deep	No	2	92,000.00	184,000.00
2	**Total Section 2**				**2,476,601.92**

SECTION 3 : MECHANICAL EQUIPMENT FOR THE FERMENTERS

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
3.1	**Design, Manufacture, Delivery, Installation and Commissioning of**				
3.1.1	Complete mechanical equipment for the 30m Fermenter including single peripheral drive bridge, floor scraper, picket fences, weir plate	No	2	978,912.01	1,957,824.02
3.1.2	200mm Diameter electrically operated knife gate valves as specified	No	2	67,955.09	135,910.19
3.1.3	Tank covers	m^2	1414	500.00	706,858.35
3.1.4	Complete odour control system	Sum	1	10,705,804.62	10,705,804.62
3.1.5	Manual Operated wall penstocks 1000mm wide x 500mm deep	No	2	77,000.00	154,000.00
3	**Total Section 3**				**13,660,397.18**

SECTION 4 : MECHANICAL EQUIPMENT FOR THE BALANCING TANKS

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
4.1	**Design, Manufacture, Delivery, Installation and Commissioning of Mechanical surface mounted mixer complete including impellors, drive shaft, slow speed coupling, gearbox, mounting plate, high speed coupling and electric motor**				
4.1.1	7.5 kW for a height from platform to floor of 4950mm	No	8	78,928.54	631,428.36
4.2	**Design, Manufacture, Delivery, Installation and Commissioning of electrically/manually operated penstocks**				
4.2.1	1500mm by 1500mm with spindle height of 8850mm	No	2	161,000.00	322,000.00
4.2.2	1500mm by 1500mm with spindle height of 5700mm	No	2	158,000.00	316,000.00
4.2.3	1500mm by 1500mm with spindle height of 5950mm	No	2	158,000.00	316,000.00
4.2.4	Portable steel frame for maintenance of the aerators complete as specified	No	1	20,006.47	20,006.47
4.3	**Balancing tank Drain Pumps**				
4.3.1	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	50,000.00	50,000.00
4.3.2	Control valves	No	2	200,733.84	401,467.67
4	**Total Section 4**				**2,056,902.50**

SECTION 5 : MECHANICAL EQUIPMENT FOR THE BNR REACTOR

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
5.1	**Design, Manufacture, Delivery, Installation and Commissioning of** **Mechanical surface mounted mixer complete including impellors, drive shaft, slow speed coupling, gearbox, mounting plate, high speed coupling and electric motor**				
5.1.1	7.5 kW for a height from platform to floor of 7000mm	No	7	110,499.96	773,499.74
5.2	**Design, Manufacture, Delivery, Installation and Commissioning of** **electrically/manually operated penstocks** complete as specified - to suit opening in a wall of				
5.2.1	1000mm by 1000mm with spindle height of 9000mm	No	2	116,000.00	232,000.00 0.00
5.2.2	1000mm by 500mm with spindle height of 2600mm	No	2	77,000.00	154,000.00
5.2.3	500mm by 500mm with spindle height of 5600mm	No	2	42,000.00	84,000.00
5.2.4	500mm by 500mm with spindle height of 8000mm	No	2	48,000.00	96,000.00
5.2.5	Adjustable weir	No	4	143,307.23	573,228.93
5.2.6	Portable steel frame for maintenance of the aerators complete as specified	No	1	25,000.00	25,000.00
5.3	**Design, Manufacture, Delivery, Installation and Commissioning of**				
5.3.01	Centrifugal Blowers	No.	6	3,102,015.80	18,612,094.80
5.3.02	Blowerroom Stainless Steel Piping, including all Piping ,Dismanteling Joints, Isolation Valves, Bellows and Pipe Support structures	Sum	1	711,774.10	711,774.10
5.3.03	Discharge Stainless Steel Piping up to Flow Measurement piping, including all Piping , Bellows and Pipe Support structures	Sum	2	1,463,602.70	2,927,205.40
5.3.04	Flow Measurement and Dropleg Stainless Steel Piping, including all Piping ,Dismanteling Joints, Butterfly and Actuator Prepared Knife Gate Valves and Pipe Support structures	Sum	2	1,282,146.50	2,564,293.00
5.3.05	Lateral and distribution pipework including anchors, supports and condensate removal system complete with Quick Connection Saddles and Diffusers where applicable	Sum	2	2,389,474.60	4,778,949.20
5.3.06	Performance Testing of entire FBDA system	Sum	1	414,000.00	414,000.00
5.3.07	RAS pumps	No.	4	750,000.00	3,000,000.00
5.3.08	GRP covers	m^2	200	500.00	100,000.00
5.3.09	A-Recycle pumps	No.	3	239,016.46	717,049.37
5.3.10	B-Recycle pumps	No.	2	138,218.63	276,437.26
5.3.11	Sampling Pumps	No.	2	50,000.00	100,000.00
5.3.12	200mm Diameter electrically operated knife gate valves as specified	No	2	67,955.09	135,910.19
5	**Total Section 5**				**36,275,441.98**

SECTION 6 : MECHANICAL EQUIPMENT FOR SECONDARY CLARIFIERS

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
6.1	**Design, Manufacture, Delivery, Installation and Commissioning of**				
6.1.1	Complete mechanical equipment for 34m Clarifier including single peripheral drive bridge, floor scraper, scum scraper, scum baffle, weir plate and scum trough	No	2	978,912.01	1,957,824.02
6.2	**Design, Manufacture, Delivery, Installation and Commisioning of electrically/manually operated penstocks**				
6.2.1	Manual Operated wall type penstocks 900mm by 900mm with spindle height of 4900mm	No	2	92,000.00	184,000.00
6.2.2	Handstop 200mm by 200mm with spindle height of2000mm	No	4	10,000.00	40,000.00
6.2.3	Launder covers	m^2	126	500.00	62,957.52
6	**Total Section 6**				**2,244,781.54**

SECTION 7 : MECHANICAL EQUIPMENT FOR THE PRIMARY SLUDGE PUMP STATION

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
7.1	**Primary Sludge Pumps**				
7.1.1	Vertical shaft mounted mixers complete with motor, gearbox,base plate, coupling and holding down bolts.	No	2	50,000.00	100,000.00
7.1.2	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	3	86,940.00	260,820.00
7.1.3	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	202,072.06	202,072.06
7.2	**Settled Sewage Pumps**				
7.2.1	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	4	104,420.00	417,680.00
7.2.2	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	202,072.06	202,072.06
7.2.3	Pump Station floor drainage pump including pipework	No	1	74,750.00	74,750.00
7.2.4	Lifting equipment	Sum	1	30,000.00	30,000.00
7	**Total Section 7**				**1,287,394.12**

Total Section 1

SECTION 8 : MECHANICAL EQUIPMENT FOR THE FERMENTER PUMP STATION

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
8.1	**Waste Fermented Sludge Pumps**				
8.1.1	Vertical shaft mounted mixers complete with motor, gearbox,base plate, coupling and holding down bolts.	No	2	57,500.00	115,000.00
8.1.2	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	2	75,555.00	151,110.00
8.1.3	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	202,072.06	202,072.06
8.1.4	Pump Station floor drainage pump complete with pipework, fittings, valves and supports.	No	1	74,750.00	74,750.00
8.2	**Recycle Fermented Sludge Pumps**				
8.2.1	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	2	105,627.50	211,255.00
8.2.2	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	202,072.06	202,072.06
8.2.3	Air extraction system	Sum	1	50,000.00	50,000.00
8	**Total Section 8**				**1,006,259.12**

SECTION 9 : MECHANICAL EQUIPMENT FOR THE WAS PUMP STATION

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
9.1	**WAS Pump Station**				
9.1.1	Vertical shaft mounted mixers complete with motor, gearbox,base plate, coupling and holding down bolts.	No	2	50,000.00	100,000.00
9.1.2	Support bridge for mixers complete with access ladder, handrailing and holding down bolts.	No	1	50,000.00	50,000.00
9.1.3	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	4	97,750.00	391,000.00
9.1.4	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	202,072.06	202,072.06
9.1.5	Pump Station floor drainage pump complete with pipework, fittings, valves and supprts.	No	1	74,750.00	74,750.00
9.1.6	Lifting equipment	Sum	1	30,000.00	30,000.00
9.1.7	Air extraction system	Sum	1	50,000.00	50,000.00
9	**Total Section 9**				**897,822.06**

SECTION 10 : MECHANICAL EQUIPMENT FOR THE WASHWATER PUMP STATION

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
10.1	**Chlorination Channel Sludge Pumps**				
10.1.1	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	2	86,940.00	173,880.00
10.1.2	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	200,733.84	200,733.84
10.2	**Washwater to HOW Pumps**				
10.2.1	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	2	154,330.00	308,660.00
10.2.2	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	200,733.84	200,733.84
10.3	**Washwater to Sludge Handling Pumps**				
10.3.1	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	2	113,505.00	227,010.00
10.3.2	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	200,733.84	200,733.84
10.3.3	Pump Station floor drainage pump complete with pipework, fittings, valves and supprts.	No	1	74,750.00	74,750.00
10.3.4	Lifting equipment	Sum	1	30,000.00	30,000.00
10.3.5	Air extraction system	Sum	1	50,000.00	50,000.00
10	**Total Section 10**				**1,091,887.67**

SECTION 11 : MECHANICAL EQUIPMENT FOR STORMFLOW DAM PUMP STATION

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
11.1	**Stormflow Dam Pumps**				
11.1.1	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	3	655,500.00	1,966,500.00
11.1.2	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	602,201.51	602,201.51
11.1.3	Pump Station floor drainage pump complete with pipework, fittings, valves and supprts.	No	1	74,750.00	74,750.00
11.1.4	Lifting equipment	Sum	1	30,000.00	30,000.00
11.1.5	Manual Screen	No	1	50,000.00	50,000.00
11.1.6	Air extraction system	Sum	1	50,000.00	50,000.00
11	**Total Section 11**				**2,773,451.51**

SECTION 12: MECHANICAL EQUIPMENT FOR FERRIC DOSING AND DISINFECTION

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
12.1	**Design, Manufacture and deliver Mechanical equipment for Ferric dosing system. In accordance with the Specification**				
12.1.1	Ferric storage tank complete with all necessary nozzles, breathers and manholes In accordance with the Specification.	No	2	222,653.97	445,307.94
12.1.2	Ferric dosing pumps complete with FRP mounting stand. In accordance with the Specification.	No	4	106,308.64	425,234.56
12.1.3	Interconnecting pipework, fittings, valves and pipe supports from the tanker off loading point to the storage tank and storage tanks to the pumps.	sum	1	35,061.51	35,061.51
12.1.4	Dosing pipework from dosing pumps to a point 1.0m outside the bund wall including fittings, valves, pressure release valves, pulstaion dampers, back pressure valves and Calibration chambers	sum	1	145,987.03	145,987.03
12.1.5	GRP constructed lean too for covering the dosing pump bunded section	m2	20	655.73	13,114.61
12.1.6	Emergency eye and shower unit including all health and safety signage.	sum	1	11,388.30	11,388.30
12.2	**Design, Manufacture and delivery of mechanical equipment for disinfection dosing**				
12.2.1	DBF Receiving tank	No	1	238,592.24	238,592.24
12.2.2	DBF Storage tanks	No	2	221,288.98	442,577.96
12.2.3	Acid wash tank complete with connecting pipework, valves,fittings and supports	Sum	1	13,730.19	13,730.19
12.2.4	Pipework, valves, fittings and suppors from the tanker offloading point to the receiving tank ad from the receiving tank to the storage tanks	Sum	1	27,273.04	27,273.04
12.2.5	Pipework, valves, fittings and suppors from the storage tanks to the suction side of the dosing pumps	Sum	1	23,445.71	23,445.71
12.2.6	Pipework, valves,fittngs and supports for the dosing pump delivery up to 1.0m outside the bunded area	Sum	1	23,445.71	23,445.71
12.2.7	Dosing pumps complete as specified	No	2	121,751.76	243,503.53
12.3	**Design, Manufacture, Delivery, Installation and Commisioning of electrically/manually operated penstocks**				
12.3.1	1800mm by 1800mm with spindle height of 3600mm	No	1	191,625.34	191,625.34
12.3.2	1000mm by 1000mm with spindle height of 3600mm	No	1	59,143.62	59,143.62
12.3.3	1000mm by 500mm with spindle height of 2600mm	No	1	29,571.81	29,571.81
12.3.4	Pump Station floor drainage pump complete with pipework, fittings, valves and supprts.	No	1	74,750.00	74,750.00
12.3.5	Sampling Pumps	No	2	50,000.00	100,000.00
12.3.6	Air extraction system	Sum	1	50,000.00	50,000.00
12	**Total Section 12**				**2,593,753.11**

JOHANNESBURG WATER

LANSERIA WASTEWATER TREATMENT WORKS

Mechanical Equipment for Liquid Stream Process Units

SECTION		TENDER AMOUNT
Section 1	HOW	R 13,289,000.00
Section 2	PST	R 2,477,000.00
Section 3	Fermenters	R 13,660,000.00
Section 4	Balancing Tanks	R 2,057,000.00
Section 5	BNR Bioreactor	R 36,275,000.00
Section 6	Clarifiers	R 2,245,000.00
Section 7	Primary Sludge Pump Station	R 1,287,000.00
Section 8	Fermenter Pump Station	R 1,006,000.00
Section 9	WAS Pump Station	R 898,000.00
Section 10	Washwater Pump Station	R 1,092,000.00
Section 11	Stormflow Dam Pump Station	R 2,773,000.00
Section 12	Ferric Dosing & Disinfection	R 2,594,000.00
	Net Total Amount Excluding VAT	R 79,653,000.00
	Add 10% Contingencies	R 7,965,300.00
	GROSS TOTAL OF TENDER	**R 87,618,300.00**

SCHEDULE 1: GENERAL REQUIREMENTS AND CONDITIONS							
ITEM	DESCRIPTION	UNIT	QTY	PRICE		TOTAL	
				R	c	R	c
1.1	**Allow for all costs and expenses in connection with the following:**						
1.1.1	All Preliminary and General costs, including Health & Safety, inspections, certificates and training	Sum				R 12,583,000.00	
TOTAL CARRIED FORWARD TO SUMMARY						**R 12,583,000.00**	

SCHEDULE 2: ANAEROBIC DIGESTER, MIXING EQUIPMENT AND PUMP STATION					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE** **R c**	**TOTAL** **R c**
2.	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
2.1.	Anaerobic digester mixing, (ANDM) self-priming centrifugal cutter pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified	No	4	R 806,400.00	R 3,225,600.00
2.2	Mixing jets system, one for each digester complete with all pipework, valves and nozzles, as specified	No	2	R 1,008,000.00	R 2,016,000.00
2.3	Computational fluid dynamic calculation and certification regarding the efficiency of the mixing system proposed and the positions of the directional elements of the system	Item	SUM	R 108,000.00	R 108,000.00
	Complete Digester Heating System including 1 heat echanger, 1 hot water pump, 2 sludge recycle pumps incl pipework, valves and fittings	Item	2	R 1,800,000.00	R 3,600,000.00
	Complete Boiler/burner system including 3 hot water boilers, gas detector expantion tanks gas boosters water softning water tank, diesel tank fans pipeowrk and controls	Item	1	R 3,168,000.00	R 3,168,000.00
	Complete Methane Gas collection system for six digesters including all gas pipework between digesters boilers waste gas burner gas take-off, valves, moister traps flame arrestors vacuum breakers meter and scrubbers etc, all as specified.	Item	1	R 4,104,000.00	R 4,104,000.00
2.11	Floatable gas-holding tank, complete as specified	No	1	R 7,920,000.00	R 7,920,000.00
2.13	Sludge feed distribution system consisting of:				
	a) All pipework	Sum	1	R 266,400.00	R 266,400.00
	b) Magflow meters	No	6	R 64,800.00	R 388,800.00
	c) Manually adjusted knife gate valve	No	6	R 5,000.00	R 30,000.00
2.14	All other plant and equipment items not included above but which are nevertheless necessary to meet the Scope of Work and/or are required for the proper, safe and effective operation of the plant	Sum	1	R 100,800.00	R 100,800.00
	(Specify)				
TOTAL CARRIED FORWARD/…………..					**R 24,927,600**

SCHEDULE 3: WAS Thickener TANKS					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**	**TOTAL**
				R c	**R c**
3	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
3.1	Was Thickeners, complete with bridges, stilling wells, flocculation baffles, scraper mechanisms, etc., all as specified	No	2	R 1,281,600.00	R 2,563,200.00
3.2	All other plant and equipment items not included above but which are nevertheless necessary to meet the Scope of Work and/or are required for the proper, safe and effective operation of the plant (Specify)	Item	1	R 518,400.00	R 518,400.00
TOTAL CARRIED FORWARD/…………..					**R 3,081,600**

SCHEDULE 4: PUMPING EQUIPMENT SCHEDULE					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**	**TOTAL**
				R c	**R c**
4	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
4.1	Anaerobic Digester feed, self-priming pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified	No	2	R 525,600.00	R 1,051,200.00
TOTAL CARRIED FORWARD/…………..					**R 1,051,200**

SCHEDULE 5: ACTUATED KNIFE-GATE VALVE AND FLOW CONTROL VALVE					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**	**TOTAL**
				R c	**R c**
5	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
5.1	200 mm diameter knife-gate valve, complete with electric actuator, as specified for automatically wasting from the WAS Thickeners	No	2	R 83,500.00	R 167,000.00
5.2	200 mm diameter knife-gate valve, complete with electric actuator, as specified for automatically wasting from the Lime Clarifiers	No	2	R 83,500.00	R 167,000.00
5.3	All other plant and equipment items not included above but which are nevertheless necessary to meet the Scope of Work and/or are required for the proper, safe and effective operation of the plant	Sum	1	R 108,000.00	R 108,000.00
	(Specify)				
TOTAL CARRIED FORWARD/…………..					**R 442,000.00**

SCHEDULE 6: HANDSTOPS, SLUICE GATES AND CHANNEL GATES					
ITEM	DESCRIPTION	UNIT	QTY	PRICE	TOTAL
				R c	R c
6	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
6.1	Wall mounted handstop and frame to suit a channel, 500mm wide by 500mm deep, complete with frame, handwheel, and gearbox if required, all as specified at the WAS Thickener division box	No.	4	R 6,500.00	R 26,000.00
6.2	Channel mounted sluice gate and frame to suit a channel, 600mm wide by 700mm deep, complete with frame, handwheel, and gearbox if required, all as specified at the Anaerobic Division Tower	No	2	R 28,000.00	R 56,000.00
6.3	Downwards opening sluice gate, to suit opening 750mm x 1000mm complete with frame, pedestal, handwheel, and gearbox (if required) 5250 spindle, all as specified at the Thickened WAS storage Tanks	No.	2	R 36,000.00	R 72,000.00
6.4	Downwards opening sluice gate, to suit opening 750mm x 1000mm complete with frame, pedestal, handwheel, and gearbox (if required) with a 5250mm spindle, all as specified at the Disgested Sludge Storage tanks	No.	2	R 36,000.00	R 72,000.00
6.5	Square handstops to suit 500mm x 500mm opening, complete at the GBT thickened Sump	No.	2	R 6,500.00	R 13,000.00
6.6	Telescopic Bellmouth at the outlet of the Anaerobic Digesters 200mm diameter with a 500mm travel	No	2	R 50,400.00	R 100,800.00
6.7	Square handstops to suit 500mm x 500mm opening, complete at the Lime Reactor	No.	5	R 6,480.00	R 32,400.00
TOTAL CARRIED FORWARD TO SUMMARY					**R 372,200.00**

