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Greater Mangaung Water Augmentation Project

Feasibility Design Report – Water Treatment Works

Xhariep Pipeline Feasibility Study



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Feasibility Design Report – Water Treatment Works

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Report Structure

This report forms part of the following suite for the study:

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1	Inception Report	P WMA 06/D00/00/3423/1
2	Site Visit Report	P WMA 06/D00/00/3423/2
3	Stakeholder Management Report	P WMA 06/D00/00/3423/3
4	Data Analysis and Collection Report	P WMA 06/D00/00/3423/4
5	Pre-feasibility Study Report	P WMA 06/D00/00/3423/5
6	Main Feasibility Study Report	P WMA 06/D00/00/3423/6
7	Geological and Materials Investigations Report	P WMA 06/D00/00/3423/7
8	Topographical Survey and Mapping Report	P WMA 06/D00/00/3423/8
9	Feasibility Design Report - Pipeline, Pump Stations & Reservoirs	P WMA 06/D00/00/3423/9
10	Socio-Economic Impact Assessment and Legal, Institutional and Financing Arrangements Report	P WMA 06/D00/00/3423/10
11	**Feasibility Design Report - Water Treatment Works**	**P WMA 06/D00/00/3423/11**
12	Land Matters	P WMA 06/D00/00/3423/12
13	DFFE Application Submission	P WMA 06/D00/00/3423/13
14	Public Participation Report	P WMA 06/D00/00/3423/14
15	DFFE BAR Submission	P WMA 06/D00/00/3423/15
16	Summary Feasibility Study Report	P WMA 06/D00/00/3423/16
17	Water Use License Application Summary Report	P WMA 06/D00/00/3423/17
18	Integrated Water and Waste Management Plan	P WMA 06/D00/00/3423/18
19	Water Resource Analysis Report	P WMA 06/D00/00/3423/19

Reference

This report is to be referred to in bibliographies as:

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DWS Report Number: P WMA 06/D00/00/3423/11

Prepared by Zutari (Pty) Ltd

Executive Summary

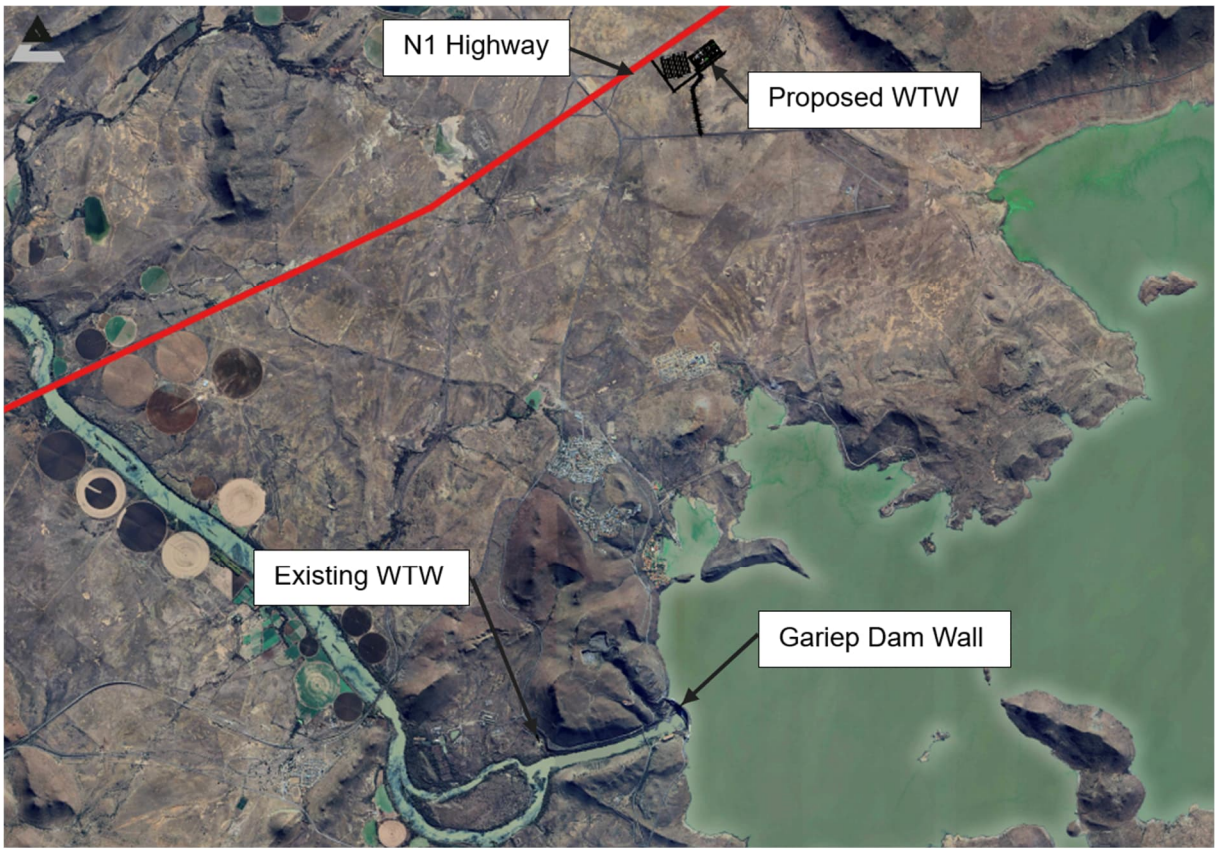
The report covers the detailed feasibility design study for the proposed Xhariep Water Treatment Plant (WTP). The report forms part of a suite of study reports into the development of the Greater Mangaung Water Augmentation Project and specifically the Xhariep Pipeline Feasibility Study. The Xhariep WTP is required to deliver potable water to beneficiaries of the scheme under the Scheme 1B1(A) option.