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT Schedule 7.1: Filter Belt Press					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**	**TOTAL**
				R c	**R c**
7.1	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
7.1.1	Gravity Belt Thickeners complete as specified	No	2	R 1,666,700.00	R 3,333,400.00
7.1.2	Filter belt press complete as specified	No	2	R 2,934,000.00	R 5,868,000.00
TOTAL CARRIED FORWARD TO SUMMARY					**R 9,201,400.00**

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT Schedule 7.2: Pumping Equipment					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**	**TOTAL**
				R c	**R c**
7.2	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
7.2.1	Horizontal centrifugal wash water feed pump and motor, complete with baseplates, motors, etc., as specified	No	2	R 237,600.00	R 475,200.00
7.2.2	Horizontal centrifugal dilution water feed pump and motor, complete with baseplates, motors, etc., as specified	No	2	R 237,600.00	R 475,200.00
7.2.3	Progressing cavity polyelectrolyte transfer pump and motor, complete with baseplates, motors, etc., as specified	No	2	R 64,800.00	R 129,600.00
7.2.4	Progressing cavity polyelectrolyte dosing pump and motor (VSD), complete with baseplates, motors, etc., as specified	No	8	R 57,600.00	R 460,800.00
7.2.5	Filter Belt press feed, self-priming pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified	No	2	R 324,000.00	R 648,000.00
7.2.6	Gravity belt Thickeners feed, self-priming pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified	No	2	R 324,000.00	R 648,000.00
TOTAL CARRIED FORWARD TO SUMMARY					**R 2,836,800.00**

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT
Schedule 7.3: Polyelectrolyte Make-Up Equipment

ITEM	DESCRIPTION	UNIT	QTY	PRICE R c	TOTAL R c
7.3	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
	Note pipe work and instrumentation measured elsewhere				
7.3.1	Polyelectrolyte bead/head feed hopper	No	2	R 41,800.00	R 83,600.00
7.3.2	Polyelectrolyte Silo	No	1	R 936,000.00	R 936,000.00
7.3.3	Rotary vane dry polyelectrolyte feeder	No	2	R 39,600.00	R 79,200.00
7.3.4	Blower/Compressor	No	2	R 57,600.00	R 115,200.00
7.3.5	Jet wet head	No	1	R 18,000.00	R 18,000.00
7.3.6	Make up tank (effective volume 20 m^3)	No	1	R 122,400.00	R 122,400.00
7.3.7	Vertical shaft mixer for make up tank	No	1	R 21,600.00	R 21,600.00
7.3.8	Stock tank (effective volume 30 m^3)	No	1	R 158,400.00	R 158,400.00
7.3.9	Vertical shaft mixer for stock tank	No	1	R 21,600.00	R 21,600.00
TOTAL BROUGHT FORWARD/…….					**R 1,556,000.00**

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT Schedule 7.4: Sludge Conveyors					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**	**TOTAL**
				R c	**R c**
7.4	**SLUDGE CONVEYORS** **Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
7.4.1	Inclined Belt conveyor for delivery of sludge from the belt press to the sludge outloading stations, complete as specified, including access to both sides of the conveyor	sum	1	R 3,600,000.00	R 3,600,000.00
7.4.2	Horizontal spiral conveyor for GBT thickened sludge removal	No	2	R 280,800.00	R 561,600.00
TOTAL CARRIED FORWARD TO SUMMARY					**R 4,161,600**

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT Schedule 7.5: Pipework and Fittings							
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**		**TOTAL**	
				R	**c**	**R**	**c**
7.5	**PIPEWORK AND FITTINGS** **Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work by others:**						
7.5.1	Wash and dilution water strainer manifold, wash water strainers and automatic backwash assembly complete as specified	No	2	R 230,400.00		R 460,800.00	
TOTAL CARRIED FORWARD /…………						**R 460,800.00**	

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT Schedule 7.6: Mixers							
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**		**TOTAL**	
				R	**c**	**R**	**c**
7.6	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**						
7.6.1	30 kW vertical shaft mixers, all as specified for installation	No	8	R 230,400.00		R 1,843,200.00	
7.6.2	30 kW vertical shaft mixers, all as specified for installation in the GBT sludge Thickened sump	No	2	R 230,400.00		R 460,800.00	
TOTAL CARRIED FORWARD /…………						**R 2,304,000.00**	

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT Schedule 7.7: Sundry Equipment					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**	**TOTAL**
				R c	**R c**
7.7	**SUNDRY EQUIPMENT** **Allow for all costs and expenses in connection with design, manufacture, quality management, painting, testing, supply, delivery, offloading, storage and installation of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
	Lifting equipment				
7.7.1	2 ton manually operated chain and hoist system in dewatering hall, complete as specified for the feed pumps	No.	1	R 691,200.00	R 691,200.00
7.7.2	5 ton electrically operated chain hoist system, complete with trolley as specified for the GBT area	No.	1	R 338,400.00	R 338,400.00
7.7.3	Crawl beam and trolley system, complete for the Poly dosing area	Sum	1	R 216,000.00	R 216,000.00
7.7.4	2 ton manually operated chain and hoist system in dewatering hall, complete as specified for the poly make-up area	No.	1	R 216,000.00	R 216,000.00
TOTAL CARRIED FORWARD /………….					**R 1,461,600.00**

SCHEDULE 8: SLUDGE DRYING BEDS

ITEM	DESCRIPTION	UNIT	QTY	PRICE		TOTAL	
				R	c	R	c
8	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**						
8.1	Solar sludge drying complete as specified, including all associated equipment for solar drying	No	2	R 1,728,000.00		R 3,456,000.00	
	TOTAL CARRIED FORWARD/…….					**R 3,456,000.00**	

SCHEDULE 9: LIME REACTOR

Schedule 9.1 Mixer

ITEM	DESCRIPTION	UNIT	QTY	PRICE	TOTAL
				R c	R c
9.1	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
9.1.1	7.7 kW vertical shaft mixers, all as specified for installation in the Lime reactor basin	No	4	R 136,800.00	R 547,200.00
9.1.2	30 kW vertical shaft mixers, all as specified for installation in the lime sludge sump basin	No	2	R 230,400.00	R 460,800.00
TOTAL CARRIED FORWARD TO SUMMARY					**R 1,008,000.00**

SCHEDULE 9: LIME REACTOR
Schedule 9.2 Lime Make-up

ITEM	DESCRIPTION	UNIT	QTY	PRICE	TOTAL
				R c	R c
9.2	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
9.2.1	Complete lime make-up system, including Silo, weighting cells and Slaker, complete as specified	No	1	R 1,339,200.00	R 1,339,200.00
9.2.2	All other plant and equipment items not included above but which are nevertheless necessary to meet the Scope of Work and/or are required for the proper, safe and effective operation of the plant (Specify):-	Item			R 0.00
					R 0.00
TOTAL CARRIED FORWARD/…………..					**R 1,339,200.00**

SCHEDULE 9: LIME REACTOR
Schedule 9.3 Lime Clarifier

ITEM	DESCRIPTION	UNIT	QTY	PRICE	TOTAL
				R c	R c
9.3	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
9.3.1	Lime Clarifier, complete with bridges, stilling wells, flocculation baffles, scraper mechanisms, etc., all as specified	No	2	R 1,584,000.00	R 3,168,000.00
9.3.2	All other plant and equipment items not included above but which are nevertheless necessary to meet the Scope of Work and/or are required for the proper, safe and effective operation of the plant (Specify)	Item	1	R 172,800.00	R 172,800.00
TOTAL CARRIED FORWARD/…………..					**R 3,340,800.00**

SCHEDULE 9: LIME REACTOR

Schedule 9.4 Lime Pump station

ITEM	DESCRIPTION	UNIT	QTY	PRICE		TOTAL	
				R	c	R	c
9.4	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**						
9.4.1	Return Lime sludge , centrifugal pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified (horizontal, dry-well or self-priming pumps shall be acceptable).	No	4	R 93,600.00		R 374,400.00	
9.4.2	All other plant and equipment items not included above but which are nevertheless necessary to meet the Scope of Work and/or are required for the proper, safe and effective operation of the plant (Specify)	Sum	1	R 21,600.00		R 21,600.00	
TOTAL CARRIED FORWARD/…………..						**R 396,000.00**	

SCHEDULE 10: RETURN PUMP STATION EQUIPMENT SCHEDULE					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**	**TOTAL**
				R c	**R c**
10.1	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
10.1.1	Filtrate centrifugal pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified (horizontal, dry-well or self-priming pumps shall be acceptable).	No	3	R 237,600.00	R 712,800.00
10.1.2	Anaerobic Digester return, self-priming pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified	No	3	R 151,200.00	R 453,600.00
10.1.3	Scum disposal (SD), self-priming rotary lobe pumpsets complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified.	No	3	R 93,600.00	R 280,800.00
10.1.4	Sump drainage submersible pumpsets, complete with duckfoot bends, quick couplings, all brackets, lifting duct, holding down bolts, lifting chains, pipework associated fittings, non return valves, isolating valves, pressure gauges, etc., as specified	No	4	R 18,000.00	R 72,000.00
TOTAL CARRIED FORWARD TO SUMMARY					**R 1,519,200.00**

JOHANNESBURG WATER
LANSERIA WASTEWATER TREATMENT WORKS:
MECHANICAL AND ELECTRICAL ENGINEERING WORKS

SUMMARY OF SCHEDULE OF PRICES			
SECTION	**DESCRIPTION**	**PAGE NO**	**AMOUNT**
			R
1.	General requirements and conditions		12,583,000.00
2.	Anaerobic digestor, mixing equipment and pump station		24,927,600.00
3.	WAS Thickening		3,081,600.00
4.	Pumping equipment		1,051,200.00
5.	Anaerobic digestor, mixing equipment and pump station		442,000.00
6.	Hand stops, sluice gates and channel gates		372,200.00
7.	Sludge dewatering equipment		21,982,200.00
8.	Sludge Drying Equipment		3,456,000.00
9.	Lime Reactor		6,084,000.00
10.	Return pump station pumping equipment schedule		1,519,200.00
SUBTOTAL 1			**75,499,000.00**
Plus 10 % CONTINGENCIES on **SUBTOTAL 1**			7,549,900.00
Plus 5 % PROVISIONAL ESCALATION ALLOWANCE on **SUBTOTAL 1**			3,774,950.00
SUBTOTAL 2			**86,823,850.00**
Plus 14 % VALUE ADDED TAX			12,155,339.00
TOTAL			**98,979,189.00**

Excalation of rates

years	5	
Rate	7.5	%
Factor	1.435629	

LANSERIA WASTE WATER TREATMENT PLANT		
SUMMARY OF BILL OF QUANTITIES		
	DESCRIPTION	**AMOUNT** **R**
1	BULK EARTHWORKS	131,186,256.00
2	RETAINING WALLS	27,423,046.00
3	ACCESS ROADS AND STORMWATER	30,617,970.00
4	HEAD OF WORKS	15,119,981.00
5	PRIMARY TREATMENT	18,562,620.00
6	FLOW BALANCING	20,201,076.00
7	BIOLOGICAL REACTOR	53,676,600.00
8	SECONDARY TREATMENT	21,718,110.00
9	DISINFECTION & FINAL EFFLUENT	13,813,643.00
10	EMERGENCY OVERFLOW DAM	15,000,000.00
11	FERMENTER AREA	9,104,407.00
12	ANCILLARY WORKS	5,605,130.00
13	BULK SERVICES	48,940,246.25
14	BUILDINGS	21,053,000.00
15	INTERCONNECTING PIPEWORK	61,932,568.60
16	MOBILE CRUSHING PLANT	15,000,000.00
SUB-TOTAL A (CIVIL COST)		**508,954,653.85**
ELECTRICAL AND C & I		**106,500,000.00**
MECHANICAL		**155,152,000.00**
SUB-TOTAL B		**770,606,653.85**
PRELIMINARY AND GENERAL		**199,638,000.00**
SUB-TOTAL C		**970,244,653.85**
ALLOW 10% FOR CONTINGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER		**97,024,465.39**
SUB-TOTAL D		**1,067,269,119.24**
ADD 14% VAT		**149,417,676.69**
FINAL ESTIMATED GRAND TOTAL		**1,216,686,795.93**

Project Cost Summary

Section	Total
1. Bulk Earthworks	R131,186,256.00
2. Retaining Walls	R27,423,046.00
3. Access Roads and Stormwater	R30,617,970.00
4. Head of Works	R15,119,981.00
5. Primary Treatment	R18,562,620.00
6. Flow Balancing	R20,201,076.00
7. Biological Reactor	R53,676,600.00
8. Secondary Treatment	R21,718,110.00
9. Disinfection & Final Effluent	R13,813,643.00
10. Emergency Overflow Dam	R15,000,000.00
11. Fermenter Area	R9,104,407.00
12. Ancillary Works	R5,605,130.00
13. Bulk Services	R48,940,246.25
14. Buildings	R21,053,000.00
15. Interconnecting Pipework	R61,932,568.60
16. Mobile Crushing Plant	R15,000,000.00
Total Civils Liquid (excl. VAT)	**R508,955,000.00**
Total Civils Sludge (excl. VAT)	**R227,580,000.00**
Electrical and C & I	**R106,500,000.00**
Mechanical (Liquid)	**R79,653,000.00**
Mechanical (Sludge)	**R75,499,000.00**
Preliminary & General	**R199,638,000.00**
Total (excl. VAT)	**R1,197,825,000.00**

ML

Master Rates

Concrete (per m^3)	R2,200.00
Formwork (per m^2)	R650.00
Reinforcement (per ton)	R13,600.00
Bulk Excavation (per m^3)	
Soft	R120.00
Intermediate	R250.00
Hard	R850.00
Restricted Excavation (per m^3)	
Soft	R180.00
Intermediate	R375.00
Hard	R1,020.00
Allowance for Mass Concrete	5%
Contingency by the Engineer	0%
Buildings Engineering (R/m²)	R6,500.00
Building Architectural (R/m²)	R10,000.00
Restricted Excavation	**100%**
Soft	20%
Intermediate	20%
Hard	60%
Bulk Excavation	**100%**
Soft	20%
Intermediate	20%
Hard	60%
Bulk Excavation & dispose (per m^3)	R120.00
Dispose	10%
Reuse	90%
Import G7 fill material	R175.00
80 mm Interlocking Paving Blocks (per m²)	R200.00
60 mm Interlocking Paving Blocks (per m²)	R150.00
150 mm C4 (per m³)	R250.00
150 mm rip and recompact (per m³)	R120.00
Precast kerbing units (per m)	R250.00
Manholes (per 1 no. off)	R6,500.00
Kerb Inlets (per 1 no. off)	R8,000.00
Grid Inlets (per m)	R2,000.00
Culverts (per 1 no. off)	R6,500.00
Emergency Dam (R/m³)	R750.00
P & G (%)	20%

Concrete Factors

RETAINING WALLS	1.00
ACCESS ROADS AND STORMWATER	1.00
HEAD OF WORKS	1.50
PRIMARY TREATMENT	1.30
FLOW BALANCING	1.13
BIOLOGICAL REACTOR	1.25
SECONDARY TREATMENT	1.30
DISINFECTION & FINAL EFFLUENT	1.20
STORM FLOW DAM	1.00
FERMENTER AREA	1.30
ANCILLARY WORKS	1.37
INTERCONNECTING PIPEWORK	1.37

Pipelines

	Description	Rate (R/m)
	Concrete Pipelines	
	Class 100D Diameter 500 Concrete Pipe	R1,100.00
	Class 100D Diameter 750 Concrete Pipe	R1,600.00
	Class 100D Diameter 900 Concrete Pipe	R2,100.00
	Class 100D Diameter 1000 Concrete Pipe	R3,000.00
	Class 100D Diameter 1200 Concrete Pipe	R4,000.00
	Class 100D Diameter 1500 Concrete Pipe	R5,750.00
100%	Class 100D Diameter 1800 Concrete Pipe	R8,000.00
	HDPE Pipelines	
	PN12.5 Diameter 160 HDPE Pipe	R450.00
	PN12.5 Diameter 500 HDPE Pipe	R1,500.00
	Stainless Steel Pipes	
	SS304 Diamter 200 Pipe	R1,200.00
	SS304 Diamter 500 Pipe	R6,000.00
	SS304 Diamter 900 Pipe	R10,000.00
	SS304 Diamter 1000 Pipe	R12,000.00
	uPVC Pipes	
	Diameter 200 Class 12	R300.00
	Weholite Pipes	
	Diameter 450	R1,288.00
	Diameter 1500	R10,640.00
	Diameter 1800	R15,528.00

BULK EARTHWORKS

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Bulk Earthworks					**R 110,746,256.00**
	Head of Works	3772	m^3		**R 2,202,848.00**
	Soft excavation	754	m^3	R 120.00	R 90,528.00
	Intermediate excavation	754	m^3	R 250.00	R 188,600.00
	Hard excavation	2263	m^3	R 850.00	R 1,923,720.00
	Dispose	0	m^3	R 120.00	R -
	Import fill G7 fill material from commercial sources	0	m^3	R 175.00	R -
	Primary Treatment	1083	m^3		**R 632,472.00**
	Soft excavation	217	m^3	R 120.00	R 25,992.00
	Intermediate excavation	217	m^3	R 250.00	R 54,150.00
	Hard excavation	650	m^3	R 850.00	R 552,330.00
	Dispose	0	m^3	R 120.00	R -
	Import fill G7 fill material from commercial sources	0	m^3	R 175.00	R -
	Balancing Tank	30124	m^3		**R 17,592,416.00**
	Soft excavation	6025	m^3	R 120.00	R 722,976.00
	Intermediate excavation	6025	m^3	R 250.00	R 1,506,200.00
	Hard excavation	18074	m^3	R 850.00	R 15,363,240.00
	Dispose	0	m^3	R 120.00	R -
	Import fill G7 fill material from commercial sources	0	m^3	R 175.00	R -
	Biological Reactor	82311	m^3		**R 48,069,624.00**
	Soft excavation	16462	m^3	R 120.00	R 1,975,464.00
	Intermediate excavation	16462	m^3	R 250.00	R 4,115,550.00
	Hard excavation	49387	m^3	R 850.00	R 41,978,610.00
	Dispose	0	m^3	R 120.00	R -
	Import fill G7 fill material from commercial sources	0	m^3	R 175.00	R -
	Secondary Treatment	59549	m^3		**R 34,776,616.00**
	Soft excavation	11910	m^3	R 120.00	R 1,429,176.00
	Intermediate excavation	11910	m^3	R 250.00	R 2,977,450.00
	Hard excavation	35729	m^3	R 850.00	R 30,369,990.00
	Dispose	0	m^3	R 120.00	R -
	Import fill G7 fill material from commercial sources	0	m^3	R 175.00	R -
	Disinfection Facility	12795	m^3		**R 7,472,280.00**
	Soft excavation	2559	m^3	R 120.00	R 307,080.00
	Intermediate excavation	2559	m^3	R 250.00	R 639,750.00
	Hard excavation	7677	m^3	R 850.00	R 6,525,450.00
	Dispose	0	m^3	R 120.00	R -
	Import fill G7 fill material from commercial sources	0	m^3	R 175.00	R -
	Terrace Layerworks				R 20,440,000.00
Layerworks	80 mm Interlocking Paving Blocks	80,000	m^2	R 200.00	R 16,000,000.00
	150 mm C4	12,000	m^3	R 250.00	R 3,000,000.00
	150 mm Rip and Recompact	12,000	m^3	R 120.00	R 1,440,000.00
SUB-TOTAL A					R 131,186,256.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 131,186,256.00
ADD 14% VAT					R 18,366,075.84
FINAL TOTAL FOR STRUCTURE					**R 149,552,331.84**