The pre-feasibility study evaluated the sites identified in earlier studies for the location of the plant, as well as alternative sites closer to the Gariep Dam abstraction point. The pre-feasibility study concluded that the previously authorised site was still the preferred location. This study therefore considers only one potential site for the WTP. The capacity of the plant is also dictated by the requirements of the scheme as defined in the Pre-feasibility Study Report (Report P WMA 06/D00/00/3423/5). The required plant capacity is 312 Mℓ/d. The site planning however provides for an additional 104 Mℓ/d to facilitate future plant expansion. The total planned site capacity is therefore 416 Mℓ/d. The sizing horizon for the WTP is 30 years.

The design of the WTP is based on the establishment of two clusters of treatment infrastructure, each consisting of two semi-independent trains of 104 Mℓ/d each. Each cluster then has a capacity of 208 Mℓ/d. It is anticipated that the site will be developed to deliver 208 Mℓ/d at first and then to be augmented with a further 104 Mℓ/d around 10 years later at which time the capacity of the WTP will be 312 Mℓ/d. The further provision of 104 Mℓ/d is not scheduled at present but will allow for consideration of delivery to the south of the proposed WTP as well as further distribution into the southern Free State Province. The plant design will reach the target daily production capacity in 22 hours per day.

The feasibility design for the abstraction of raw water, the conveyance thereof to the WTP and the distribution of the treated water is presented in Report P WMA 06/D00/00/3423/9. This report will deal only with the design elements of the treatment component of the scheme. All other related elements including specialist studies, specialist engagements, and legal and institutional matters are dealt with in a series of reports also published under this project.

The proposed treatment site is located approximately 5 km north of the Xhariep Town and immediately east of the N1 highway as shown in the figure below. Access to the site will be by exiting to the north from the R701. The site is not currently being utilized for any intensive agricultural or other activities. The site is located between 1280 and 1300 m above mean sea level (AMSL).



General location of the proposed WTP for Scheme 1B

A separate report covers the geology and the geotechnical characteristics of the proposed site. A stand-out feature of the site, however, is that it is underlain by rock at shallow depth. Most trail pits encountered rock at less than 1m depth with an average of around 0.5m. There is not sufficient soft material to allow for the excavation of pipe trenches for the main process pipelines. The design therefore requires that most main structures, treatment reactors and pipelines be constructed and installed above ground to reduce the cost of excavation and to avoid the requirement for excessive pumping between process units.

Several sources of data were consulted to define the quality of raw water to be treated at the proposed WTP. These included historical data for the Gariep Dam from the archives of the Department of Water and Sanitation (DWS), historical data for the existing Gariep Dam WTP which was obtained from the Vaal Central Water Board (VCWB) (previously Bloem Water), and an in-depth monitoring programme which was undertaken as part of this study. The latter consisted of 12 samples over the period spanning March 2024 to August 2024 (6 months) and which focussed on gaps identified in the DWS and VCWB data.

The analysis of the raw water quality indicates the following treatment requirements after evaluation and consideration of the errant data:

- Turbidity levels are moderately high and require treatment intervention.
- Total aluminium levels are high. The dissolved aluminium levels are very low and do not require treatment. The non-dissolved fraction will be removed along with general turbidity if care is taken not to re-dissolve the aluminium through extensive pH manipulation.
- The microbiological indicators will be removed adequatly through normal disinfection protocols. No positive results were noted for chlorine resistant cysts or oocysts in any of the water qualty data sets.
- A small number of datapoints reflected very high dissolved organic carbon (DOC) levels. All the high values were however reported prior to 2003. Subsequent reports all indicated DOC levels below the national standard. No specific treatment regimes are included to address organic carbon removal.

- Both the Ryznar index as well as CCPP indicate that the water is aggressive and will require stabilisation.
- The additional sampling of the water source and analysis for a significantly expanded set of parameters indicated little to no risk associated with chlorophyll-a or contaminants of emerging concern at the proposed treatment plant.
- Some historical data sets indicate a number of determinands are present at levels of concern. The high initial values are likely the result of laboratory detection limits exceeding the specified water quality targets.The latest data sets indicate that these values, when appropriately analysed, are below levels of concern.

Based on the available water quality data the water can be described as of very good quality. Turbidity, microbiology, and stability are the only determinants requiring particular attention. Conventional flocculation, settling and filtration is proposed. A comparable process is currently successfully employed at the Gariep Dam WTW. The new Xhariep WTW will additionally focus on stabilisation and a suitable disinfection strategy.

Laboratory tests indicate that the preferred flocculant for treatment of the source water is a poli-aluminium chloride flocculant. The average design dosage of 12 mg/ℓ and maximum of 35 mg/ℓ are informed by laboratory tests as well as current operational experience at the existing Gariep Dam WTW.

Water quality data and laboratory tests indicate that stabilisation is required to achieve the required CCPP target of 2 to 5 mg/ℓ. An options analysis indicates that hydrated lime at around 5 to 10 mg/ℓ is the most economical approach to stabilisation.

A chlorine demand study was undertaken that indicated a single chlorine dose at the treatment plant would not be sufficient to sustain chlorine levels in the transfer system. Chloramination cannot be considered as Mangaung Metropolitan Municipality (MMM) does not presently receive chloraminated water from its other sources and the mixing of chloraminated and non-chloraminated water cannot be permitted. The system will therefore be chlorinated with a booster injection of chlorine at the Booster Pump Station at which time the water will have been in the transfer system for around 48 hours. Chlorine decay models indicate that this approach will result in a chlorine residual being present in the water when it reaches the receiving reservoirs in Mangaung. A comparison of chlorination systems indicated that chlorine gas systems are more economical than on-site chlorine generation systems. This report is based on the use of 1 tonne chlorine gas drums. More economical gas delivery approaches may be available, but this can only be confirmed following direct negotiation with chlorine gas suppliers.

Main disinfection will take place in the on-site storage reservoir. The reservoir will be partitioned to allow for 30 minutes of contact time. At a residual level of 4 mg/ℓ chlorine the CT-requirement for Giardia, Cryptosporidium as well as viruses will be satisfied. The stated chlorine level is required to ensure a residual of chlorine remains present when the water reaches the chlorine booster station. The total chlorine dose at the WTW is estimated to be in the order of 6.7 mg/ℓ on average and 7.9 mg/ℓ at maximum. The booster dosage requirement is estimated to be 3 mg/ℓ.

The chlorine dosing requirements are high and suggest that trihalomethane production may be a risk. Laboratory tests indicate a marginal risk for this albeit at higher chlorine dosages and on untreated water. Trihalomethanes will have to be monitored as a risk determinand once the WTW is in operation.

The storage reservoir make provision for another 30 minutes of storage for high lift pump balancing purposes. This is anticipated to be sufficient to allow for smooth operation of the high lift pumps. The high lift pumping station design is handled as part of the Feasibility Design Report (Report P WMA 06/D00/00/3423/9).

The treatment technology proposed for the WTP can be described as conventional:

- Flocculation and clarification will take place in a pulsator clarifier. Experience at other treatment sites along the Orange River indicate that pulsators operate acceptably if routine maintenance is in place. The pulsators also typically operate at higher rates than horizontal settlers and radial flow clarifiers resulting in a smaller footprint and lower costs. The proposed design is based on a loading rate of 2.5 m/h which is conservative for pulsators but will be appropriate for the

occasional turbidity peaks that may exceed 200 NTU in extreme cases. A total of 12 separate pulsators will be required to deliver 312 Mℓ/d. The modular design will allow for diversion of flow to the remaining units if a unit is to be removed from operation for maintenance purposes.

- The rapid gravity sand filters are designed for deep penetration of floc into the filter bed. The filter beds are 1 m deep and the effective media size (d_{10}) is 0.9 mm. The filter will be cleaned using a combined air and water scour to facilitate collapse pulsing which will be followed by a water rinse. A total of 30 filters, with a surface area of 84.7 m^2 each, are required to deliver 312 Mℓ/d. The filter loading rate is 6 m/hr with all 30 filters operational and 6.67 m/hr if three filters have been removed from operation for maintenance purposes.

Treatment residuals will be thickened in sludge ponds. Mechanical thickening was not considered as an alternative due to the additional operational complexity that this brings to a WTW as well as the fact that sufficient land is available to allow for consideration of the low cost and effort alternative of ponds. Pond supernatant will be returned to the inlet works to ensure efficient use of the water resource. An options analysis was undertaken to compare various pond construction approaches. A Hyson cell lined pond was found to be most cost effective. The lining will allow for mechanical cleaning of the pond at a higher frequency than for clay lined ponds, hence a smaller pond area can be specified, and at a lower cost than comparably sized concrete lined ponds.

The following support buildings have been included in the feasibility design:

- Administration and control building with a laboratory, meeting rooms, control offices and staff facilities;
- A maintance workshop with workshop floor area supported by overhead cranes, store areas, offices, meeting rooms and facilities for maintenance personnel; and
- Chemical storage areas for bulk chemical storage and housing of dosing equipment. Chlorine is stored and controlled from separate facilities that can be developed in a phased manner.

All structures, services and installed plant shall be designed and constructed to meet DWS standards as well as the WTW owner's standards where these exceed the requirement of DWS.

The mechanical equipment lists for the WTW are provided in **Appendix F**. The equipment selections, power ratings and capacities are preliminary, and will be finalized during detailed design. A summary of the estimated power consumptions required for Phase 1 (208 Mℓ/d) and Phase 1 and 2 (312 Mℓ/d) is shown in the table below. The table excludes the high lift pumping station which is included in Report P WMA 06/D00/00/3423/9.

Summary of the estimated energy consumption required at the Xhariep WTP for Phase 1 and 2 (excluding high lift pumping station)

			Phase 1		Phase 2		Phase 1 & 2	
		Unit	Absorbed power	Rated power	Absorbed power	Rated power	Absorbed power	Rated power
1	**Inlet works**	kW	24	32	0	0	24	32
2	**Flocculation and coagulation**	kW	72	92	36	46	108	138
3	**Rapid gravity sand filters**	kW	183	256	183	256	365	512
4	**Clear water storage**	kW	2	2	1	2	2	3
5	**Chemical dosing**	kW	101	133	47	71	148	204
6	**Residual handling**	kW	89	120	79	110	167	230
7	**Service water**	kW	3	5	3	4	6	9
8	**Service buildings**	kW	25	25	0	0	25	25
	PLANT TOTAL	**kW**	**501**	**664**	**351**	**489**	**852**	**1152**

The design approach for the electronic works shall achieve the following:

- Centralised control of the WTP allowing for easy and convenient operation.

- The installation can be controlled and monitored remotely from the administration building's SCADA, the Xhariep scheme's remote command center or in the field at the Human Machine Interfaces (HMI) at various possible locations, like filters and dosing systems.

The estimated expenditure to complete the detailed design and construct the WTW was prepared based on historical cost data collected from plants of a similar nature and technology level. The estimate is summarized in the table below.