RETAINING WALLS

				Calculated By:	NG
				Checked By:	NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**3928**	**m^3**	**R 2,200.00**	**R 8,641,600.00**
	Walls and Floors	3928	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**196.4**	**m^3**	**R 2,200.00**	**R 432,080.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**471.36**	**Ton**	**R 13,600.00**	**R 6,410,496.00**
Formwork	**Total Formwork**	**13985**	**m^2**	**R 650.00**	**R 9,090,250.00**
	Vertical	**13985**	**m^2**	**R 650.00**	**R 9,090,250.00**
	Walls	12865	m^2		
	Footings	1120	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
	Horizontal	**0**	**m^2**	**R 650.00**	**R -**
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**3940**	**m^3**		**R 2,848,620.00**
	Soft	788	m^3	R 180.00	R 141,840.00
	Intermediate	788	m^3	R 375.00	R 295,500.00
	Hard	2364	m^3	R 1,020.00	R 2,411,280.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 27,423,046.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 27,423,046.00
ADD 14% VAT					R 3,839,226.44
FINAL TOTAL FOR STRUCTURE					**R 31,262,272.44**

INTERNAL ACCESS ROADS AND STORMWATER

			Calculated By:		NG
			Checked By:		NR

Item	Description	Total Quantity Regular	Unit	Rate	Amount
ACCESS ROADS					**R 17,247,920.00**
Excavation	Soft	9,168	m^3	R 180.00	R 1,650,240.00
	Intermediate	4,584	m^3	R 375.00	R 1,719,000.00
	Hard	4,584	m^3	R 1,020.00	R 4,675,680.00
Fill Material	Fill	1,000	m^3	R 175.00	R 175,000.00
Layerworks	80 mm Interlocking Paving Blocks	20,000	m^2	R 200.00	R 4,000,000.00
	60 mm Interlocking Paving Blocks	4,500	m^3	R 150.00	R 675,000.00
	150 mm C4	3,600	m^3	R 250.00	R 900,000.00
	150 mm G7	4,000	m^3	R 175.00	R 700,000.00
	150 mm R&R	4,400	m^3	R 120.00	R 528,000.00
Kerbing	Precast kerbing units	7,500	m	R 250.00	R 1,875,000.00
Road Markings and Signage	Yellow/white lines, painted signs, sign boards	1	Sum	R 350,000.00	R 350,000.00
STORMWATER					**R 13,370,050.00**
Trench Excavation	Soft	4,300.00	m^3	R 180.00	R 774,000.00
	Intermediate	1,550.00	m^3	R 375.00	R 581,250.00
	Hard	2,050.00	m^3	R 1,020.00	R 2,091,000.00
Backfill	Fill	5,616.00	m^3	R 175.00	R 982,800.00
Stormwater Precast Elements	Dia. 450 mm	510.00	m	R 1,100.00	R 561,000.00
	Dia. 625 mm	120.00	m	R 1,600.00	R 192,000.00
	Dia. 1050 mm	350.00	m	R 3,000.00	R 1,050,000.00
	Discharging in to river	1.00	Sum	R 200,000.00	R 200,000.00
	Manholes	20.00	No.	R 6,500.00	R 130,000.00
	Kerb Inlets	7.00	No.	R 8,000.00	R 56,000.00
	Grid Inlets	1,350.00	m	R 2,000.00	R 2,700,000.00
	Culverts	150.00	No.	R 6,500.00	R 975,000.00
Earth Berm	Compacted and grassed	500.00	m	R 750.00	R 375,000.00
In-situ Concrete	Concrete slab for culverts (Top)	150.00	m^3	R 2,200.00	R 330,000.00
	Concrete base for culverts (bottom)	150.00	m^3	R 2,200.00	R 330,000.00
	Wingwalls for culverts	240.00	m^3	R 2,200.00	R 528,000.00
Reinforcement	For in-situ concrete for culverts	65.00	t	R 13,600.00	R 884,000.00
Formwork	For in-situ concrete for culverts	800.00	m^2	R 650.00	R 520,000.00
Blinding	For in-situ concrete for culverts	50.00	m^3	R 2,200.00	R 110,000.00
SUB-TOTAL A					R 30,617,970.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 30,617,970.00
ADD 14% VAT					R 4,286,515.80
FINAL TOTAL FOR STRUCTURE					**R 34,904,485.80**

R 13,312.16

2300
R 7,499.10

HEAD OF WORKS

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**1454**	**m^3**	**R 2,200.00**	**R 4,798,200.00**
	Walls and Floors	1454	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**72.7**	**m^3**	**R 2,200.00**	**R 159,940.00**
Reinforcing Steel	**Calculated at 140 kg/m^3 of Structural Concrete**	**204**	**Ton**	**R 13,600.00**	**R 2,768,416.00**
Formwork	**Total Formwork**	**5952**	**m^2**	**R 650.00**	**R 3,868,800.00**
	Vertical	**5539**	**m^2**	**R 650.00**	**R 3,600,350.00**
	Walls and Floors	5539	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
	Horizontal	**413**	**m^2**	**R 650.00**	**R 268,450.00**
	Soffit of roof slabs	137	m^2		
	Soffit of walkways and suspended floors	276	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**4875**	**m^3**		**R 3,524,625.00**
	Soft	975	m^3	R 180.00	R 175,500.00
	Intermediate	975	m^3	R 375.00	R 365,625.00
	Hard	2925	m^3	R 1,020.00	R 2,983,500.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 15,119,981.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 15,119,981.00
ADD 14% VAT					R 2,116,797.34
FINAL TOTAL FOR STRUCTURE					**R 17,236,778.34**

R 10,398.89

PRIMARY TREATMENT

			Calculated By:		NG
			Checked By:		NR

Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**782**	**m^3**	**R 2,200.00**	**R 2,236,520.00**
	Walls and floors	782	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**39.1**	**m^3**	**R 2,200.00**	**R 86,020.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**93.84**	**Ton**	**R 13,600.00**	**R 1,276,224.00**
Formwork	**Total Formwork**	**2586**	**m^2**	**R 650.00**	**R 1,680,900.00**
	Vertical	**2536**	**m^2**	**R 650.00**	**R 1,648,400.00**
	Walls	2096	m^2		
	Launder Walls	288	m^2		
	Floors	78	m^2		
	Columns	74	m^2		
			m^2		
			m^2		
	Horizontal	**50**	**m^2**	**R 650.00**	**R 32,500.00**
	Launder floor	42	m^2		
	Centre structure	8	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**18372**	**m^3**		**R 13,282,956.00**
	Soft	3674.4	m^3	R 180.00	R 661,392.00
	Intermediate	3674.4	m^3	R 375.00	R 1,377,900.00
	Hard	11023.2	m^3	R 1,020.00	R 11,243,664.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 18,562,620.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 18,562,620.00
ADD 14% VAT					R 2,598,766.80
FINAL TOTAL FOR STRUCTURE					**R 21,161,386.80**

FLOW BALANCING

Item	Description	Total Quantity Regular	Unit	Rate	Amount
			Calculated By:		NG
			Checked By:		NR
Concrete	**Total Structural Concrete**	**1413**	**m^3**	**R 2,200.00**	**R 3,512,718.00**
	Walls and floors	1413	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**70.65**	**m^3**	**R 2,200.00**	**R 155,430.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**169.56**	**Ton**	**R 13,600.00**	**R 2,306,016.00**
Formwork	**Total Formwork**	**5154**	**m^2**	**R 650.00**	**R 3,350,100.00**
	Vertical	**5079**	**m^2**	**R 650.00**	**R 3,301,350.00**
	Walls	4450	m^2		
	Footings	306	m^2		
	Columns	323	m^2		
			m^2		
			m^2		
			m^2		
	Horizontal	**75**	**m^2**	**R 650.00**	**R 48,750.00**
	Soffits of walkways	75	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**15044**	**m^3**		**R 10,876,812.00**
	Soft	3008.8	m^3	R 180.00	R 541,584.00
	Intermediate	3008.8	m^3	R 375.00	R 1,128,300.00
	Hard	9026.4	m^3	R 1,020.00	R 9,206,928.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 20,201,076.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 20,201,076.00
ADD 14% VAT					R 2,828,150.64
FINAL TOTAL FOR STRUCTURE					**R 23,029,226.64**

BIOLOGICAL REACTOR

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**3950**	**m^3**	**R 2,200.00**	**R 10,862,500.00**
	Walls and floors	3950	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**197.5**	**m^3**	**R 2,200.00**	**R 434,500.00**
Reinforcing Steel	**Calculated at 100 kg/m^3 of Structural Concrete**	**395**	**Ton**	**R 13,600.00**	**R 5,372,000.00**
Formwork	**Total Formwork**	**15835**	**m^2**	**R 650.00**	**R 10,292,750.00**
	Vertical	**15525**	**m^2**	**R 650.00**	**R 10,091,250.00**
	Walls and floors	15525	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
	Horizontal	**310**	**m^2**	**R 650.00**	**R 201,500.00**
	Soffits walkways	310	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		36950	**m^3**		**R 26,714,850.00**
	Soft	7390	m^3	R 180.00	R 1,330,200.00
	Intermediate	7390	m^3	R 375.00	R 2,771,250.00
	Hard	22170	m^3	R 1,020.00	R 22,613,400.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 53,676,600.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 53,676,600.00
ADD 14% VAT					R 7,514,724.00
FINAL TOTAL FOR STRUCTURE					**R 61,191,324.00**

R 13,589.01

SECONDARY TREATMENT

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**1227**	**m^3**	**R 2,200.00**	**R 3,509,220.00**
	Walls and floors	1227	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**61.35**	**m^3**	**R 2,200.00**	**R 134,970.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**147.24**	**Ton**	**R 13,600.00**	**R 2,002,464.00**
Formwork	**Total Formwork**	**4290**	**m^2**	**R 650.00**	**R 2,788,500.00**
	Vertical	**4215**	**m^2**	**R 650.00**	**R 2,739,750.00**
	Walls	3714	m^2		
	Launder walls	384	m^2		
	Floor	117	m^2		
			m^2		
			m^2		
			m^2		
	Horizontal	**75**	**m^2**	**R 650.00**	**R 48,750.00**
	Launder Floor	63	m^2		
	Center Structure	12	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**18372**	**m^3**		**R 13,282,956.00**
	Soft	3674.4	m^3	R 180.00	R 661,392.00
	Intermediate	3674.4	m^3	R 375.00	R 1,377,900.00
	Hard	11023.2	m^3	R 1,020.00	R 11,243,664.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 21,718,110.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 21,718,110.00
ADD 14% VAT					R 3,040,535.40
FINAL TOTAL FOR STRUCTURE					**R 24,758,645.40**

DISINFECTION & FINAL EFFLUENT

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**1497**	**m^3**	**R 2,200.00**	**R 3,952,080.00**
	Walls and floors	1497	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**74.85**	**m^3**	**R 2,200.00**	**R 164,670.00**
Reinforcing Steel	**Calculated at 100 kg/m^3 of Structural Concrete**	**149.7**	**Ton**	**R 13,600.00**	**R 2,035,920.00**
Formwork	**Total Formwork**	**3832**	**m^2**	**R 650.00**	**R 2,490,800.00**
	Vertical	**3780**	**m^2**	**R 650.00**	**R 2,457,000.00**
	Walls of contact channel	3606	m^2		
	Floor of contact channel	74	m^2		
	DBF bund	100	m^2		
			m^2		
			m^2		
			m^2		
	Horizontal	**52**	**m^2**	**R 650.00**	**R 33,800.00**
	Soffits of walkways	43	m^2		
	Soffit of scum baffle	9	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**7151**	**m^3**		**R 5,170,173.00**
	Soft	1430.2	m^3	R 180.00	R 257,436.00
	Intermediate	1430.2	m^3	R 375.00	R 536,325.00
	Hard	4290.6	m^3	R 1,020.00	R 4,376,412.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 13,813,643.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 13,813,643.00
ADD 14% VAT					R 1,933,910.02
FINAL TOTAL FOR STRUCTURE					**R 15,747,553.02**

EMERGENCY OVERFLOW DAM

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
	Capacity of Dam	**20000**	**m^3**	**R 750.00**	**R 15,000,000.00**
			m^3		
SUB-TOTAL A					R 15,000,000.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 15,000,000.00
ADD 14% VAT					R 2,100,000.00
FINAL TOTAL FOR STRUCTURE					**R 17,100,000.00**

FERMENTER AREA

				Calculated By:	NG
				Checked By:	NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**632**	**m^3**	**R 2,200.00**	**R 1,807,520.00**
	Walls and floors	632	m^3		
			m^3		
			m^3		
			m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**31.6**	**m^3**	**R 2,200.00**	**R 69,520.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**75.84**	**Ton**	**R 13,600.00**	**R 1,031,424.00**
Formwork	**Total Formwork**	**755**	**m^2**	**R 650.00**	**R 490,750.00**
	Vertical	**623**	**m^2**	**R 650.00**	**R 404,950.00**
	Tank walls	262	m^2		
	Launder walls	180	m^2		
	Floors	69	m^2		
	Columns	112	m^2		
			m^2		
			m^2		
	Horizontal	**132**	**m^2**	**R 650.00**	**R 85,800.00**
	Launder floor	128	m^2		
	Center structure	4	m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**7891**	**m^3**		**R 5,705,193.00**
	Soft	1578.2	m^3	R 180.00	R 284,076.00
	Intermediate	1578.2	m^3	R 375.00	R 591,825.00
	Hard	4734.6	m^3	R 1,020.00	R 4,829,292.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 9,104,407.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 9,104,407.00
ADD 14% VAT					R 1,274,616.98
FINAL TOTAL FOR STRUCTURE					**R 10,379,023.98**

ANCILLARY WORKS

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**357**	**m^3**	**R 2,200.00**	**R 1,075,998.00**
	PST division box	192	m^3		
	Balancing tank division box	92	m^3		
	Final clarifier division box	55	m^3		
	Fermenter division box	18	m^3		
			m^3		
			m^3		
	Provisional: Mass Concrete	**17.85**	**m^3**	**R 2,200.00**	**R 39,270.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**42.84**	**Ton**	**R 13,600.00**	**R 582,624.00**
Formwork	**Total Formwork**	**1444**	**m^2**	**R 650.00**	**R 938,600.00**
	Vertical	**1444**	**m^2**	**R 650.00**	**R 938,600.00**
	PST division box	559	m^2		
	Balancing tank division box	416	m^2		
	Final clarifier division box	323	m^2		
	Fermenter division box	146	m^2		
			m^2		
			m^2		
	Horizontal	**0**	**m^2**	**R 650.00**	**R -**
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
			m^2		
Restricted Excavations		**4106**	**m^3**		**R 2,968,638.00**
	Soft	821.2	m^3	R 180.00	R 147,816.00
	Intermediate	821.2	m^3	R 375.00	R 307,950.00
	Hard	2463.6	m^3	R 1,020.00	R 2,512,872.00
					R -
					R -
					R -
					R -
SUB-TOTAL A					R 5,605,130.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 5,605,130.00
ADD 14% VAT					R 784,718.20
FINAL TOTAL FOR STRUCTURE					**R 6,389,848.20**

BULK SERVICES

Item	Description	Total Quantity Regular	Unit	Rate	Amount
	Calculated By:				NG
	Checked By:				NR
Main Access Road	**Total Main Access Roads**				**R 42,940,246.25**
	Accomodation of traffic				R 2,341,265.00
	Clearing and grubbing				R 517,975.00
	Dayworks and hire of construction equipment				R 375,540.00
	Prefabricated culverts				R 370,840.00
	Mass earthworks				R 13,366,675.00
	Pavement layers of gravel material				R 6,172,000.00
	Stabilization				R 2,965,200.00
	Crushed stone base				R 3,645,000.00
	Prime coat				R 680,560.00
	Asphalt base and surfacing				R 6,829,800.00
	Treatment of an existing surface exhibiting certain defects				R 100,000.00
	Fencing				R 5,000,000.00
	Road signs				R 83,525.00
	Road markings				R 80,716.25
	Finishing the road and road reserve and treating old roads				R 111,150.00
	Testing materials and workmanship				R 300,000.00
Potable Water	**Bulk Potable Water Pipeline**		**Sum**		**R 6,000,000.00**
					R -
SUB-TOTAL A					R 48,940,246.25
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 48,940,246.25
ADD 14% VAT					R 6,851,634.48
FINAL TOTAL FOR STRUCTURE					**R 55,791,880.73**

BUILDINGS

			Calculated By:		NG
			Checked By:		NR
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Buildings	**Architectural and Engineering Buildings**				**R 21,053,000.00**
	Combined Blower and Control Building	220	m^2	6500	1,430,000.00
	Primary Sludge Pump Station	186	m^2	6500	1,209,000.00
	Blower Building	367	m^2	6500	2,385,500.00
	WAS Pump Station	102	m^2	6500	663,000.00
	Wash Water and Sludge Pump Station	160	m^2	6500	1,040,000.00
	Emergency Overflow Dam Pump Station	120	m^2	6500	780,000.00
	Fermented Sludge Pump Station	98	m^2	6500	637,000.00
	Monitoring Building	36	m^2	6500	234,000.00
	Workshop and Storage Building	673	m^2	6500	4,374,500.00
	Electrical substations	200	m^2	6500	1,300,000.00
	Ablution Facility	100	m^2	10000	1,000,000.00
	Admin Building (incl. gatehouse and entrance)	600	m^2	10000	6,000,000.00
					R -
SUB-TOTAL A					R 21,053,000.00
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 21,053,000.00
ADD 14% VAT					R 2,947,420.00
FINAL TOTAL FOR STRUCTURE					**R 24,000,420.00**