Estimated Capital Expenditure for the Xhariep WTP

Description	Estimated CAPEX		
	Complete Phase 312 Mℓ/d [1]	Phase 1 208 Mℓ/d [2]	Phase 2 +104 Mℓ/d [3]
Preliminary and General	**R 619 300 000**	**R 463 060 000**	**R 323 230 000**
Civil works	**R 1 811 570 000**	**R 1 425 630 000**	**R 836 900 000**
Mechanical works	**R 542 740 000**	**R 347 860 000**	**R 371 830 000**
Electronic works	**R 7 130 000**	**R 4 570 000**	**R 4 890 000**
Subtotal capital cost (excl. VAT)	**R 2 992 620 000**	**R 2 248 730 000**	**R 1 544 990 000**
Contract Price Adjustment (CPA) @7% p.a.	R 673 470 000	R 506 070 000	R 347 690 000
Allowance for foreign exchange variation @ 5% p.a.	R 577 870 000	R 434 230 000	R 298 340 000
Contingency @ 15%	R 636 600 000	R 478 360 000	R 328 660 000
Project cost (excl. VAT)	**R 4 880 560 000**	**R 3 667 390 000**	**R 2 519 680 000**
Professional fees (excl. VAT)	**R 311 240 000**	**R 233 870 000**	**R 160 680 000**
Total project cost (excl. VAT)	**R 5 191 800 000**	**R 3 901 260 000**	**R 2 680 360 000**
Cost per mega Liter (R/Mℓ)	R 16 650 000	R 18 760 000	R 25 780 000

Notes:
1 Cost Estimate Base Date – November 2025.
2 Cost Estimate Base Date – November 2025
3 Cost estimate Base Date – November 2035 (assumed implementation 10 years after Phase 1).

The annual cost of ownership was also estimated based on the estimate costs for maintenance, staffing, energy, chemicals and sludge disposal. The ownership cost estimate is summarized in the table below.

Estimated Annual Operation and Maintenance Budget for the Xhariep WTP

Description	Estimated Annual Maintenance and Operating Budget		
	Complete Phase 312 Mℓ/d [1]	Phase 1 208 Mℓ/d [2]	Phase 2 +104 Mℓ/d [3]
Maintenance	R 59 580 000	R 43 730 000	R 30 910 000
Labour	R 17 460 000	R 14 440 000	R 6 720 000
Energy	R 47 670 000	R 30 510 000	R 55 770 000
Chemicals	R 71 590 000	R 47 730 000	R 34 360 000
Sludge Disposal	R 13 940 000	R 9 300 000	R 10 020 000
TOTAL OPEX (Excl. VAT)	**R 210 240 000**	**R145 710 000**	**R 137 780 000**
Plant Cost (Amortised @ 20 years)	R 633 040 000	R 475 680 000	R 326 820 000
TOTAL ANNUAL COST OF OWNERSHIP (Excl. VAT)	**R 843 280 000**	**R 621 390 000**	**R 464 600 000**

Notes:
1 Estimated operation and maintenance budget required for first year of plant operation based on 2025 Costs
2 Estimated operation and maintenance budget required for first year of plant operation based on 2035 Costs

The environmental and social requirements for the project have been evaluated along with those of the overall Xhariep Pipeline Project. Issues that are relevant to the treatment site are addressed in companion reports under this project. The same applies to regulatory requirements and institutional arrangements as they pertain to this project.

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Figure 1-2: General location of the proposed WTP for Scheme 1B

Figure 1-3: View of the proposed WTP site from the N1 highway

Figure 4-1: Box plots of the chlorophyll-a concentrations at different sampling sites in the Orange River system for an extended period (not specified) (Venter, 2000)

Figure 5-1: Sludge lagoon linings

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Abbreviations

Acronym	Description
AADD	Average Annual Daily Demand
AMSL	Above mean sea level
BW	Bloem Water
CBD	Central business district
CCPP	Calcium carbonate precipitation potential
CT-value	Concentration time value
DEM	Digital Elevation Model
DWS	Department of Water & Sanitation
EFR	Environmental flow requirements
EC&I	Electronic Control and Instrumentation
EIA	Environmental Impact Assessment
GIS	Geographical information systems
IAP	Interested and Affected Parties
IDP	Integrated Development Plan
ISP	Internal Strategic Perspective
IWULA	Integrated Water Use License Application
LI	Langelier Index
MMM	Mangaung Metropolitan Municipality
NWRP	DWS Directorate: National Water Resource Planning
ORS	Orange River System
P/s	Pump station
PPP	Private Public Partnerships
PPPr	Public Participation Process
PRV	Pressure reducing valve
RDP	Reconstruction and Development Programme
RO	Reverse osmosis
RPST	Reconciliation Planning Support Tool
SCADA	Supervisory Control and Data Acquisition
SDF	Spatial Development Plan
SMC	Study Management Committee
ToR	Terms of Reference
UAW	Unaccounted for Water
URV	Unit Reference Values
VCWB	Vaal Central Water Board
WARMS	Water Authorisation and Registration Management System
WC/WDM	Water Conservation and Water Demand Management
WMA	Water Management Area
WSDP	Water Service Development Plan
WTW or WTP	Water Treatment Works or Water Treatment Plant (used interchangeably)

Measurement units

Symbol	Description
µg/ℓ	Microgram per litre
Ha	Hectares
km	Kilometres
m	Meters
m³/a	Cubic meters per annum
m³/d	Cubic meters per day
m³/s	Cubic meters per second
mg/ℓ	Milligram per litre
million m³	Million cubic meters
million m³/a	Million cubic meters per annum
Mℓ/d	Megalitre per day
mm/a	Millimetres per annum

Terms

Term	Description
Gariep Dam WTP	Existing Gariep Dam Water Treatment Plant or Works
Xhariep WTP	Proposed Xhariep Water Treatment Plant or Works

1 Introduction

1.1 Background

The Water Reconciliation Strategy Study for the Larger Bulk Water Supply Systems: Greater Bloemfontein Area (DWS, 2012) (henceforth referred to as the "2012 Reconciliation Strategy") identified that the Greater Bloemfontein Water Supply System (GBWSS) would need to secure a sustainable water supply for the future water demands in the area. The 2012 Reconciliation Strategy recommended that the development of a major surface water augmentation scheme should be given consideration as a possible option in conjunction with the implementation of various other interventions.

Following the 2012 Reconciliation Strategy, the area experienced water shortages and the major surface water augmentation scheme option, now called the Greater Mangaung Water Augmentation Project – Xhariep Pipeline, was accelerated. Vaal Central Water Board (VCWB), previously known as Bloem Water, and Mangaung Metropolitan Municipality (MMM) independently investigated various route options from Gariep Dam to tie-in points within the GBWSS area. The Zutari pre-feasibility study (DWS, 2023) evaluated the same options and included additional refinements. The study concluded that Scheme 1B1(A) (see Report P WMA 06/D00/00/3423/5) was the preferred option to take forward into a detailed feasibility stage study.

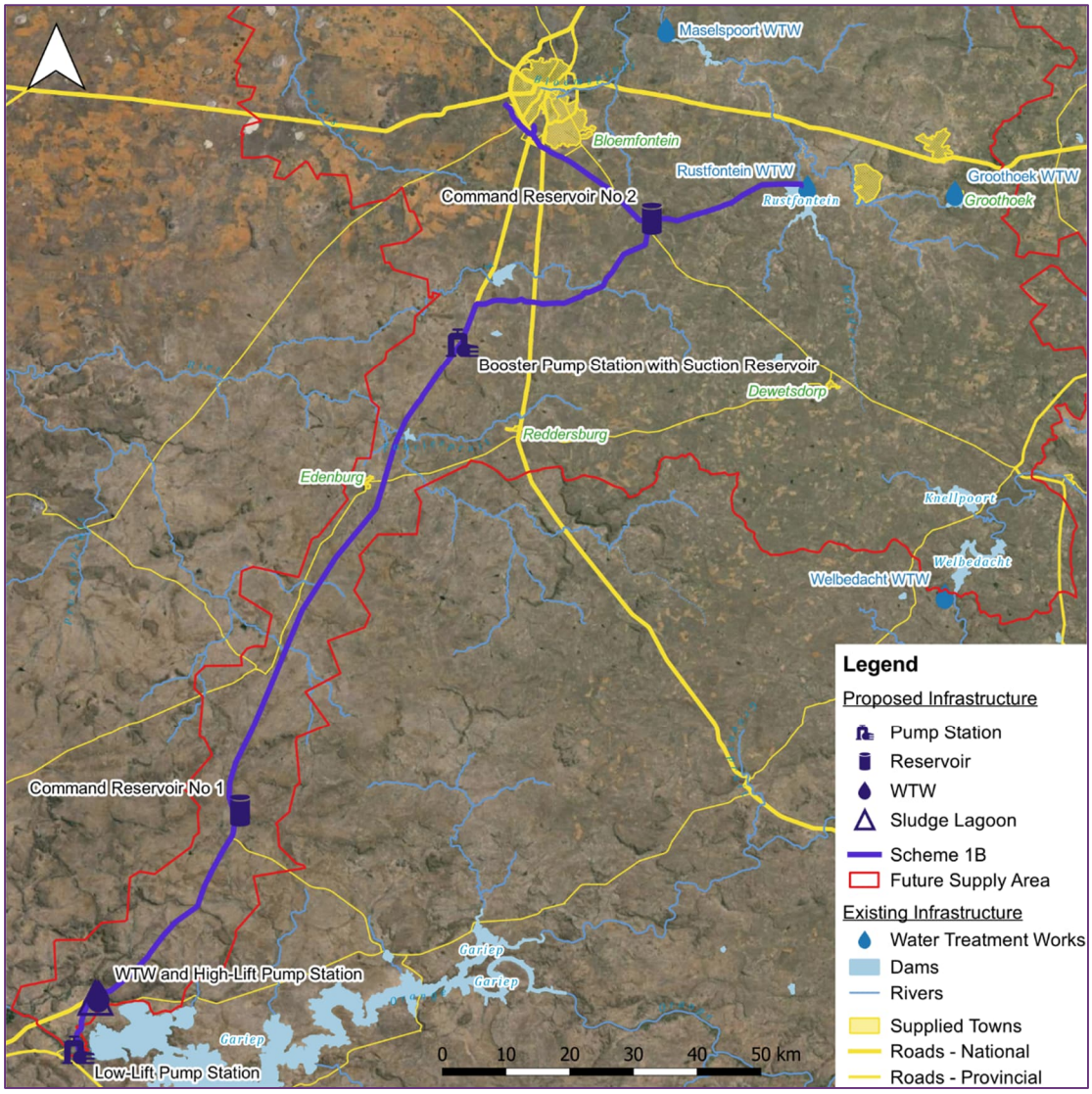


Figure 1-1: Configuration of Scheme 1B1(A)

After concluding the pre-feasibility stage, DWS approved the preferred option to be taken into the detailed feasibility study phase, the water use license application and the environmental authorisation process.

1.2 Purpose of this Report

The Xhariep Water Treatment Plant (WTP) is required to deliver potable water to beneficiaries of the scheme under the Scheme 1B1(A) option (refer to Figure 1-1).

The objectives of the detailed feasibility stage study will be to:

- Assess the technical, financial, economic, and environmental aspects at detailed feasibility level,
- Assess the risks and redundancy of the proposed bulk infrastructure system when operated in conjunction with the existing bulk infrastructure,
- Assess the impact of the project on existing systems including the Orange River System (ORS),
- Integration and utilisation of the available capacities in the existing infrastructure, and,
- Conduct stakeholder engagement workshops.

The bulk of the above-mentioned elements are addressed in the Main Feasibility Study Report (Report P WMA 06/D00/00/3423/6).

This report evaluates and reports mainly on the detailed feasibility design elements and development options for the Xhariep WTP.

1.3 Goals and Objectives

The overall project aims to deliver a sustainable solution to address the total potable water demand in terms of:

- New infrastructure;
- Treated water quality;
- Regulatory requirements; and
- Impact on the environment.

The objective of this feasibility study is to define a design basis to be accommodated in the development of the treatment works.

1.4 Scope of Works

The development of a new water treatment supply scheme will typically consist of the following elements:

- Abstraction of source water;
- Conveyance of raw water to the intended WTP;
- Physical and chemical treatment of the water to meet water quality requirements; and
- High lift pump station and potable water bulk water distribution infrastructure to end users.