INTERCONNECTING PIPEWORK

		Calculated By:			NG
		Checked By:			NR
Item	**Description**	**Total Quantity Regular**	**Unit**	**Rate**	**Amount**
Pipelines	**Interconnecting Pipework**				**R 32,337,315.60**
	Concrete Pipelines				**R 9,745,800.00**
	Class 100D Diameter 500 Concrete Pipe	27	m	R 1,100.00	R 29,700.00
	Class 100D Diameter 750 Concrete Pipe	97	m	R 1,600.00	R 155,200.00
	Class 100D Diameter 900 Concrete Pipe	64	m	R 2,100.00	R 134,400.00
	Class 100D Diameter 1000 Concrete Pipe	230	m	R 3,000.00	R 690,000.00
	Class 100D Diameter 1200 Concrete Pipe	39	m	R 4,000.00	R 156,000.00
	Class 100D Diameter 1500 Concrete Pipe	382	m	R 5,750.00	R 2,196,500.00
	Class 100D Diameter 1800 Concrete Pipe	798	m	R 8,000.00	R 6,384,000.00
	HDPE Pipelines				**R 5,647,500.00**
	PN12.5 Diameter 160 HDPE Pipe	4915	m	R 450.00	R 2,211,750.00
	PN12.5 Diameter 160 HDPE Pipe	5415	m	R 450.00	R 2,436,750.00
	PN12.5 Diameter 500 HDPE Pipe	666	m	R 1,500.00	R 999,000.00
	Stainless Steel Pipes				**R 2,622,800.00**
	SS304 Diamter 200 Pipe	39	m	R 1,200.00	R 46,800.00
	SS304 Diamter 500 Pipe	46	m	R 6,000.00	R 276,000.00
	SS304 Diamter 900 Pipe	50	m	R 10,000.00	R 500,000.00
	SS304 Diamter 1000 Pipe	150	m	R 12,000.00	R 1,800,000.00
	uPVC Pipes				**R 1,005,900.00**
	Diameter 200 Class 12	3353	m	R 300.00	R 1,005,900.00
	Weoholite Pipes				**R 4,581,880.00**
	Diameter 450	348	m	R 1,288.00	R 448,224.00
	Diameter 1500	101	m	R 10,640.00	R 1,074,640.00
	Diameter 1800	197	m	R 15,528.00	R 3,059,016.00
Restricted Excavations		39761	**m^3**		**R 29,595,253.00**
	Soft	7952	m^3	R 180.00	R 1,431,396.00
	Intermediate	7952	m^3	R 375.00	R 2,982,075.00
	Hard	23857	m^3	R 1,020.00	R 24,333,732.00
	Import G7 material from commercial sources	4846	m^3	R 175.00	R 848,050.00
					R -
					R -
SUB-TOTAL A					R 61,932,568.60
CONTIGENCIES TO BE SPENT IN PART OR AS A WHOLE AT THE SOLE DISCRETION OF THE ENGINEER					R -
SUB-TOTAL B					R 61,932,568.60
ADD 14% VAT					R 8,670,559.60
FINAL TOTAL FOR STRUCTURE					**R 70,603,128.20**

Project Cost Summary (SLUDGE)

Section	Total
WAS THICKENER FEED BOX	426,415.00
WAS THICKENER	3,399,120.00
WAS MANHOLES & BOXES	2,648,660.00
ANAEROBIC DIGESTER INLET TOWER	1,990,575.00
ANAEROBIC DIGESTER	8,616,600.00
BOILER HOUSE	2,568,600.00
GAS HOLDER	4,393,060.00
FBP BUILDING	19,996,760.00
OUTLOADING STATION	6,870,600.00
SOLAR DRYING BEDS	21,668,160.00
SLUDGE STORAGE AREA	4,571,500.00
GRIT DRYING BEDS	1,897,680.00
RETURN PUMP STATION	3,097,740.00
LIME THICKENER	4,024,080.00
LIME REACTOR AND SILO BUND	1,725,600.00
LIME SLUDGE PUMP STATION	910,080.00
INTERCONNECTING PIPEWORK	12,086,541.53
RESTRICTED AND BULK EARTHWORKS	76,446,400.00
RETAINING WALLS	14,774,000.00
PRELIMINARY, GENERAL AND OVERHEADS (20 %)	35,467,634.31
Total Civils Sludge (excl. VAT)	**R227,579,805.84**
Electrical and C & I	**R0.00**
Mechanical	
Total (excl. VAT)	**R227,579,805.84**

Master Rates (SLUDGE)

Concrete (per m^3)	R2,200.00
Formwork (per m^2)	R650.00
Reinforcement (per ton)	R13,600.00
Bulk Excavation (per m^3)	
Soft	R120.00
Intermediate	R250.00
Hard	R850.00
Restricted Excavation (per m^3)	
Soft	R180.00
Intermediate	R375.00
Hard	R1,020.00
Allowance for Mass Concrete	5%
Contingency by the Engineer	0%
Buildings Engineering (R/m²)	R6,500.00
Building Architectural (R/m²)	R10,000.00
Restricted Excavation	**100%**
Soft	20%
Intermediate	20%
Hard	60%
Bulk Excavation	**100%**
Soft	20%
Intermediate	20%
Hard	60%
Bulk Excavation & dispose (per m^3)	R120.00
Dispose	10%
Reuse	90%
Import G7 fill material	R250.00
Emergency Dam (R/m³)	R750.00
P & G (%)	20%

Between Floor Panels (incl. reargaurd)	R570.00
Between Wall Panels (incl. waterbar)	R570.00
Handrails with Kicker plates	R1,760.00
Grid Flooring (GRP) (per m^2)	R1,500.00
Grid Flooring (GMS) (per m^2)	R1,500.00
Brickwork (230, one plain one facebrick)	R750.00
Victorian Style Roof	R2,500.00
Portal Frame	R2,600.00
Cladding	R2,400.00

100%

Concrete Factors (SLUDGE)

WAS THICKENER FEED BOX	1.10
WAS THICKENER	1.20
WAS MANHOLES & BOXES	1.40
ANAEROBIC DIGESTER INLET TOWER	1.50
ANAEROBIC DIGESTER	1.20
BOILER HOUSE	1.20
GAS HOLDER	1.40
FBP BUILDING	1.40
OUTLOADING STATION	1.10
SOLAR DRYING BEDS	1.20
SLUDGE STORAGE AREA	1.00
GRIT DRYING BEDS	1.20
RETURN PUMP STATION	1.20
LIME THICKENER	1.20
LIME REACTOR AND SILO BUND	1.20
LIME SLUDGE PUMP STATION	1.20
INTERCONNECTING PIPEWORK	1.20
RESTRICTED AND BULK EARTHWORKS	1.10
RETAINING WALLS	1.00

WAS THICKENER FEED BOX QUANTITIES

			Calculated by:	HJvR	29/07/2016
			Checked by:	JP	01/08/2016

Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**35.00**	**m^3**	**R 2,200.00**	**R 77,000.00**
	Floor slab of inlet tower sump	5.00	m^3		
	Floor slab of box	5.00	m^3		
	Walls of inlet tower sump	5.00	m^3		
	Walls of box	20.00	m^3		
	Provisional (5%): Mass Concrete	**2.00**	**m^3**	**R 2,200.00**	**R 4,400.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**5.00**	**Ton**	**R 13,600.00**	**R 68,000.00**
Formwork	**Total Formwork**	**165.00**	**m^2**		
	Vertical	**160.00**	**m^2**	**R 650.00**	**R 104,000.00**
	Sides of Floor slab of inlet tower sump	5.00	m^2		
	Sides of Floor slab of box	5.00	m^2		
	Sides of Walls of inlet tower sump	10.00	m^2		
	Sides of Walls of box	140.00	m^2		
	Horizontal	**5.00**	**m^2**	**R 650.00**	**R 3,250.00**
	Soffits of Box outs	5.00	m^2		
Joints	**Total Joints**	**100.00**	**m**		
	Between Floor Panels (incl. reargaurd)	50.00	m	R 570.00	R 28,500.00
	Between Wall Panels (incl. waterbar)	50.00	m	R 570.00	R 28,500.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates	25.00	m	R 1,760.00	R 44,000.00
	Grid Flooring	20.00	m^2	R 1,500.00	R 30,000.00
SUB-TOTAL A					R 387,650.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 38,765.00
FINAL TOTAL FOR STRUCTURE					R 426,415.00

WAS THICKENER QUANTITIES

Item	Description	Total Quantity Regular	Unit	Rate	Amount
	Calculated by:			HJvR	29/07/2016
	Checked by:			JP	01/08/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**340.00**	**m^3**	**R 2,200.00**	**R 748,000.00**
	Floor slab and footing of sludge hopper	10.00	m^3		
	Walls of sludge hopper	10.00	m^3		
	Footing of tank retaining walls	40.00	m^3		
	Floor slab of tank	60.00	m^3		
	Walls of tank	180.00	m^3		
	Floor Slabs of launders and boxes	10.00	m^3		
	Walls of launders and boxes	10.00	m^3		
	Centre column	20.00	m^3		
	Provisional (5%): Mass Concrete	**17.00**	**m^3**	**R 2,200.00**	**R 37,400.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**41.00**	**Ton**	**R 13,600.00**	**R 557,600.00**
Formwork	**Total Formwork**	**1570.00**	**m^2**		
	Vertical	**1510.00**	**m^2**	**R 650.00**	**R 981,500.00**
	Sides of Floor slab and footing of sludge hopper	10.00	m^2		
	Sides of Walls of sludge hopper	60.00	m^2		
	Sides of Footing of tank retaining walls	40.00	m^2		
	Sides of Walls of tank	1120.00	m^2		
	Sides of Floor Slabs of launders and boxes	40.00	m^2		
	Side of Walls of launders and boxes	80.00	m^2		
	Sides of Centre column	60.00	m^2		
	Sides of Pipe casings	100.00	m^2		
	Horizontal	**60.00**	**m^2**	**R 650.00**	**R 39,000.00**
	Soffits of Launders and boxes	60.00	m^2		
Joints	**Total Joints**	**250.00**	**m**		
	Between Floor Panels (incl. reargaurd)	240.00	m	R 570.00	R 136,800.00
	Between Wall Panels (incl. waterbar) (Provisional)	10.00	m	R 570.00	R 5,700.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates	160.00	m	R 1,760.00	R 281,600.00
	Grid Flooring	30.00	m^2	R 1,500.00	R 45,000.00
SUB-TOTAL A					R 2,832,600.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 566,520.00
FINAL TOTAL FOR STRUCTURE					R 3,399,120.00

WAS MANHOLES AND BOXES QUANTITIES

Calculated by: HJvR

Checked by: JP

Item	Description	Total Quantity Regular	Unit	Rate
Concrete	**Total Structural Concrete**	**290.00**	**m^3**	**R 2,200.00**
	Floor slab and footing of effluent manholes	40.00	m^3	
	Walls of Effluent manholes	40.00	m^3	
	Cover slab of effluent manholes	40.00	m^3	
	Floor slab and footing of scum manholes	40.00	m^3	
	Walls of Scum manholes	40.00	m^3	
	Cover slab of scum manholes	40.00	m^3	
	Floor slab of sludge valve boxes	20.00	m^3	
	Walls of sludge valve boxes	20.00	m^3	
	Roof slab of sludge valve boxes	10.00	m^3	
	Provisional (5%): Mass Concrete	**15.00**	**m^3**	**R 2,200.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**35.00**	**Ton**	**R 13,600.00**
Formwork	**Total Formwork**	**960.00**	**m^2**	
	Vertical	**920.00**	**m^2**	**R 650.00**
	Sides of Floor slab and footing of effluent manholes	40.00	m^2	
	Sides of Walls of Effluent manholes	320.00	m^2	
	Sides of Cover slab of effluent manholes	40.00	m^2	
	Sides of Floor slab and footing of scum manholes	40.00	m^2	
	Sides of Walls of Scum manholes	320.00	m^2	
	Sides of Cover slab of scum manholes	40.00	m^2	
	Sides of Floor slab of sludge valve boxes	10.00	m^2	
	Sides of Walls of sludge valve boxes	100.00	m^2	
	Sides of Roof slab of sludge valve boxes	10.00	m^2	
	Horizontal	**40.00**	**m^2**	**R 650.00**
	Soffit of Cover slab of effluent manholes	40.00	m^2	
	Soffit of Cover slab of scum manholes	40.00	m^2	
	Soffit of Roof slab of sludge valve boxes	20.00	m^2	
Joints	**Total Joints**	**80.00**	**m**	
	Between Floor Panels (incl. reargaurd) (Provisional)	20.00	m	R 570.00
	Between Wall Panels (incl. waterbar) (Provisional)	60.00	m	R 570.00
Structural Steelwork	**Items:**			
	Handrails with Kicker plates (Provisional)	30.00	m	R 1,760.00
	Grid Flooring (Provisional)	15.00	m^2	R 1,500.00
SUB-TOTAL A				
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED				
FINAL TOTAL FOR STRUCTURE				

29/07/2016
01/08/2016
Amount
R 638,000.00
R 33,000.00
R 476,000.00
R 598,000.00
R 26,000.00
R 11,400.00
R 34,200.00
R 52,800.00
R 22,500.00
R 1,891,900.00
R 756,760.00
R 2,648,660.00

ANAEROBIC DIGESTER INLET TOWER QUANTITIES

Item	Description	Total Quantity Regular	Unit	Rate	Amount
			Calculated by:	HB	28/07/2016
			Checked by:	JP	28/07/2016
Concrete	**Total Structural Concrete**	**140.00**	**m^3**	**R 2,200.00**	**R 308,000.00**
	Pad foundations	30.00	m^3		
	Columns	30.00	m^3		
	Support beams between Columns	20.00	m^3		
	Elevated floor slab of tank	20.00	m^3		
	Walls of tank and Inlet tower	40.00	m^3		
	Provisional (5%): Mass Concrete	**7.00**	**m^3**	**R 2,200.00**	**R 15,400.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**17.00**	**Ton**	**R 13,600.00**	**R 231,200.00**
Formwork	**Total Formwork**	**525.00**	**m^2**		
	Vertical	**420.00**	**m^2**	**R 650.00**	**R 273,000.00**
	Sides of Pad foundations	40.00	m^2		
	Sides of Columns	150.00	m^2		
	Sides of Support beams between Columns	40.00	m^2		
	Sides of Elevated floor slab of tank	10.00	m^2		
	Sides of Walls of tank and Inlet tower	180.00	m^2		
	Horizontal	**105.00**	**m^2**	**R 650.00**	**R 68,250.00**
	Soffits of Support beams between Columns	60.00	m^2		
	Soffit of Elevated floor slab of tank	40.00	m^2		
	Soffits of Box outs	5.00	m^2		
Joints	**Total Joints**	**100.00**	**m**		
	Between Floor Panels (incl. reargaurd)	50.00	m	R 570.00	R 28,500.00
	Between Wall Panels (incl. waterbar)	50.00	m	R 570.00	R 28,500.00
Structural Steelwork	**Items:**				
	Handrails with Kicker Plates	170.00	m	R 1,760.00	R 299,200.00
	Grid Flooring	50.00	m^2	R 1,500.00	R 75,000.00
SUB-TOTAL A					R 1,327,050.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 663,525.00
FINAL TOTAL FOR STRUCTURE					R 1,990,575.00

ANAEROBIC DIGESTER QUANTITIES

		Calculated by:		HB	28/07/2016
		Checked by:		JP	28/07/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**1050.00**	**m^3**	**R 2,200.00**	**R 2,310,000.00**
	Floor slab and Footing	280.00	m^3		
	Walls	520.00	m^3		
	Roof slab	220.00	m^3		
	Scum box floor and walls	10.00	m^3		
	Overflow walls and walkway	20.00	m^3		
	Provisional (5%): Mass Concrete	**53.00**	**m^3**	**R 2,200.00**	**R 116,600.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**126.00**	**Ton**	**R 13,600.00**	**R 1,713,600.00**
Formwork	**Total Formwork**	**3510.00**	**m^2**		
	Vertical	**2950.00**	**m^2**	**R 650.00**	**R 1,917,500.00**
	Sides of Footing and Sump	100.00	m^2		
	Sides of Walls	2560.00	m^2		
	Sides of Roof slab	120.00	m^2		
	Sides of Roof slab stairs and risers	10.00	m^2		
	Sides of Scum box floor and walls	60.00	m^2		
	Sides of Overflow walls and walkway	100.00	m^2		
	Horizontal	**560.00**	**m^2**	**R 650.00**	**R 364,000.00**
	Soffits of Roof slab	520.00	m^2		
	Soffit of Scum box floor	20.00	m^2		
	Soffit of Overflow walkway	20.00	m^2		
Joints	**Total Joints**	**600.00**	**m**		
	Between Floor Panels (incl. reargaurd)	300.00	m	R 570.00	R 171,000.00
	Between Wall Panels (incl. waterbar)	300.00	m	R 570.00	R 171,000.00
Structural Steelwork	**Items:**				
	Handrails with Kicker Plates	230.00	m	R 1,760.00	R 404,800.00
	Grid Flooring	8.00	m^2	R 1,500.00	R 12,000.00
SUB-TOTAL A					R 7,180,500.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 1,436,100.00
FINAL TOTAL FOR STRUCTURE					R 8,616,600.00

BOILER HOUSE QUANTITIES

		Calculated by:		HB	28/07/2016
		Checked by:		JP	29/07/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**270.00**	**m^3**	**R 2,200.00**	**R 594,000.00**
	Pad foundations	40.00	m^3		
	Strip footings	40.00	m^3		
	Columns	20.00	m^3		
	Beams	40.00	m^3		
	Floor slabs of trenchs	40.00	m^3		
	Floor slabs	60.00	m^3		
	Bund walls	10.00	m^3		
	Plinths	10.00	m^3		
	Ramps	10.00	m^3		
	Provisional (5%): Mass Concrete	**14.00**	**m^3**	**R 2,200**	**R 30,800.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**33.00**	**Ton**	**R 13,600**	**R 448,800.00**
Formwork	**Total Formwork**	**850.00**	**m^2**		
	Vertical	**790.00**	**m^2**	**R 650.00**	**R 513,500.00**
	Sides of Pad foundations	80.00	m^2		
	Sides of Strip footings	100.00	m^2		
	Sides of Columns	200.00	m^2		
	Sides of Beams	180.00	m^2		
	Sides of Floor slabs of trenchs	40.00	m^2		
	Sides of Floor slabs	60.00	m^2		
	Sides of Bund Walls	80.00	m^2		
	Sides of Plinths	40.00	m^2		
	Sides of Ramps	10.00	m^2		
	Horizontal	**60.00**	**m^2**	**R 650.00**	**R 39,000.00**
	Soffits of Beams	60.00	m^2		
Brickwork	**All Wall Thicknesses**	**680.00**	**m^2**	**R 0**	**R 0.00**
Joints	**Total Joints**	**200.00**	**m**		
	Between Floor Panels (incl. reargaurd)	100.00	m	R 570.00	R 57,000.00
	Between Wall Panels (incl. waterbar)	100.00	m	R 570.00	R 57,000.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates (Provisional)	40.00	m	1760	R 70,400.00
	Grid Flooring (Provisional)	220.00	m^2	1500	R 330,000.00
Roofing	**Items:**				
	Trusses, Purlins, Grids and Bracing	420.00	m^2	R 2,500.00	R 1,050,000.00
SUB-TOTAL A					R 2,140,500.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 428,100.00
FINAL TOTAL FOR STRUCTURE					R 2,568,600.00