The feasibility study into the abstraction of raw water, the conveyance thereof to the WTP and the distribution of the treated water is presented in Report P WMA 06/D00/00/3423/9. This report will deal only with the treatment component of the scheme.

1.5 Project Locality

The proposed WTP will be located along the N1 highway north of the Gariep Dam wall as shown in Figure 1-2. The site is located at the following coordinates: 30°32'45.66"S, 25°30'33.81"E. The site is

located on farm portion RE/495 of the farm Donkerpoort Schoolsite which is approximately 5km north of the town of Gariep. A photo of the site has been included in Figure 1-3.

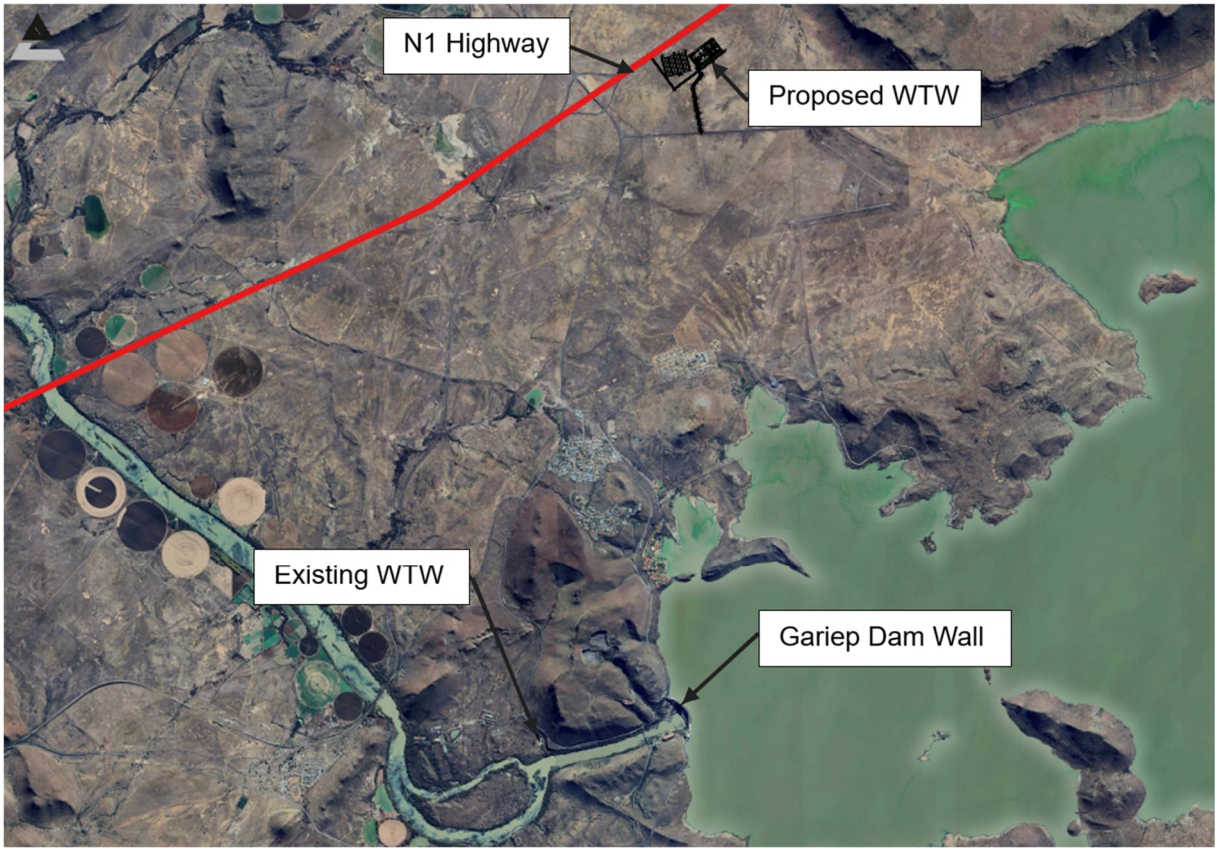


Figure 1-2: General location of the proposed WTP for Scheme 1B



Figure 1-3: View of the proposed WTP site from the N1 highway

1.6 Previous Studies, Reports and Reference Information

This Feasibility Design Report – Water Treatment Works is a refinement and further development of the discussion presented in the Pre-feasibility Study Report (Report No: P WMA 06/D00/00/3423/5). This report supersedes the discussion in the Pre-feasibility Study Report and where differences in approach and philosophy are noted between the reports, this report will stand as the latest revision on that matter.

1.7 Stakeholder Engagement

Refer to the Main Feasibility Study Report (Report P WMA 06/D00/00/3423/6) on any matters related to stakeholder engagement.

1.8 Report Structure

The purpose of this Feasibility Design Report – Water Treatment Works is to document the proposed design of the Xhariep WTP. The report is structured as follows:

- Chapter 1 presents the background and objectives of the study and report.
- Chapter 2 provides details on the location and site of the WTP.
- Chapter 3 provides relevant information on the sizing of the WTP.
- Chapter 4 provides a characterisation of the raw water from the Gariep Dam, and it provides insights into the treatment needs of the water.
- Chapter 5 presents the required process design as well as the reactor sizing and configurations.
- Chapter 6 discusses the preliminary design for the civil components of the WTP.
- Chapter 7 discusses the preliminary design for the mechanical components of the WTP.
- Chapter 8 discusses the preliminary design for the electrical components of the WTP.
- Chapter 9 discusses the preliminary design for the electronic control and instrumentation of the WTP.
- Chapter 10 discusses matters related to the operation, maintenance and general asset management associated with the proposed WTP.
- Chapter 11 documents the economic and financial assessments performed as part of this design study.
- Chapter 12 touches on the environmental and social considerations relevant to the establishment of the WTP.
- Chapter 13 addresses the regulatory requirements associated with owning an operating a WTP.
- Chapter 14 references the institutional arrangements around the ownership and operation of the WTP.
- Chapter 15 contains the conclusions and recommendations on the way forward.

2 Land and Site Characteristics

2.1 Site description

The proposed site can be described as typically southern Free State grass and shrubland with a limited number of trees. The site is flat and slopes gently in a south-westerly direction from approximately 1300 m to 1280 m above mean sea level (AMSL).

The site is framed:

- on the far northwestern end by a natural ridge;
- on the northeastern side by the N1 highway;
- on the far southern end by the R701 road; and
- on the west by open land characterised by some erosion gullies that drain in a southern direction.

There are no significant land features that define the site. The site is not presently being utilised for any intensive agricultural activities.

2.2 Land and Topographical Surveys

2.2.1 Land Ownership / Deed Verification

Land ownership will be resolved under the larger Greater Mangaung Augmentation Project and is further discussed in the Land Matters Report.

2.2.2 Topographical Survey – Available Survey Information

The topographical survey for the overall scheme was handled under the larger Greater Mangaung Augmentation Project.

The topographic survey included a Light Detection and Ranging (LiDAR) survey for which specifications were:

- An airborne survey of the project area for the preferred option. The airborne survey included the classified data points in LiDAR Aerial Survey (LAS) file format (X;Y;Z format) with an aerial photo backdrop;
- Installation of ground control points and benchmarks that can be used as reference points during construction;
- Line mapping of the project areas; and
- Collection of all the relevant cadastral data to show existing servitudes and property/farm boundaries.

2.3 Geology

A detailed geotechnical study of the full project site including the WTP site, has been undertaken. Refer to Report P WMA 06/D00/00/3423/7 for the Geological and Materials Investigations Report.

The treatment plant site is located on the Middleton Formation within the Beaufort Group of the Karoo Supergroup. The geology is typically characterized by mudstone with underlying sandstone and siltstone[1].

Test pits and boreholes from the project site indicate that refusal is at shallow depths (around 0.1 - 1.1 m).

2.3.1 Geotechnical Design Considerations

Geotechnical design considerations related to the treatment plant site are captured in Report P WMA 06/D00/00/3423/7 (Geological and Materials Investigations Report).

A critical restriction to the design of the water treatment plant is that rock and hard material will be encountered across the site at very shallow depths. Trail pits indicate refusal occurs at depths varying from 0.1 m to 1.1 m. The relevant test pits with refusal depths are summarised in Table 2-1.

Table 2-1: Site relevant test pit data (refusals)

Test Pit ID	Refusal (m)	Note	Location
TP6	0.30	Refusal on medium hard rock (MHR)	S30 32.653 E25 30.802
TP7	0.50	Refusal on MHR	S30 32.646 E25 30.703
TP8	0.50	Refusal on MHR	S30 32.741 E25 30.664
TP9	0.10	Refusal on MHR	S30 32.743 E25 30.553
TP10	0.30	Refusal on MHR	S30 32.855 E25 30.482
TP11	0.60	Refusal on MHR	S30 32.881 E25 30.345
TP12	0.40	Refusal on MHR	S30 32.794 E25 30.34
TP13	0.60	Refusal on MHR	S30 32.730 E25 30.444
TP14	1.10	Refusal on MHR	S30 32.876 E25 30.414
TP15	0.20	Refusal on MHR	S30 32.815 E25 30.513

2.4 Flood Line Information

The site is situated on a flat but elevated plain away from significant water courses.

The Gariep Dam full supply level (FSL) is 1258.7 m AMSL while the plant will be constructed between approximately 1280 m to 1380 m AMSL. As such, the site will not be influenced by the Gariep Dam and the Orange River, in general, under flood conditions.

Stormwater drainage gulleys frame the site on the eastern boundary of the water treatment site. These gulleys drain away from the site to the south. Water draining along the N1 highway to the north of the WTP, passes under the highway via a culvert to the west of the highway and WTP, some 380-400 m from the WTP. The overland drainage is not expected to impact on the WTP site.

Overland stormwater drainage will be managed in the following manner:

- A series of berms will deflect overland flow from entering the treatment site; and
- On-site stormwater management strategies will be utilised to direct on-site stormwater flow.

The design and placement of these are to be finalised as part of the detailed design phase of the project.

[1] https://en.wikipedia.org/wiki/Middleton_Formation

3 Treatment Plant Capacity

3.1 Design Capacity and Proposed Phasing

The WTP will be designed for a daily demand of 312 Mℓ/d (including peaks and losses) over a 22-hour period. The capacity of the proposed plant provides for a peak supply of 114 million m³ of treated water per annum with allowances for conveyance losses as well as summer peak factors.

Provision is made to construct the WTP in 104 Mℓ/d modules. It is assumed that the first phase will be developed immediately and the second phase as the need arises.

The first phase will include two 104 Mℓ/d process modules, providing treatment capacity of 208 Mℓ/d. The second phase will expand the plant by 104 Mℓ/d, bringing the ultimate design capacity of the treatment works to 312 Mℓ/d. During design, provision will be made to further expand the plant with another 104 Mℓ/d process module to accommodate future expansion of the distribution network or and increased demand on the system. The overall site planning will therefore be planned for a 416 Mℓ/d water treatment plant.

3.2 Water Conservation and Demand Management

The following water conservation principles are included in the design development of the WTP:

- Wash water and sludge water collection and recovery strategies consisting of collection infrastructure, settling ponds and a recovery pump station is included;
- A water efficient filter backwash system (combined air & water strategy) has been selected; and
- Water efficient settler deslugde systems have been selected.

4 Raw Water Characteristics and Treatment Objectives

4.1 Raw Water Supply

The supply of raw water to the treatment site is discussed in detail in the “Feasibility Design Report” (P WMA 06/D00/00/3423/9).