GAS HOLDER QUANTITIES

		Calculated by:		HB	05/09/2016
		Checked by:		JP	31/08/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**380.00**	**m^3**	**R 2,200.00**	**R 836,000.00**
	Foundation	360.00	m^3		
	Plinths	10.00	m^3		
	Inlet valve box	10.00	m^3		
	Provisional (5%): Mass Concrete	**19.00**	**m^3**	**R 2,200.00**	**R 41,800.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**46.00**	**Ton**	**R 13,600.00**	**R 625,600.00**
Formwork	**Total Formwork**	**200.00**	**m^2**		
	Vertical	**200.00**	**m^2**	**R 650.00**	**R 130,000.00**
	Sides of Foundation	80.00	m^2		
	Sides of Plinths	40.00	m^2		
	Sides of Inlet valve box	80.00	m^2		
Joints	**Total Joints**	**250.00**	**m**		
	Between Floor Panels (incl. reargaurd)	100.00	m	R 570.00	R 57,000.00
	Between Wall Panels (incl. waterbar)	150.00	m	R 570.00	R 85,500.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates (Provisional)	450.00	m	R 1,760.00	R 792,000.00
	Grid Flooring (Provisional)	380.00	m^2	R 1,500.00	R 570,000.00
SUB-TOTAL A					R 3,137,900.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 1,255,160.00
FINAL TOTAL FOR STRUCTURE					R 4,393,060.00

FBP BUILDING QUANTITIES

Item	Description	Total Quantity Regular	Unit	Rate
			Calculated by:	JE
			Checked by:	NS
Concrete	**Total Structural Concrete**	**2070.00**	**m^3**	**R 2,200.00**
	Floor slab of wet well, basement, ground floor and first floor	1050.00	m^3	
	Walls wet well, beams and columns of building	700.00	m^3	
	Walls of sumps, basement floor and cable trenches	110.00	m^3	
	Wet well platforms, walkways and columns	110.00	m^3	
	Plinths and stairs	100.00	m^3	
	Provisional (5%): Mass Concrete	**104.00**	**m^3**	**R 2,200.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**249.00**	**Ton**	**R 13,600.00**
Formwork	**Total Formwork**	**8330.00**	**m^2**	
	Vertical	**6980.00**	**m^2**	**R 650.00**
	Sides of Floor slab of wet well, basement, ground floor and first floor	320.00	m^2	
	Sides of Walls of wet well, beams and columns of building	3290.00	m^2	
	Sides of Walls of sumps, basement floor and cable trenches	2780.00	m^2	
	Sides of Wet well platforms, walkways and columns	340.00	m^2	
	Sides of Plinths and stairs	250.00	m^2	
	Horizontal	**1350.00**	**m^2**	**R 650.00**
	Soffits of slabs, walkways and stairs	1350.00	m^2	
Brickwork	**All Wall of Various Thicknesses**	**1650.00**	**m^2**	**R 0.00**
Joints	**Total Joints**	**200.00**	**m**	
	Between Floor Panels (incl. reargaurd) (Provisional)	100.00	m	R 570.00
	Between Wall Panels (incl. waterbar) (Provisional)	100.00	m	R 570.00
Structural Steelwork	**Items:**			
	Handrails with Kicker plates (Provisional)	320.00	m	R 1,760.00
	Grid Flooring (Provisional)	15.00	m^2	R 1,500.00
Roofing	**Items:**			
	Portal Frame: Bolts, Cleats, Plates, Mild Steel Trusses, Mild Steel Columns, Mild Steel Beams, Purlins, Grids and Bracing	1150.00	m^2	R 2,600.00
	Clading	1150.00	m^2	R 2,400.00
SUB-TOTAL A				
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED				
FINAL TOTAL FOR STRUCTURE				

25/08/2016
31/08/2016
Amount
R 4,554,000.00
R 228,800.00
R 3,386,400.00
R 4,537,000.00
R 877,500.00
R 0.00
R 57,000.00
R 57,000.00
R 563,200.00
R 22,500.00
R 2,990,000.00
R 2,760,000.00
R 14,283,400.00
R 5,713,360.00
R 19,996,760.00

OUTLOADING STATION QUANTITIES

			Calculated by:	HJvR	01/08/2016
			Checked by:	JP	02/08/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**360.00**	**m^3**	**R 2,200.00**	**R 792,000.00**
	Floor slab	150.00	m^3		
	Retaining walls and footing	210.00	m^3		
	Provisional (5%): Mass Concrete	**18.00**	**m^3**	**R 2,200.00**	**R 39,600.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**44.00**	**Ton**	**R 13,600.00**	**R 598,400.00**
Formwork	**Total Formwork**	**740.00**	**m^2**		
	Vertical	**740.00**	**m^2**	**R 650.00**	**R 481,000.00**
	Sides of Floor slab	10.00	m^2		
	Sides of Retaining walls and footing	730.00	m^2		
Joints	**Total Joints**	**500.00**	**m**		
	Between Floor Panels (incl. reargaurd)	430.00	m	R 570.00	R 245,100.00
	Between Wall Panels (incl. waterbar)	70.00	m	R 570.00	R 39,900.00
Roofing	**Items:**				
				2500.00	
	Portal Frame: Bolts, Cleats, Plates, Mild Steel Trusses, Mild Steel Columns, Mild Steel Beams, Purlins, Grids and Bracing	810.00	m^2	R 2,600.00	R 2,106,000.00
	Clading	810.00	m^2	R 2,400.00	R 1,944,000.00
SUB-TOTAL A					R 6,246,000.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 624,600.00
FINAL TOTAL FOR STRUCTURE					R 6,870,600.00

SOLAR DRYING BEDS

Item	Description	Total Quantity Regular	Unit	Rate	Amount
			Calculated by:	JE	26/08/2016
			Checked by:	IS	31/08/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**860.00**	**m^3**	**R 2,200.00**	**R 1,892,000.00**
	Floor slab & walls	640.00	m^3		
	Retaining walls and footing	220.00	m^3		
	Provisional (5%): Mass Concrete	**43.00**	**m^3**	**R 2,200.00**	**R 94,600.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**104.00**	**Ton**	**R 13,600.00**	**R 1,414,400.00**
Formwork	**Total Formwork**	**1240.00**	**m^2**		
	Vertical	**1240.00**	**m^2**	**R 650.00**	**R 806,000.00**
	Sides of Floor slab	200.00	m^2		
	Sides of Retaining walls, footing & walls	1040.00	m^2		
Brickwork	**All Wall of Various Thicknesses**	**60.00**	**m^2**	**R 0.00**	**R 0.00**
Joints	**Total Joints**	**1140.00**	**m**		
	Between Floor Panels (incl. reargaurd) PROV	1100.00	m	R 570.00	R 627,000.00
	Between Wall Panels (incl. waterbar) PROV	40.00	m	R 570.00	R 22,800.00
Roofing	**Items:**				
	Portal Frame: Bolts, Cleats, Plates, Mild Steel Trusses, Mild Steel Columns, Mild Steel Beams, Purlins, Grids and Bracing	2880.00	m^2	R 2,600.00	R 7,488,000.00
	Clading	2380.00	m^2	R 2,400.00	R 5,712,000.00
SUB-TOTAL A					R 18,056,800.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 3,611,360.00
FINAL TOTAL FOR STRUCTURE					R 21,668,160.00

SLUDGE STORAGE AREA

Item	Description	Total Quantity Regular	Unit	Rate	Amount
			Calculated by:	JE	26/08/2016
			Checked by:	IS	31/08/2016
Concrete	**Total Structural Concrete**	**705.00**	**m^3**	**R 2,200.00**	**R 1,551,000.00**
	Floor slab & walls	700.00	m^3		
	Retaining walls and footing (Incl. kerbs)	5.00	m^3		
	Provisional (5%): Mass Concrete	**36.00**	**m^3**	**R 2,200.00**	**R 79,200.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**85.00**	**Ton**	**R 13,600.00**	**R 1,156,000.00**
Formwork	**Total Formwork**	**870.00**	**m^2**		
	Vertical	**870.00**	**m^2**	**R 650.00**	**R 565,500.00**
	Sides of Floor slab	400.00	m^2		
	Sides of Retaining walls, footing & walls	470.00	m^2		
Joints	**Total Joints**	**2140.00**	**m**		
	Between Floor Panels (incl. reargaurd)	2080.00	m	R 570.00	R 1,185,600.00
	Between Wall Panels (incl. waterbar)	60.00	m	R 570.00	R 34,200.00
SUB-TOTAL A					R 4,571,500.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 0.00
FINAL TOTAL FOR STRUCTURE					R 4,571,500.00

GRIT DRYING BEDS QUANTITIES

Item	Description	Total Quantity Regular	Unit	Rate	Amount
			Calculated by:	HJvR	01/08/2016
			Checked by:	JP	02/08/2016
Concrete	**Total Structural Concrete**	**260.00**	**m^3**	**R 2,200.00**	**R 572,000.00**
	Floor slab of beds and ramps	180.00	m^3		
	Floor slab of channels	20.00	m^3		
	Walls of beds	20.00	m^3		
	Walls of channels	40.00	m^3		
	Provisional (5%): Mass Concrete	**13.00**	**m^3**	**R 2,200.00**	**R 28,600.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**32.00**	**Ton**	**R 13,600.00**	**R 435,200.00**
Formwork	**Total Formwork**	**550.00**	**m^2**		
	Vertical	**550.00**	**m^2**	**R 650.00**	**R 357,500.00**
	Sides of Floor slab of beds and ramps	40.00	m^2		
	Sides of Floor slab of channels	40.00	m^2		
	Sides of Walls of beds	120.00	m^2		
	Sides of of channels	350.00	m^2		
Joints	**Total Joints**	**330.00**	**m**		
	Between Floor Panels (incl. reargaurd)	320.00	m	R 570.00	R 182,400.00
	Between Wall Panels (incl. waterbar)	10.00	m	R 570.00	R 5,700.00
SUB-TOTAL A					R 1,581,400.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 316,280.00
FINAL TOTAL FOR STRUCTURE					R 1,897,680.00

RETURN PUMP STATION QUANTITIES

		Calculated by:		HJvR	01/08/2016
		Checked by:		JP	01/08/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**285.00**	**m^3**	**R 2,200.00**	**R 627,000.00**
	Floor slab of dry well, sumps and wet wells	100.00	m^3		
	Walls Slab dry well, sumps and wet wells	140.00	m^3		
	Cover slabs and walkways	30.00	m^3		
	Beams	5.00	m^3		
	Plinths	5.00	m^3		
	Ramps	5.00	m^3		
	Provisional (5%): Mass Concrete	**15.00**	**m^3**	**R 2,200.00**	**R 33,000.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**35.00**	**Ton**	**R 13,600.00**	**R 476,000.00**
Formwork	**Total Formwork**	**1085.00**	**m^2**		
	Vertical	**1015.00**	**m^2**	**R 650.00**	**R 659,750.00**
	Sides of Floor slab of dry well, sumps and wet wells	50.00	m^2		
	Sides of Walls Slab dry well, sumps and wet wells	900.00	m^2		
	Sides of Cover slabs and walkways	30.00	m^2		
	Sides of Beams	10.00	m^2		
	Sides of Plinths	20.00	m^2		
	Sides of Ramps	5.00	m^2		
	Horizontal	**70.00**	**m^2**	**R 650.00**	**R 45,500.00**
	Soffits of Cover slabs and walkways	70.00	m^2		
Brickwork	**All Wall of Various Thicknesses**	**117.83**	**m^2**	**R 0.00**	**R 0.00**
Joints	**Total Joints**	**200.00**	**m**		
	Between Floor Panels (incl. reargaurd) (Provisional)	130.00	m	R 570.00	R 74,100.00
	Between Wall Panels (incl. waterbar) (Provisional)	70.00	m	R 570.00	R 39,900.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates (Provisional)	120.00	m	R 1,760.00	R 211,200.00
	Grid Flooring (Provisional)	10.00	m^2	R 1,500.00	R 15,000.00
Roofing	**Items:**				
	Trusses, Purlins, Grids and Bracing	160.00	m^2	R 2,500.00	R 400,000.00
SUB-TOTAL A					R 2,581,450.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 516,290.00
FINAL TOTAL FOR STRUCTURE					R 3,097,740.00

LIME THICKENER QUANTITIES

Item	Description	Total Quantity Regular	Unit	Rate	Amount
			Calculated by:	JP	25/08/2016
			Checked by:	DB	31/08/2016
Concrete	**Total Structural Concrete**	**430.00**	**m^3**	**R 2,200.00**	**R 946,000.00**
	Floor slab and footing of sludge hopper	10.00	m^3		
	Walls of sludge hopper	10.00	m^3		
	Footing of tank retaining walls	40.00	m^3		
	Floor slab of tank	100.00	m^3		
	Walls of tank	220.00	m^3		
	Floor Slabs of launders and boxes	20.00	m^3		
	Walls of launders and boxes	10.00	m^3		
	Centre column	20.00	m^3		
	Provisional (5%): Mass Concrete	**22.00**	**m^3**	**R 2,200.00**	**R 48,400.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**52.00**	**Ton**	**R 13,600.00**	**R 707,200.00**
Formwork	**Total Formwork**	**1830.00**	**m^2**		
	Vertical	**1770.00**	**m^2**	**R 650.00**	**R 1,150,500.00**
	Sides of Floor slab and footing of sludge hopper	10.00	m^2		
	Sides of Walls of sludge hopper	60.00	m^2		
	Sides of Footing of tank retaining walls	60.00	m^2		
	Sides of Walls of tank	1380.00	m^2		
	Sides of Floor Slabs of launders and boxes	40.00	m^2		
	Side of Walls of launders and boxes	120.00	m^2		
	Sides of Centre column	60.00	m^2		
	Sides of Pipe casings (Provisional)	40.00	m^2		
	Horizontal	**60.00**	**m^2**	**R 650.00**	**R 39,000.00**
	Soffits of Launders and boxes	60.00	m^2		
Joints	**Total Joints**	**230.00**	**m**		
	Between Floor Panels (incl. reargaurd)	220.00	m	R 570.00	R 125,400.00
	Between Wall Panels (incl. waterbar) (Provisional)	10.00	m	R 570.00	R 5,700.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates	120.00	m	R 1,760.00	R 211,200.00
	Grid Flooring	80.00	m^2	R 1,500.00	R 120,000.00
SUB-TOTAL A					R 3,353,400.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 670,680.00
FINAL TOTAL FOR STRUCTURE					R 4,024,080.00

LIME REACTOR AND SILO BUND QUANTITIES

Item	Description	Total Quantity Regular	Unit	Rate	Amount
	Calculated by:			JP	25/08/2016
	Checked by:			DB	31/08/2016
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**210.00**	**m^3**	**R 2,200.00**	**R 462,000.00**
	Floor slab	60.00	m^3		
	Floor slab of platforms, launders and boxes	10.00	m^3		
	Walls and columns	100.00	m^3		
	Walls of launders and boxes	5.00	m^3		
	Stairs	5.00	m^3		
	Silo bund	30.00	m^3		
	Provisional (5%): Mass Concrete	**11.00**	**m^3**	**R 2,200.00**	**R 24,200.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**26.00**	**Ton**	**R 13,600.00**	**R 353,600.00**
Formwork	**Total Formwork**	**620.00**	**m^2**		
	Vertical	**560.00**	**m^2**	**R 650.00**	**R 364,000.00**
	Sides of Floor slab	30.00	m^2		
	Sides of Floor slab of platforms, launders and boxes	20.00	m^2		
	Sides of Walls and columns	450.00	m^2		
	Sides of Walls of launders, boxes and stairs	30.00	m^2		
	Sides of Silo bund	30.00	m^2		
	Horizontal	**60.00**	**m^2**	**R 650.00**	**R 39,000.00**
	Soffits of Platforms, launders, boxes and stairs	60.00	m^2		
Joints	**Total Joints**	**100.00**	**m**		
	Between Floor Panels (incl. reargaurd)	80.00	m	R 570.00	R 45,600.00
	Between Wall Panels (incl. waterbar)	20.00	m	R 570.00	R 11,400.00
Structural Steelwork	**Items:**				
	Handrails with Kicker plates	70.00	m	R 1,760.00	R 123,200.00
	Grid Flooring	10.00	m^2	R 1,500.00	R 15,000.00
SUB-TOTAL A					R 1,438,000.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 287,600.00
FINAL TOTAL FOR STRUCTURE					R 1,725,600.00

LIME SLUDGE PUMP STATION QUANTIT

Item	Description	Total Quantity Regular	Unit	Rate
			Calculated by:	JP
			Checked by:	DB
Concrete	**Total Structural Concrete**	**80.00**	**m^3**	**R 2,200.00**
	Floor slab of dry well, sumps and wet wells	20.00	m^3	
	Walls Slab dry well, sumps and wet wells	30.00	m^3	
	Walkways and stairs	10.00	m^3	
	Beams	5.00	m^3	
	Plinths and ramps	5.00	m^3	
	Roof Slab	10.00	m^3	
	Provisional (5%): Mass Concrete	**4.00**	**m^3**	**R 2,200.00**
Reinforcing Steel	**Calculated at 120kg/m^3 of Structural Concrete**	**10.00**	**Ton**	**R 13,600.00**
Formwork	**Total Formwork**	**380.00**	**m^2**	
	Vertical	**290.00**	**m^2**	**R 650.00**
	Sides of Floor slab of dry well, sumps and wet wells	10.00	m^2	
	Sides of Walls Slab dry well, sumps and wet wells	230.00	m^2	
	Sides of Walkways and stairs	20.00	m^2	
	Sides of Beams	5.00	m^2	
	Sides of Plinths and ramps	5.00	m^2	
	Sides of Roof Slab	20.00	m^2	
	Horizontal	**90.00**	**m^2**	**R 650.00**
	Soffits of Roof slab, walkways and stairs	90.00	m^2	
Brickwork	**All Wall of Various Thicknesses**	**90.00**	**m^2**	**R 0.00**
Joints	**Total Joints**	**220.00**	**m**	
	Between Floor Panels (incl. reargaurd) (Provisional)	200.00	m	R 570.00
	Between Wall Panels (incl. waterbar) (Provisional)	20.00	m	R 570.00
Structural Steelwork	**Items:**			
	Handrails with Kicker plates (Provisional)	20.00	m	R 1,760.00
	Grid Flooring (Provisional)	20.00	m^2	R 1,500.00
SUB-TOTAL A				
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED				
FINAL TOTAL FOR STRUCTURE				

TIES
25/08/2016
31/08/2016
Amount
R 176,000.00
R 8,800.00
R 136,000.00
R 188,500.00
R 58,500.00
R 0.00
R 114,000.00
R 11,400.00
R 35,200.00
R 30,000.00
R 758,400.00
R 151,680.00
R 910,080.00

INTERCONNECTING PIPEWORK QUANTITIES

Item	PFD	Liquid	Diameter (mm)	Material	From	To	Total Quantity Regular	Unit	Rate	Amount
						Calculated by:			DJB	05/09/2016
						Checked by:			IS	
Pipe Runs and Handling Fees	12	WAS	200	uPVC	Flow Diversion Structure	WAS Gravity Thickeners	80	m	R 130.00	R 10,400.00
	12	Scum	200	uPVC	WAS Gravity Thickeners	Scum Sump	270	m	R 130.00	R 35,100.00
	12	Thickener Overflow	200	uPVC	WAS Gravity Thickeners	Filtrate Sump	310	m	R 130.00	R 40,300.00
	12	Thickener Underflow	300	uPVC	WAS Gravity Thickeners	GBT	170	m	R 250.00	R 42,500.00
	13	WF Sludge	200	uPVC	Sludge Fermenters	GBT Tickened Sludge Storage Sump	145	m	R 130.00	R 18,850.00
	13	Primary Scum	200	uPVC	Primary Sedimentation Tanks	GBT Tickened Sludge Storage Sump	145	m	R 130.00	R 18,850.00
	14	Thickened Sludge	200	uPVC	GBT Building	Distribution Tower	200	m	R 130.00	R 26,000.00
	14	Thickened Sludge	200	Steel	Distribution Tower	Anaerobic Digesters (6 off)	110	m	R 1,300.00	R 143,000.00
	14	Grit & Sludge	200	uPVC	Anaerobic Digesters	Grit Drying Beds	210	m	R 130.00	R 27,300.00
	14	Digested Sludge	200	uPVC	Anaerobic Digesters (Drain)	Digested Sludge Storage Tanks	565	m	R 130.00	R 73,450.00
	14	Digester Overflow	200	uPVC	Anaerobic Digesters	Struvite Reactors	335	m	R 130.00	R 43,550.00
	14	Grit Decant	200	uPVC	Grit Drying Beds	Filtrate Sump (?)	105	m	R 130.00	R 13,650.00
	14	Gas	400	Steel	Boiler Houses	Gas Holding Tanks	200	m	R 4,000.00	R 800,000.00
	15	Lime Underflow	200	uPVC	Lime Clarifier	Digested Sludge Storage Tanks	65	m	R 130.00	R 8,450.00
	16	Gas	400	Steel	Anaerobic Digesters	Boiler Houses	300	m	R 4,000.00	R 1,200,080.00
	16	Gas	400	Steel	Boiler Houses	Heat Exchangers	100	m	R 4,000.00	R 400,000.00
	19	Stormwater Run-Off	500	Concrete	Sludge Stockpiling Area	Stormflow Dam	800	m	R 800.00	R 640,000.00
	20	BFP & GBT Filtrate	200	uPVC	BFP Building	Lime Reaction Tanks	35	m	R 130.00	R 4,550.00
	20	Lime Make-Up	200	uPVC	Lime Make-Up Tanks	Lime Reaction Tanks	25	m	R 130.00	R 3,250.00
	20	Lime Overflow	200	uPVC	Lime Clarifier	Filtrate Sump	45	m	R 130.00	R 5,905.90
	20	Lime Scum	200	uPVC	Lime Clarifier	Scum Sump	80	m	R 130.00	R 10,423.40
	20	Filtrate	200	uPVC	Filtrate Sump	Head of Works	1200	m	R 130.00	R 156,000.00
								m		R 0.00
Pipe Bends and Handling Fees			200	uPVC	45° Bend		35	No.	R 600.00	R 21,000.00
			200	uPVC	90° Bend		70	No.	R 600.00	R 42,000.00
			300	uPVC	45° Bend		10	No.	R 2,100.00	R 21,000.00
			300	uPVC	90° Bend		10	No.	R 2,100.00	R 21,000.00
			400	Steel	45° Bend		15	No.	R 10,000.00	R 150,000.00
			400	Steel	90° Bend		2	No.	R 10,000.00	R 20,000.00
			500	Concrete	45° Bend		2	No.	R 15,000.00	R 30,000.00
			500	Concrete	90° Bend		5	No.	R 15,000.00	R 75,000.00
Pipe Tees and Handling Fees			200	uPVC			20	No.	R 600.00	R 12,000.00
			400	Steel			8	No.	R 15,000.00	R 120,000.00
Estimated Pipe Excavations					**Over 0mm up to 500mm Diameter for Depths:**					
					0 m- 2m		2580	m^3	R 450.00	R 1,161,000.00
					2 m- 4m		2211	m^3	R 900.00	R 1,989,900.00
					Extra Over Items for :					
					Excavation in Hard Rock (Assumed 20 %)		959	m^3	R 1,000.00	R 959,000.00
					Excavation in Unsuitable Material from Bottom of Trench (Assumed 10 %)		480	m^3	R 100.00	R 48,000.00
					Excavation and Backfill by Hand in Restricted Areas (Assumed 10 %)		480	m^3	R 150.00	R 72,000.00
					Shoring of Trenches where Instructed by Engineer (Assumed 5 %)		240	m^3	R 250.00	R 60,000.00
Test, Supply, Handle, Lay, Bed Class C					Over 0mm upto 500mm Diameter for Depths:		4786	m	R 250.00	R 1,196,402.50
Bedding Pipes					**From Trench Excavations**					
			200		Bedding		406	m^3	R 200.00	R 81,260.13
					Blanket		1355	m^3	R 200.00	R 270,945.60
			300		Bedding		22	m^3	R 200.00	R 4,348.60
					Blanket		73	m^3	R 200.00	R 14,667.60
			500		Bedding		146	m^3	R 200.00	R 29,120.00
					Blanket		489	m^3	R 200.00	R 97,856.00
			200, 300, 500		Backfill		2301	m^3	R 200.00	R 460,200.00
SUB-TOTAL A: REFER TO CALCULATIONS FOR BREAKDOWN										R 10,072,117.53
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED										R 2,014,424.00
FINAL TOTAL FOR STRUCTURE										R 12,086,541.53

RESTRICTED AND BULK EARTHWORKS

			Calculated by:	JE / LM	01/09/2016
			Checked by:		
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Bulk Earthworks	**Clear & Grub**	**84400.00**	**m^2**	**R 3.00**	**R 253,200.00**
	Bulk Excavation	**92560.00**	m^3		
	0 - 2m	57040.00	m^3	R 120.00	R 6,844,800.00
	2 - 4m	27360.00	m^3	R 850.00	R 23,256,000.00
	4 - 6m	7180.00	m^3	R 850.00	R 6,103,000.00
	6 - 8m	980.00	m^3	R 850.00	R 833,000.00
	8 - 10m	0.00	m^3	R 850.00	R 0.00
	10 - 12m	0.00	m^3	R 850.00	R 0.00
	Bulk Fill	**48790.00**	**m^3**		
	Re-useable Material (incl.)	45630.00	m^3	R 0.00	R 0.00
	Imported from Commercial Sources	3160.00	m^3	R 250.00	R 790,000.00
	Blasting	**29210.00**	**m^3**		
	Blasting in Hard Rock (incl.)	29210.00	**m^3**	R 0.00	R 0.00
Restricted Excavation	**Anaerobic Digester Cluster**	**11450.00**	**m^3**		
	0 - 2m	5190.00	m^3	R 1,020.00	R 5,293,800.00
	2 - 4m	4550.00	m^3	R 1,020.00	R 4,641,000.00
	4 - 6m	1710.00	m^3	R 1,020.00	R 1,744,200.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	WAS Thickener Cluster	**360.00**	**m^3**		
	0 - 2m	320.00	m^3	R 1,020.00	R 326,400.00
	2 - 4m	40.00	m^3	R 1,020.00	R 40,800.00
	4 - 6m	0.00	m^3	R 1,020.00	R 0.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	Gas Holder	**360.00**	**m^3**		
	0 - 2m	340.00	m^3	R 1,020.00	R 346,800.00
	2 - 4m	20.00	m^3	R 1,020.00	R 20,400.00
	4 - 6m	0.00	m^3	R 1,020.00	R 0.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	GBT & FBP Building	**3680.00**	**m^3**		
	0 - 2m	3420.00	m^3	R 1,020.00	R 3,488,400.00
	2 - 4m	150.00	m^3	R 1,020.00	R 153,000.00
	4 - 6m	110.00	m^3	R 1,020.00	R 112,200.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	Grit Drying Beds	**770.00**	**m^3**		
	0 - 2m	**770.00**	m^3	R 1,020.00	R 785,400.00
	2 - 4m	**0.00**	m^3	R 1,020.00	R 0.00
	4 - 6m	**0.00**	m^3	R 1,020.00	R 0.00
	6 - 8m	**0.00**	m^3	R 1,020.00	R 0.00
	Lime Cluster	**5070.00**	**m^3**		
	0 - 2m	2240.00	m^3	R 1,020.00	R 2,284,800.00
	2 - 4m	1920.00	m^3	R 1,020.00	R 1,958,400.00
	4 - 6m	880.00	m^3	R 1,020.00	R 897,600.00
	6 - 8m	30.00	m^3	R 1,020.00	R 30,600.00
	Return Pump Station	**1600.00**	**m^3**		
	0 - 2m	950.00	m^3	R 1,020.00	R 969,000.00
	2 - 4m	540.00	m^3	R 1,020.00	R 550,800.00
	4 - 6m	110.00	m^3	R 1,020.00	R 112,200.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	Solar Drying Beds	**5860.00**	**m^3**		
	0 - 2m	**5860.00**	m^3	R 1,020.00	R 5,977,200.00
	2 - 4m	**0.00**	m^3	R 1,020.00	R 0.00
	4 - 6m	**0.00**	m^3	R 1,020.00	R 0.00
	6 - 8m	**0.00**	m^3	R 1,020.00	R 0.00
	Outloading Station	**570.00**	**m^3**		

Item	Description	Total Quantity Regular	Unit	Rate	Amount
	0 - 2m	570.00	m^3	R 1,020.00	R 581,400.00
	2 - 4m	0.00	m^3	R 1,020.00	R 0.00
	4 - 6m	0.00	m^3	R 1,020.00	R 0.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	Sludge Stockpiling Area	**3080.00**	**m^3**		
	0 - 2m	3080.00	m^3	R 1,020.00	R 3,141,600.00
	2 - 4m	0.00	m^3	R 1,020.00	R 0.00
	4 - 6m	0.00	m^3	R 1,020.00	R 0.00
	6 - 8m	0.00	m^3	R 1,020.00	R 0.00
	Excavate and Dispose of Unsuitbale Material and Hard rock	**40920.00**	**m^3**	**R 120.00**	**R 4,910,400.00**
SUB-TOTAL A					R 76,446,400.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 0.00
FINAL TOTAL FOR STRUCTURE					R 76,446,400.00

RESTRICTED AND BULK EARTHWORKS

			Calculated by:	TD	01/09/2016
			Checked by:		
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Concrete	**Total Structural Concrete**	**2360.00**	**m^3**	**R 2,200.00**	**R 5,192,000.00**
	Walls and Floors	2360.00	m^3		
	Provisional: Mass Concrete	**118.00**	**m^3**	**R 2,200.00**	**R 259,600.00**
Reinforcing Steel	**Calculated at 120 kg/m^3 of Structural Concrete**	**284.00**	**Ton**	**R 13,600.00**	**R 3,862,400.00**
Formwork	**Total Formwork**	**8400.00**	**m^2**		
	Vertical	**8400.00**	**m^2**	**R 650.00**	**R 5,460,000.00**
	Walls	7720.00	m^2		
	Footings	680.00	m^2		
SUB-TOTAL A					R 14,774,000.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 0.00
FINAL TOTAL FOR STRUCTURE					R 14,774,000.00

		0 to 2m	2 to 4m	4 to 6m	6 to 8m	TOTAL
Lime clarifier	m^3	3365.49	226.03	0	0	3591.52
Digester	m^3	6445.71	2018.68	146.34	0	8610.73
Was thickener	m^3	1154.5	13.73	0	0	1168.23
Grit Drying Bed	m^3	0.32	0	0	0	0.32
Sludge Drying Bed	m^3	22715.76	13269.91	5753.55	981.1	42720.32
Sludge Stockpiling Area	m^3	9138.88	5233.13	1280.41	0	15652.42
Belt Press building	m^3	1056.22	284.58	0	0	1340.8
	TOTAL	**43876.88**	**21046.06**	**7180.3**	**981.1**	
ADJUSTED (30% MORE)	**TOTAL**	**57039.94**	**27359.88**	**9334.39**	**1275.43**	

	Blasting(m^3)	+ 30%
Lime clarifier	226.03	293.839
Digester	2165.02	2814.526
Was thickener	13.73	17.849
Grit Drying Bed	0	0
Sludge Drying Bed	20004.56	26005.93
Sludge Stockpiling Area	6513.54	8467.602
Belt Press building	284.58	369.954

	FILL	+ 30%
Lime clarifier	1081.47	1405.911
Digester	22624.86	29412.32
Was thickener	7100.79	9231.027
Grit Drying Bed	5040.28	6552.364
Sludge Drying Bed	1630.6	2119.78
Sludge Stockpiling Area	53.68	69.784
Belt Press building	0	0
TOTAL		**48791.18**
TOTAL RE-USABLE		45631.96

CLEAR & GRUB	48468	m^2
+ 30%	**63008.4**	

TOTAL + 30%			Total
4668.976		Lime clarifier	3591.52
11193.949		Digester	8610.73
1518.699		Was thickener	1168.23
0.416		Grit Drying Bed	0.32
55536.416		Sludge Drying Bed	42720.32
20348.146		Sludge Stockpiling Area	15652.42
1743.04		Belt Press building	1340.8
		TOTAL ROCK	

From 2m	From 4m	From 6m	From 8m	2D Area	Fill
226.03	0	0	0	4592.59	1081.47
2165.02	146.34	0	0	14877.33	22624.86
13.73	0	0	0	4283.83	7100.79
0	0	0	0	2319.22	5040.28
20004.56	6734.65	981.1	0	15869.24	1630.6
6513.54	1280.41	0	0	5843.59	53.68
284.58				682.2	0
29207.46					

Anaerobic Digester Cluster

Digester					no of		
0 - 2m	756.82			756.82	6	4540.92	
2 - 4m	756.82			756.82	6	4540.92	
4 - 6m	270.56315	13.35		283.9132	6	1703.479	
Boiler House							
0 - 2m	259.2384	11.7312		270.9696	2	541.9392	Assumed F(
2 - 4m				0	2	0	
4 - 6m				0	2	0	
Division Tower							
0 - 2m	103.8251507			103.8252	1	103.8252	
2 - 4m				0	1	0	Assumed F(
4 - 6m				0	1	0	

WAS Thickener Cluster

0 - 2m	36.50812	32.53	8.758	77.79612	4	311.1845	Feed Box e:
2 - 4m	1.31	7.1725		8.4825	4	33.93	
4 - 6m				0	4	0	

Gas Holder

0 - 2m	295.677	40.28		335.957	1	335.957	Assumed F(
2 - 4m		13.3931		13.3931	1	13.3931	
4 - 6m				0	1	0	

GBT & FBP Building (incl conveyor cut)

0 - 2m	3377.4129	42.27	506.1033	3925.786	1	3925.786	Assumed F(
2 - 4m	149.95			149.95	1	149.95	
4 - 6m	108.62			108.62	1	108.62	

Grit Drying Beds

0 - 2m	581.80278	91.767	91.1872	764.757	1	764.757	Assumed F(
2 - 4m					1	0	
4 - 6m					1	0	

Lime Cluster (incl Lime dosing)

0 - 2m	830.96			830.96	2	1661.92	2 Clarifiers
2 - 4m	830.96			830.96	2	1661.92	
4 - 6m	361.4676	77		438.4676	2	876.9352	

6 - 8m	13.9675		13.9675	2	27.935	
Dosing & Pump Station						
0 - 2m	29.028	204	233.028	1	233.028	
2 - 4m		51	51	1	51	
4 - 6m		0.8125	0.8125	1	0.8125	
6 - 8m			0	1	0	
Lime Reator						
0 - 2m	344.43		344.43	1	344.43	
2 - 4m	198.04725		198.0473	1	198.0473	
4 - 6m			0	1	0	
6 - 8m			0	1	0	
				Return PS		
0 - 2m	943.85		943.85	1	943.85	Assumed N
2 - 4m	259.55875	276.8993	536.458	1	536.458	
4 - 6m	0.88	105.0308	105.9108	1	105.9108	
				Solar Drying Beds		
0 - 2m	509.5278	467.0672	976.595	6	5859.57	Assumed N
2 - 4m			0	1	0	
4 - 6m			0	1	0	
				Outloading Station		
0 - 2m	477.48	89.23845	566.7185	1	566.7185	Assumed N
2 - 4m			0	1	0	
4 - 6m			0	1	0	
				Sludge Storage Bunker		
0 - 2m	3029.91085	41.5616	3071.472	1	3071.472	Assumed N
2 - 4m			0	1	0	
4 - 6m			0	1	0	

Totals

Anaerobic Digester Cluster	
0 - 2m	5186.684
2 - 4m	4540.92
4 - 6m	1703.479

GL to be 100mm below door

GL 500mm above concrete footing

xcluded, Manholes Excluded (floating)

Anaerobic Digester Cluster	
0 - 2m	311.1845
2 - 4m	33.93
4 - 6m	0

GL is 50mm below concrete footing

Gas Holder	
0 - 2m	335.957
2 - 4m	13.3931
4 - 6m	0

GL is 50mm below concrete footing

GBT & FBP Building	
0 - 2m	3925.786
2 - 4m	149.95
4 - 6m	108.62

GL is 50mm below TOC

Grit Drying Beds	
0 - 2m	764.757
2 - 4m	0
4 - 6m	0

Lime Cluster	
0 - 2m	2239.378
2 - 4m	1910.967

4 - 6m	877.7477
6 - 8m	27.935

GL is 50mm below TOC

Return PS	
0 - 2m	943.85
2 - 4m	536.458
4 - 6m	105.9108

GL is 50mm below TOC of Footing/Floor

Solar Drying Beds	
0 - 2m	5859.57
2 - 4m	0
4 - 6m	0

GL is 50mm below TOC of Floor

Solar Drying Beds	
0 - 2m	566.7185
2 - 4m	0
4 - 6m	0

GL is 100mm below TOC of Kerb

Solar Drying Beds	
0 - 2m	3071.472
2 - 4m	0
4 - 6m	0

RETAINING WALLS

		Calculated by:		JE / LM	01/09/2016
		Checked by:			
Item	Description	Total Quantity Regular	Unit	Rate	Amount
Retaining Walls	**Sub Total For Retaining Walls**	**2730.00**	**m**		
	0 - 2m Sub Total	**1500.00**	**m**	**R 0.00**	**R 0.00**
	2 - 4m Sub Total	**765.00**	**m**	**R 0.00**	**R 0.00**
	4 - 6m Sub Total	**355.00**	**m**	**R 0.00**	**R 0.00**
	6 - 8m Sub Total	**110.00**	**m**	**R 0.00**	**R 0.00**
	Lime Cluster Terrace (1286.00m)				
	0 - 2m	195.00	m		
	2 - 4m	40.00	m		
	4 - 6m	0.00	m		
	6 - 8m	0.00	m		
	Anaerobobic Digester Cluster (1289.00m)				
	0 - 2m	330.00	m		
	2 - 4m	190.00	m		
	4 - 6m	40.00	m		
	6 - 8m	0.00	m		
	WAS Thickener Cluster (1291.34m)				
	0 - 2m	120.00	m		
	2 - 4m	60.00	m		
	4 - 6m	10.00	m		
	6 - 8m	0.00	m		
	Grit Drying Beds (1289.00m)				
	0 - 2m	85.00	m		
	2 - 4m	35.00	m		
	4 - 6m	0.00	m		
	6 - 8m	0.00	m		
	Solar Drying Beds (1293.40m)				
	0 - 2m	495.00	m		
	2 - 4m	245.00	m		
	4 - 6m	185.00	m		
	6 - 8m	110.00	m		
	Sludge Stockpiling Area (1293.40m)				
	0 - 2m	215.00	m		
	2 - 4m	165.00	m		
	4 - 6m	115.00	m		
	6 - 8m	0.00	m		
	GBT & FBP Building (1288.85m)				
	0 - 2m	60.00	m		
	2 - 4m	30.00	m		
	4 - 6m	5.00	m		
	6 - 8m	0.00	m		
SUB-TOTAL A					R 0.00
ALLOW FACTORING FOR ADDITIONAL ITEMS NOT SPECIFICALLY MEASURED					R 0.00
FINAL TOTAL FOR STRUCTURE					R 0.00

SECTION 1 : MECHANICAL EQUIPMENT FOR THE HEAD OF WORKS

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
1.1	**Design, Manufacture, Delivery, Installation and Commissioning of Clamshell Bucket Stone removal equipment**				
1.1.1	500 liter Clamshell buckets	No	1	81,880.00	81,880.00
1.1.2	Steel A-frame with crawl beam including trolley, electric hoist	No	1	75,000.00	75,000.00
1.2	**Design, Manufacture, Delivery, Installation and Commissioning of Coarse Screening equipment**				
1.2.1	Complete Mechanically front raked Screen for a 1500mm wide channel with 12mm bar spacing	No	2	480,000.00	960,000.00
1.3	**Design, Manufacture, Delivery, Installation and Commissioning of Coarse Screenings handling Equipment**				
1.3.1	Hydraulic Screenings conveyor complete in	No	1	220,000.00	220,000.00
1.3.2	Screenings press / compactor complete in	No	2	625,000.00	1,250,000.00
1.4	**Design, Manufacture, Delivery, Installation and Commisioning of electrically/manually operated penstocks**				
1.4.1	Manual Operated channel penstocks dimensions 2000mm wide x 2000mm deep	No	4	215,000.00	860,000.00
1.4.2	Electrically Actuated channel penstocks dimensions 1500mm wide x 2000mm deep	No	2	194,000.00	388,000.00
1.4.3	Electrically Actuated channel penstocks dimensions 1500mm wide x 1900mm deep	No	2	194,000.00	388,000.00
1.4.4	Electrically Actuated channel gates complete 1300mm wide x 1900mm deep	No	2	160,000.00	320,000.00
1.4.5	Electrically Actuated channel gates complete 1300mm wide x 2000mm deep	No	2	160,000.00	320,000.00
1.4.6	Electrically Actuated channel gates complete 2600mm wide x 2450mm deep	No	2	248,000.00	496,000.00
1.4.7	Electrically Actuated channel gates complete 2600mm wide x 2950mm deep	No	2	261,000.00	522,000.00
1.4.8	Manual Operated wall penstocks 1800mm wide x 1800mm deep	No	2	194,000.00	388,000.00
1	**Total**				**6,268,880.00**

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
BROUGHT FORWARD					6,268,880.00
1.5	**Design, Manufacture, Delivery, Installation and Commissioning of the Grit handling Equipment**				
1.5.1	Internal pipework for each vortex degritter including - washwater, compressed air, air blower and grit	No	2	80,293.53	160,587.07
1.5.2	Complete Airlift system	No	2	350,000.00	700,000.00
1.5.3	Grit classifiers complete with feed troughs and hand stops including air lift pipework from each vortex chamber to the grit classifiers.	No	2	200,000.00	400,000.00
1.5.4	Washwater strorage tank, 2 pumps, pipework, valves and supports for each vortex chamber to connect to the pipework priced under item 2.4.1	sum	2	97,422.82	194,845.64
1.6	**Design, Manufacture, Delivery, Installation and Commissioning of Fine Screening equipment**				
1.6.1	Complete Mechanically Drum Type Screen for a 2600mm wide channel with 6mm openings	No	2	2,180,000.00	4,360,000.00
1.7	**Design, Manufacture, Delivery, Installation and Commissioning of Fine Screenings handling Equipment**				
1.7.1	Hydraulic Screenings conveyor complete at Fine Screens	No	1	220,000.00	220,000.00
1.7.2	Screenings press / compactor complete at Fine Screens	No	1	625,000.00	625,000.00
1.8	**Design, Manufacture, Delivery, Installation and Commissioning of Miscelaneous equipment**				
1.8.1	Skips	No	6	35,000.00	210,000.00
1.8.2	Manual Screen	No	3	50,000.00	150,000.00
1	**Total Section 1**				**13,289,312.71**

SECTION 2 : MECHANICAL EQUIPMENT FOR THE PST's

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
2.1	**Design, Manufacture, Delivery, Installation and Commissioning of**				
2.1.1	Complete mechanical equipment for 34m PST including single peripheral drive bridge, floor scraper, scum scraper, scum baffle, weir plate and scum trough	No	2	978,912.01	1,957,824.02
2.1.2	200mm Diameter electrically operated knife gate valves as specified	No	4	67,955.09	271,820.38
2.1.3	Launder covers	m^2	125.92	500.00	62,957.52
2.1.4	Manual Operated wall penstocks 900mm wide x 900mm deep	No	2	92,000.00	184,000.00
2	**Total Section 2**				**2,476,601.92**

SECTION 3 : MECHANICAL EQUIPMENT FOR THE FERMENTERS

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
3.1	**Design, Manufacture, Delivery, Installation and Commissioning of**				
3.1.1	Complete mechanical equipment for the 30m Fermenter including single peripheral drive bridge, floor scraper, picket fences, weir plate	No	2	978,912.01	1,957,824.02
3.1.2	200mm Diameter electrically operated knife gate valves as specified	No	2	67,955.09	135,910.19
3.1.3	Tank covers	m^2	1414	500.00	706,858.35
3.1.4	Complete odour control system	Sum	1	10,705,804.62	10,705,804.62
3.1.5	Manual Operated wall penstocks 1000mm wide x 500mm deep	No	2	77,000.00	154,000.00
3	**Total Section 3**				**13,660,397.18**

SECTION 4 : MECHANICAL EQUIPMENT FOR THE BALANCING TANKS

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
4.1	**Design, Manufacture, Delivery, Installation and Commissioning of Mechanical surface mounted mixer complete including impellors, drive shaft, slow speed coupling, gearbox, mounting plate, high speed coupling and electric motor**				
4.1.1	7.5 kW for a height from platform to floor of 4950mm	No	8	78,928.54	631,428.36
4.2	**Design, Manufacture, Delivery, Installation and Commissioning of electrically/manually operated penstocks**				
4.2.1	1500mm by 1500mm with spindle height of 8850mm	No	2	161,000.00	322,000.00
4.2.2	1500mm by 1500mm with spindle height of 5700mm	No	2	158,000.00	316,000.00
4.2.3	1500mm by 1500mm with spindle height of 5950mm	No	2	158,000.00	316,000.00
4.2.4	Portable steel frame for maintenance of the aerators complete as specified	No	1	20,006.47	20,006.47
4.3	**Balancing tank Drain Pumps**				
4.3.1	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	50,000.00	50,000.00
4.3.2	Control valves	No	2	200,733.84	401,467.67
4	**Total Section 4**				**2,056,902.50**

SECTION 5 : MECHANICAL EQUIPMENT FOR THE BNR REACTOR

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
5.1	**Design, Manufacture, Delivery, Installation and Commissioning of** **Mechanical surface mounted mixer complete including impellors, drive shaft, slow speed coupling, gearbox, mounting plate, high speed coupling and electric motor**				
5.1.1	7.5 kW for a height from platform to floor of 7000mm	No	7	110,499.96	773,499.74
5.2	**Design, Manufacture, Delivery, Installation and Commissioning of** **electrically/manually operated penstocks** complete as specified - to suit opening in a wall of				
5.2.1	1000mm by 1000mm with spindle height of 9000mm	No	2	116,000.00	232,000.00
					0.00
5.2.2	1000mm by 500mm with spindle height of 2600mm	No	2	77,000.00	154,000.00
5.2.3	500mm by 500mm with spindle height of 5600mm	No	2	42,000.00	84,000.00
5.2.4	500mm by 500mm with spindle height of 8000mm	No	2	48,000.00	96,000.00
5.2.5	Adjustable weir	No	4	143,307.23	573,228.93
5.2.6	Portable steel frame for maintenance of the aerators complete as specified	No	1	25,000.00	25,000.00
5.3	**Design, Manufacture, Delivery, Installation and Commissioning of**				
5.3.01	Centrifugal Blowers	No.	6	3,102,015.80	18,612,094.80
5.3.02	Blowerroom Stainless Steel Piping, including all Piping ,Dismanteling Joints, Isolation Valves, Bellows and Pipe Support structures	Sum	1	711,774.10	711,774.10
5.3.03	Discharge Stainless Steel Piping up to Flow Measurement piping, including all Piping , Bellows and Pipe Support structures	Sum	2	1,463,602.70	2,927,205.40
5.3.04	Flow Measurement and Dropleg Stainless Steel Piping, including all Piping ,Dismanteling Joints, Butterfly and Actuator Prepared Knife Gate Valves and Pipe Support structures	Sum	2	1,282,146.50	2,564,293.00
5.3.05	Lateral and distribution pipework including anchors, supports and condensate removal system complete with Quick Connection Saddles and Diffusers where applicable	Sum	2	2,389,474.60	4,778,949.20
5.3.06	Performance Testing of entire FBDA system	Sum	1	414,000.00	414,000.00
5.3.07	RAS pumps	No.	4	750,000.00	3,000,000.00
5.3.08	GRP covers	m^2	200	500.00	100,000.00
5.3.09	A-Recycle pumps	No.	3	239,016.46	717,049.37
5.3.10	B-Recycle pumps	No.	2	138,218.63	276,437.26
5.3.11	Sampling Pumps	No.	2	50,000.00	100,000.00
5.3.12	200mm Diameter electrically operated knife gate valves as specified	No	2	67,955.09	135,910.19
5	**Total Section 5**				**36,275,441.98**

SECTION 6 : MECHANICAL EQUIPMENT FOR SECONDARY CLARIFIERS

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
6.1	**Design, Manufacture, Delivery, Installation and Commissioning of**				
6.1.1	Complete mechanical equipment for 34m Clarifier including single peripheral drive bridge, floor scraper, scum scraper, scum baffle, weir plate and scum trough	No	2	978,912.01	1,957,824.02
6.2	**Design, Manufacture, Delivery, Installation and Commisioning of electrically/manually operated penstocks**				
6.2.1	Manual Operated wall type penstocks 900mm by 900mm with spindle height of 4900mm	No	2	92,000.00	184,000.00
6.2.2	Handstop 200mm by 200mm with spindle height of2000mm	No	4	10,000.00	40,000.00
6.2.3	Launder covers	m^2	126	500.00	62,957.52
6	**Total Section 6**				**2,244,781.54**

SECTION 7 : MECHANICAL EQUIPMENT FOR THE PRIMARY SLUDGE PUMP STATION

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
7.1	**Primary Sludge Pumps**				
7.1.1	Vertical shaft mounted mixers complete with motor, gearbox,base plate, coupling and holding down bolts.	No	2	50,000.00	100,000.00
7.1.2	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	3	86,940.00	260,820.00
7.1.3	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	202,072.06	202,072.06
7.2	**Settled Sewage Pumps**				
7.2.1	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	4	104,420.00	417,680.00
7.2.2	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	202,072.06	202,072.06
7.2.3	Pump Station floor drainage pump including pipework	No	1	74,750.00	74,750.00
7.2.4	Lifting equipment	Sum	1	30,000.00	30,000.00
7	**Total Section 7**				**1,287,394.12**

Total Section 1

SECTION 8 : MECHANICAL EQUIPMENT FOR THE FERMENTER PUMP STATION

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
8.1	**Waste Fermented Sludge Pumps**				
8.1.1	Vertical shaft mounted mixers complete with motor, gearbox,base plate, coupling and holding down bolts.	No	2	57,500.00	115,000.00
8.1.2	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	2	75,555.00	151,110.00
8.1.3	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	202,072.06	202,072.06
8.1.4	Pump Station floor drainage pump complete with pipework, fittings, valves and supports.	No	1	74,750.00	74,750.00
8.2	**Recycle Fermented Sludge Pumps**				
8.2.1	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	2	105,627.50	211,255.00
8.2.2	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	202,072.06	202,072.06
8.2.3	Air extraction system	Sum	1	50,000.00	50,000.00
8	**Total Section 8**				**1,006,259.12**

SECTION 9 : MECHANICAL EQUIPMENT FOR THE WAS PUMP STATION

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
9.1	**WAS Pump Station**				
9.1.1	Vertical shaft mounted mixers complete with motor, gearbox,base plate, coupling and holding down bolts.	No	2	50,000.00	100,000.00
9.1.2	Support bridge for mixers complete with access ladder, handrailing and holding down bolts.	No	1	50,000.00	50,000.00
9.1.3	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	4	97,750.00	391,000.00
9.1.4	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	202,072.06	202,072.06
9.1.5	Pump Station floor drainage pump complete with pipework, fittings, valves and supprts.	No	1	74,750.00	74,750.00
9.1.6	Lifting equipment	Sum	1	30,000.00	30,000.00
9.1.7	Air extraction system	Sum	1	50,000.00	50,000.00
9	**Total Section 9**				**897,822.06**

SECTION 10 : MECHANICAL EQUIPMENT FOR THE WASHWATER PUMP STATION

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
10.1	**Chlorination Channel Sludge Pumps**				
10.1.1	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	2	86,940.00	173,880.00
10.1.2	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	200,733.84	200,733.84
10.2	**Washwater to HOW Pumps**				
10.2.1	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	2	154,330.00	308,660.00
10.2.2	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	200,733.84	200,733.84
10.3	**Washwater to Sludge Handling Pumps**				
10.3.1	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	2	113,505.00	227,010.00
10.3.2	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	200,733.84	200,733.84
10.3.3	Pump Station floor drainage pump complete with pipework, fittings, valves and supprts.	No	1	74,750.00	74,750.00
10.3.4	Lifting equipment	Sum	1	30,000.00	30,000.00
10.3.5	Air extraction system	Sum	1	50,000.00	50,000.00
10	**Total Section 10**				**1,091,887.67**

SECTION 11 : MECHANICAL EQUIPMENT FOR STORMFLOW DAM PUMP STATION

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
11.1	**Stormflow Dam Pumps**				
11.1.1	Centrifugal pumps complete with motor, base plate, coupling and coupling guard.	No	3	655,500.00	1,966,500.00
11.1.2	Suction and Discharge pipe work, valves, fittings and pipe supports.	sum	1	602,201.51	602,201.51
11.1.3	Pump Station floor drainage pump complete with pipework, fittings, valves and supprts.	No	1	74,750.00	74,750.00
11.1.4	Lifting equipment	Sum	1	30,000.00	30,000.00
11.1.5	Manual Screen	No	1	50,000.00	50,000.00
11.1.6	Air extraction system	Sum	1	50,000.00	50,000.00
11	**Total Section 11**				**2,773,451.51**

SECTION 12: MECHANICAL EQUIPMENT FOR FERRIC DOSING AND DISINFECTION

ITEM NO	DESCRIPTION	UNIT	QUANTITY	RATE	AMOUNT
12.1	**Design, Manufacture and deliver Mechanical equipment for Ferric dosing system. In accordance with the Specification**				
12.1.1	Ferric storage tank complete with all necessary nozzles, breathers and manholes In accordance with the Specification.	No	2	222,653.97	445,307.94
12.1.2	Ferric dosing pumps complete with FRP mounting stand. In accordance with the Specification.	No	4	106,308.64	425,234.56
12.1.3	Interconnecting pipework, fittings, valves and pipe supports from the tanker off loading point to the storage tank and storage tanks to the pumps.	sum	1	35,061.51	35,061.51
12.1.4	Dosing pipework from dosing pumps to a point 1.0m outside the bund wall including fittings, valves, pressure release valves, pulstaion dampers, back pressure valves and Calibration chambers	sum	1	145,987.03	145,987.03
12.1.5	GRP constructed lean too for covering the dosing pump bunded section	m2	20	655.73	13,114.61
12.1.6	Emergency eye and shower unit including all health and safety signage.	sum	1	11,388.30	11,388.30
12.2	**Design, Manufacture and delivery of mechanical equipment for disinfection dosing**				
12.2.1	DBF Receiving tank	No	1	238,592.24	238,592.24
12.2.2	DBF Storage tanks	No	2	221,288.98	442,577.96
12.2.3	Acid wash tank complete with connecting pipework, valves,fittings and supports	Sum	1	13,730.19	13,730.19
12.2.4	Pipework, valves, fittings and suppors from the tanker offloading point to the receiving tank ad from the receiving tank to the storage tanks	Sum	1	27,273.04	27,273.04
12.2.5	Pipework, valves, fittings and suppors from the storage tanks to the suction side of the dosing pumps	Sum	1	23,445.71	23,445.71
12.2.6	Pipework, valves,fittngs and supports for the dosing pump delivery up to 1.0m outside the bunded area	Sum	1	23,445.71	23,445.71
12.2.7	Dosing pumps complete as specified	No	2	121,751.76	243,503.53
12.3	**Design, Manufacture, Delivery, Installation and Commisioning of electrically/manually operated penstocks**				
12.3.1	1800mm by 1800mm with spindle height of 3600mm	No	1	191,625.34	191,625.34
12.3.2	1000mm by 1000mm with spindle height of 3600mm	No	1	59,143.62	59,143.62
12.3.3	1000mm by 500mm with spindle height of 2600mm	No	1	29,571.81	29,571.81
12.3.4	Pump Station floor drainage pump complete with pipework, fittings, valves and supprts.	No	1	74,750.00	74,750.00
12.3.5	Sampling Pumps	No	2	50,000.00	100,000.00
12.3.6	Air extraction system	Sum	1	50,000.00	50,000.00
12	**Total Section 12**				**2,593,753.11**

JOHANNESBURG WATER

LANSERIA WASTEWATER TREATMENT WORKS

Mechanical Equipment for Liquid Stream Process Units

SECTION		TENDER AMOUNT
Section 1	HOW	R 13,289,000.00
Section 2	PST	R 2,477,000.00
Section 3	Fermenters	R 13,660,000.00
Section 4	Balancing Tanks	R 2,057,000.00
Section 5	BNR Bioreactor	R 36,275,000.00
Section 6	Clarifiers	R 2,245,000.00
Section 7	Primary Sludge Pump Station	R 1,287,000.00
Section 8	Fermenter Pump Station	R 1,006,000.00
Section 9	WAS Pump Station	R 898,000.00
Section 10	Washwater Pump Station	R 1,092,000.00
Section 11	Stormflow Dam Pump Station	R 2,773,000.00
Section 12	Ferric Dosing & Disinfection	R 2,594,000.00
	Net Total Amount Excluding VAT	R 79,653,000.00
	Add 10% Contingencies	R 7,965,300.00
	GROSS TOTAL OF TENDER	**R 87,618,300.00**

SCHEDULE 1: GENERAL REQUIREMENTS AND CONDITIONS							
ITEM	DESCRIPTION	UNIT	QTY	PRICE		TOTAL	
				R	c	R	c
1.1	**Allow for all costs and expenses in connection with the following:**						
1.1.1	All Preliminary and General costs, including Health & Safety, inspections, certificates and training	Sum				R 12,583,000.00	
TOTAL CARRIED FORWARD TO SUMMARY						**R 12,583,000.00**	

SCHEDULE 2: ANAEROBIC DIGESTER, MIXING EQUIPMENT AND PUMP STATION					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE** **R c**	**TOTAL** **R c**
2.	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
2.1.	Anaerobic digester mixing, (ANDM) self-priming centrifugal cutter pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified	No	4	R 806,400.00	R 3,225,600.00
2.2	Mixing jets system, one for each digester complete with all pipework, valves and nozzles, as specified	No	2	R 1,008,000.00	R 2,016,000.00
2.3	Computational fluid dynamic calculation and certification regarding the efficiency of the mixing system proposed and the positions of the directional elements of the system	Item	SUM	R 108,000.00	R 108,000.00
	Complete Digester Heating System including 1 heat echanger, 1 hot water pump, 2 sludge recycle pumps incl pipework, valves and fittings	Item	2	R 1,800,000.00	R 3,600,000.00
	Complete Boiler/burner system including 3 hot water boilers, gas detector expantion tanks gas boosters water softning water tank, diesel tank fans pipeowrk and controls	Item	1	R 3,168,000.00	R 3,168,000.00
	Complete Methane Gas collection system for six digesters including all gas pipework between digesters boilers waste gas burner gas take-off, valves, moister traps flame arrestors vacuum breakers meter and scrubbers etc, all as specified.	Item	1	R 4,104,000.00	R 4,104,000.00
2.11	Floatable gas-holding tank, complete as specified	No	1	R 7,920,000.00	R 7,920,000.00
2.13	Sludge feed distribution system consisting of:				
	a) All pipework	Sum	1	R 266,400.00	R 266,400.00
	b) Magflow meters	No	6	R 64,800.00	R 388,800.00
	c) Manually adjusted knife gate valve	No	6	R 5,000.00	R 30,000.00
2.14	All other plant and equipment items not included above but which are nevertheless necessary to meet the Scope of Work and/or are required for the proper, safe and effective operation of the plant	Sum	1	R 100,800.00	R 100,800.00
	(Specify)				
TOTAL CARRIED FORWARD/…………..					**R 24,927,600**

SCHEDULE 3: WAS Thickener TANKS					
ITEM	DESCRIPTION	UNIT	QTY	PRICE	TOTAL
				R c	R c
3	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
3.1	Was Thickeners, complete with bridges, stilling wells, flocculation baffles, scraper mechanisms, etc., all as specified	No	2	R 1,281,600.00	R 2,563,200.00
3.2	All other plant and equipment items not included above but which are nevertheless necessary to meet the Scope of Work and/or are required for the proper, safe and effective operation of the plant (Specify)	Item	1	R 518,400.00	R 518,400.00
TOTAL CARRIED FORWARD/…………..					**R 3,081,600**

SCHEDULE 4: PUMPING EQUIPMENT SCHEDULE					
ITEM	DESCRIPTION	UNIT	QTY	PRICE	TOTAL
				R c	R c
4	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
4.1	Anaerobic Digester feed, self-priming pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified	No	2	R 525,600.00	R 1,051,200.00
TOTAL CARRIED FORWARD/…………..					**R 1,051,200**

SCHEDULE 5: ACTUATED KNIFE-GATE VALVE AND FLOW CONTROL VALVE					
ITEM	DESCRIPTION	UNIT	QTY	PRICE	TOTAL
				R c	R c
5	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
5.1	200 mm diameter knife-gate valve, complete with electric actuator, as specified for automatically wasting from the WAS Thickeners	No	2	R 83,500.00	R 167,000.00
5.2	200 mm diameter knife-gate valve, complete with electric actuator, as specified for automatically wasting from the Lime Clarifiers	No	2	R 83,500.00	R 167,000.00
5.3	All other plant and equipment items not included above but which are nevertheless necessary to meet the Scope of Work and/or are required for the proper, safe and effective operation of the plant	Sum	1	R 108,000.00	R 108,000.00
	(Specify)				
TOTAL CARRIED FORWARD/…………..					**R 442,000.00**

SCHEDULE 6: HANDSTOPS, SLUICE GATES AND CHANNEL GATES					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**	**TOTAL**
				R c	**R c**
6	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
6.1	Wall mounted handstop and frame to suit a channel, 500mm wide by 500mm deep, complete with frame, handwheel, and gearbox if required, all as specified at the WAS Thickener division box	No.	4	R 6,500.00	R 26,000.00
6.2	Channel mounted sluice gate and frame to suit a channel, 600mm wide by 700mm deep, complete with frame, handwheel, and gearbox if required, all as specified at the Anaerobic Division Tower	No	2	R 28,000.00	R 56,000.00
6.3	Downwards opening sluice gate, to suit opening 750mm x 1000mm complete with frame, pedestal, handwheel, and gearbox (if required) 5250 spindle, all as specified at the Thickened WAS storage Tanks	No.	2	R 36,000.00	R 72,000.00
6.4	Downwards opening sluice gate, to suit opening 750mm x 1000mm complete with frame, pedestal, handwheel, and gearbox (if required) with a 5250mm spindle, all as specified at the Disgested Sludge Storage tanks	No.	2	R 36,000.00	R 72,000.00
6.5	Square handstops to suit 500mm x 500mm opening, complete at the GBT thickened Sump	No.	2	R 6,500.00	R 13,000.00
6.6	Telescopic Bellmouth at the outlet of the Anaerobic Digesters 200mm diameter with a 500mm travel	No	2	R 50,400.00	R 100,800.00
6.7	Square handstops to suit 500mm x 500mm opening, complete at the Lime Reactor	No.	5	R 6,480.00	R 32,400.00
TOTAL CARRIED FORWARD TO SUMMARY					**R 372,200.00**

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT Schedule 7.1: Filter Belt Press					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**	**TOTAL**
				R c	**R c**
7.1	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
7.1.1	Gravity Belt Thickeners complete as specified	No	2	R 1,666,700.00	R 3,333,400.00
7.1.2	Filter belt press complete as specified	No	2	R 2,934,000.00	R 5,868,000.00
TOTAL CARRIED FORWARD TO SUMMARY					**R 9,201,400.00**

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT
Schedule 7.2: Pumping Equipment

ITEM	DESCRIPTION	UNIT	QTY	PRICE		TOTAL	
				R	c	R	c
7.2	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**						
7.2.1	Horizontal centrifugal wash water feed pump and motor, complete with baseplates, motors, etc., as specified	No	2	R 237,600.00		R 475,200.00	
7.2.2	Horizontal centrifugal dilution water feed pump and motor, complete with baseplates, motors, etc., as specified	No	2	R 237,600.00		R 475,200.00	
7.2.3	Progressing cavity polyelectrolyte transfer pump and motor, complete with baseplates, motors, etc., as specified	No	2	R 64,800.00		R 129,600.00	
7.2.4	Progressing cavity polyelectrolyte dosing pump and motor (VSD), complete with baseplates, motors, etc., as specified	No	8	R 57,600.00		R 460,800.00	
7.2.5	Filter Belt press feed, self-priming pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified	No	2	R 324,000.00		R 648,000.00	
7.2.6	Gravity belt Thickeners feed, self-priming pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified	No	2	R 324,000.00		R 648,000.00	
TOTAL CARRIED FORWARD TO SUMMARY						**R 2,836,800.00**	

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT
Schedule 7.3: Polyelectrolyte Make-Up Equipment

ITEM	DESCRIPTION	UNIT	QTY	PRICE		TOTAL	
				R	c	R	c
7.3	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**						
	Note pipe work and instrumentation measured elsewhere						
7.3.1	Polyelectrolyte bead/head feed hopper	No	2	R 41,800.00		R 83,600.00	
7.3.2	Polyelectrolyte Silo	No	1	R 936,000.00		R 936,000.00	
7.3.3	Rotary vane dry polyelectrolyte feeder	No	2	R 39,600.00		R 79,200.00	
7.3.4	Blower/Compressor	No	2	R 57,600.00		R 115,200.00	
7.3.5	Jet wet head	No	1	R 18,000.00		R 18,000.00	
7.3.6	Make up tank (effective volume 20 m^3)	No	1	R 122,400.00		R 122,400.00	
7.3.7	Vertical shaft mixer for make up tank	No	1	R 21,600.00		R 21,600.00	
7.3.8	Stock tank (effective volume 30 m^3)	No	1	R 158,400.00		R 158,400.00	
7.3.9	Vertical shaft mixer for stock tank	No	1	R 21,600.00		R 21,600.00	
TOTAL BROUGHT FORWARD/…….						**R 1,556,000.00**	

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT Schedule 7.4: Sludge Conveyors							
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**		**TOTAL**	
				R	**c**	**R**	**c**
7.4	**SLUDGE CONVEYORS** **Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**						
7.4.1	Inclined Belt conveyor for delivery of sludge from the belt press to the sludge outloading stations, complete as specified, including access to both sides of the conveyor	sum	1	R 3,600,000.00		R 3,600,000.00	
7.4.2	Horizontal spiral conveyor for GBT thickened sludge removal	No	2	R 280,800.00		R 561,600.00	
TOTAL CARRIED FORWARD TO SUMMARY						**R 4,161,600**	

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT Schedule 7.5: Pipework and Fittings							
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**		**TOTAL**	
				R	**c**	**R**	**c**
7.5	**PIPEWORK AND FITTINGS** **Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work by others:**						
7.5.1	Wash and dilution water strainer manifold, wash water strainers and automatic backwash assembly complete as specified	No	2	R 230,400.00		R 460,800.00	
TOTAL CARRIED FORWARD /…………						**R 460,800.00**	

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT Schedule 7.6: Mixers							
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**		**TOTAL**	
				R	**c**	**R**	**c**
7.6	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**						
7.6.1	30 kW vertical shaft mixers, all as specified for installation	No	8	R 230,400.00		R 1,843,200.00	
7.6.2	30 kW vertical shaft mixers, all as specified for installation in the GBT sludge Thickened sump	No	2	R 230,400.00		R 460,800.00	
TOTAL CARRIED FORWARD /…………						**R 2,304,000.00**	

SCHEDULE 7: SLUDGE DEWATERING EQUIPMENT Schedule 7.7: Sundry Equipment					
ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**PRICE**	**TOTAL**
				R c	**R c**
7.7	**SUNDRY EQUIPMENT** **Allow for all costs and expenses in connection with design, manufacture, quality management, painting, testing, supply, delivery, offloading, storage and installation of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
	Lifting equipment				
7.7.1	2 ton manually operated chain and hoist system in dewatering hall, complete as specified for the feed pumps	No.	1	R 691,200.00	R 691,200.00
7.7.2	5 ton electrically operated chain hoist system, complete with trolley as specified for the GBT area	No.	1	R 338,400.00	R 338,400.00
7.7.3	Crawl beam and trolley system, complete for the Poly dosing area	Sum	1	R 216,000.00	R 216,000.00
7.7.4	2 ton manually operated chain and hoist system in dewatering hall, complete as specified for the poly make-up area	No.	1	R 216,000.00	R 216,000.00
TOTAL CARRIED FORWARD /…………					**R 1,461,600.00**

SCHEDULE 8: SLUDGE DRYING BEDS

ITEM	DESCRIPTION	UNIT	QTY	PRICE		TOTAL	
				R	c	R	c
8	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**						
8.1	Solar sludge drying complete as specified, including all associated equipment for solar drying	No	2	R 1,728,000.00		R 3,456,000.00	
	TOTAL CARRIED FORWARD/…….					**R 3,456,000.00**	

SCHEDULE 9: LIME REACTOR

Schedule 9.1 Mixer

ITEM	DESCRIPTION	UNIT	QTY	PRICE R c	TOTAL R c
9.1	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
9.1.1	7.7 kW vertical shaft mixers, all as specified for installation in the Lime reactor basin	No	4	R 136,800.00	R 547,200.00
9.1.2	30 kW vertical shaft mixers, all as specified for installation in the lime sludge sump basin	No	2	R 230,400.00	R 460,800.00
TOTAL CARRIED FORWARD TO SUMMARY					**R 1,008,000.00**

SCHEDULE 9: LIME REACTOR
Schedule 9.2 Lime Make-up

ITEM	DESCRIPTION	UNIT	QTY	PRICE R c	TOTAL R c
9.2	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
9.2.1	Complete lime make-up system, including Silo, weighting cells and Slaker, complete as specified	No	1	R 1,339,200.00	R 1,339,200.00
9.2.2	All other plant and equipment items not included above but which are nevertheless necessary to meet the Scope of Work and/or are required for the proper, safe and effective operation of the plant (Specify):-	Item			R 0.00
					R 0.00
TOTAL CARRIED FORWARD/…………..					**R 1,339,200.00**

SCHEDULE 9: LIME REACTOR

Schedule 9.3 Lime Clarifier

ITEM	DESCRIPTION	UNIT	QTY	PRICE R c	TOTAL R c
9.3	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
9.3.1	Lime Clarifier, complete with bridges, stilling wells, flocculation baffles, scraper mechanisms, etc., all as specified	No	2	R 1,584,000.00	R 3,168,000.00
9.3.2	All other plant and equipment items not included above but which are nevertheless necessary to meet the Scope of Work and/or are required for the proper, safe and effective operation of the plant (Specify)	Item	1	R 172,800.00	R 172,800.00
TOTAL CARRIED FORWARD/…………..					**R 3,340,800.00**

SCHEDULE 9: LIME REACTOR
Schedule 9.4 Lime Pump station

ITEM	DESCRIPTION	UNIT	QTY	PRICE	TOTAL
				R c	R c
9.4	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
9.4.1	Return Lime sludge , centrifugal pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified (horizontal, dry-well or self-priming pumps shall be acceptable).	No	4	R 93,600.00	R 374,400.00
9.4.2	All other plant and equipment items not included above but which are nevertheless necessary to meet the Scope of Work and/or are required for the proper, safe and effective operation of the plant (Specify)	Sum	1	R 21,600.00	R 21,600.00
TOTAL CARRIED FORWARD/…………..					**R 396,000.00**

ITEM	DESCRIPTION	UNIT	QTY	PRICE	TOTAL
SCHEDULE 10: RETURN PUMP STATION EQUIPMENT SCHEDULE					
				R c	R c
10.1	**Allow for all costs and expenses in connection with the design, manufacture, quality management, painting, testing, supply, delivery, offloading and storage of the following materials and equipment, including quality assurance, setting out of works and checking work carried out by others:**				
10.1.1	Filtrate centrifugal pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified (horizontal, dry-well or self-priming pumps shall be acceptable).	No	3	R 237,600.00	R 712,800.00
10.1.2	Anaerobic Digester return, self-priming pump sets, complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified	No	3	R 151,200.00	R 453,600.00
10.1.3	Scum disposal (SD), self-priming rotary lobe pumpsets complete with suction and delivery pipework and associated fittings, valves, baseplates, motors, etc., as specified.	No	3	R 93,600.00	R 280,800.00
10.1.4	Sump drainage submersible pumpsets, complete with duckfoot bends, quick couplings, all brackets, lifting duct, holding down bolts, lifting chains, pipework associated fittings, non return valves, isolating valves, pressure gauges, etc., as specified	No	4	R 18,000.00	R 72,000.00
TOTAL CARRIED FORWARD TO SUMMARY					**R 1,519,200.00**

JOHANNESBURG WATER
LANSERIA WASTEWATER TREATMENT WORKS:
MECHANICAL AND ELECTRICAL ENGINEERING WORKS

SUMMARY OF SCHEDULE OF PRICES			
SECTION	**DESCRIPTION**	**PAGE NO**	**AMOUNT** **R**
1.	General requirements and conditions		12,583,000.00
2.	Anaerobic digestor, mixing equipment and pump station		24,927,600.00
3.	WAS Thickening		3,081,600.00
4.	Pumping equipment		1,051,200.00
5.	Anaerobic digestor, mixing equipment and pump station		442,000.00
6.	Hand stops, sluice gates and channel gates		372,200.00
7.	Sludge dewatering equipment		21,982,200.00
8.	Sludge Drying Equipment		3,456,000.00
9.	Lime Reactor		6,084,000.00
10.	Return pump station pumping equipment schedule		1,519,200.00
SUBTOTAL 1			**75,499,000.00**
Plus 10 % CONTINGENCIES on **SUBTOTAL 1**			7,549,900.00
Plus 5 % PROVISIONAL ESCALATION ALLOWANCE on **SUBTOTAL 1**			3,774,950.00
SUBTOTAL 2			**86,823,850.00**
Plus 14 % VALUE ADDED TAX			12,155,339.00
TOTAL			**98,979,189.00**

Excalation of rates

years	5	
Rate	7.5	%
Factor	1.435629	