In short, raw water is collected from the Gariep Dam via existing abstraction infrastructure and is then delivered to the treatment plat via a new raw water pump station and rising main.

4.2 Water Quality and Characterisation

The objective of a water quality assessment is to characterise the raw water quality that will be abstracted at Gariep Dam.

4.2.1 Raw Water Quality Data

Historical raw water quality data for the Gariep Dam is available for two periods, 2004 - 2017 and 2018 - 2022. The data was sourced from the DWS and VCWB respectively. The DWS dataset consists of 564 samples drawn in intervals varying from hours to months. The VCWB dataset consists of 75 samples drawn typically at monthly intervals. Each sample was analysed for several determinands. This resulted in each significant determinand being measured in the order of 70 to 220 times over the period. The exact count of samples per determinand is indicated in Table 4-1.

The determinands covered in the DWS and VCWB dataset are operations and compliance focussed and do not cover all determinands required to determine all the specific design needs of a new WTP.

The absence of certain parameters from the available dataset is a concern. No algal bloom related data (e.g., chlorophyll-a, taste and odour, algal toxins, etc.) or data related to Contaminants of Emerging Concern (CECs), was available for the water abstracted into the existing Gariep WTP. A study (Venter, 2000) reported that the average chlorophyll-a concentration ranged between 0.4 - 1084 µg/l, with an average concentration of 10.8 µg/l. The high value was measured in February 1999 but was reported by the author as an exceptionally high value. The box plots in Figure 4-1 summarise the chlorophyll-a concentrations at various points along the upper Orange River catchment (up to the year 2000). The data from the Gariep Dam was of particular interest to this study. The peak levels are of concern and may require the addition of flotation to the treatment process.

Some DWS chlorophyll-a data was available for water sampled near the dam wall. The measured levels were sufficiently high at times to justify a dedicated treatment step. It was however uncertain how much of the algal load will be drawn into the WTP.

There was also no indication of the status of Contaminants of Emerging Concern (CECs) in the dam from the available data.

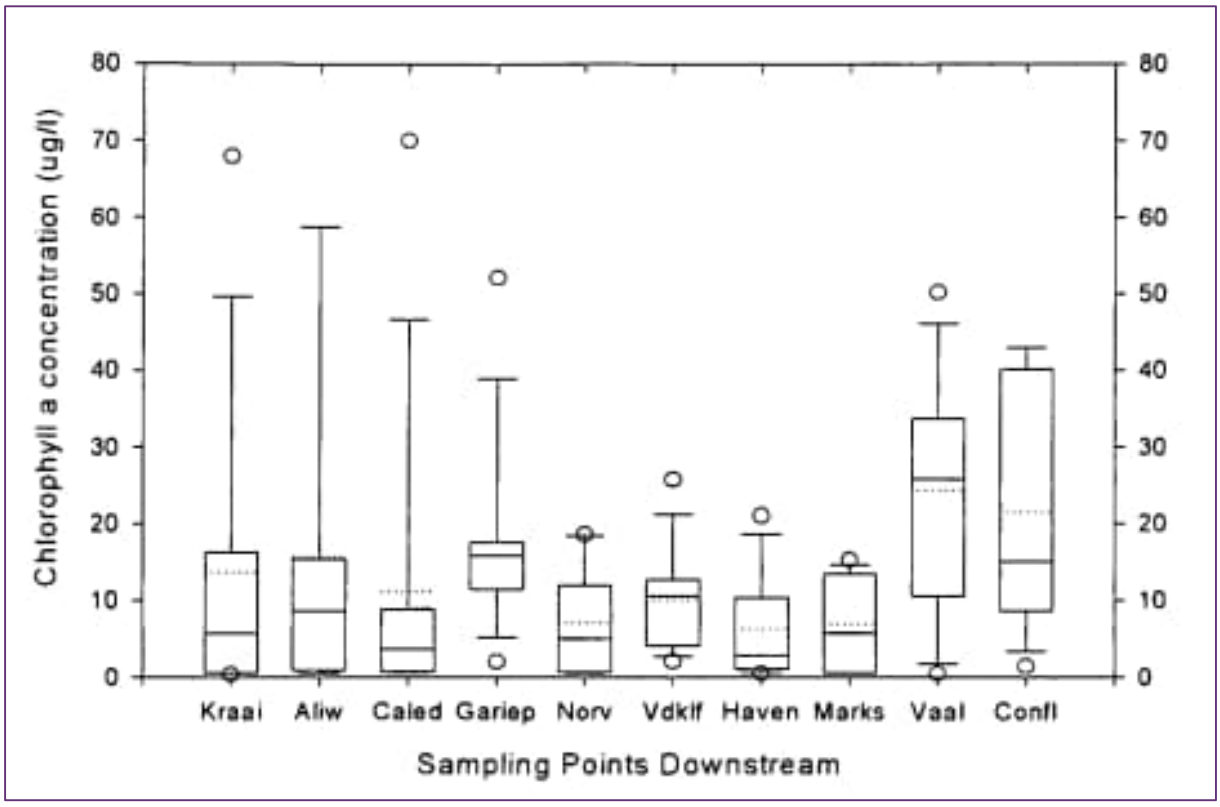


Figure 4-1: Box plots of the chlorophyll-a concentrations at different sampling sites in the Orange River system for an extended period (not specified) (Venter, 2000)

An additional and expanded set of water quality data was therefore generated through a dedicated sampling and analysis run that spanned 12 samples over the period spanning March 2024 to August 2024 (6 months). The water quality reports for the 6-month period are included in Appendix A.

An analysis was performed on the data focusing on a comparison of the data to the South African drinking water quality specification (SANS241-1, 2015) as well as WHO guidelines (World Health Organisation, 2017). The analysis aimed to highlight determinands that do not meet the drinking water quality standard and that justify treatment interventions.

The raw water characteristics for the feed water from the Gariep Dam are provided in Table 4-1.

Table 4-1: Expected raw water characteristics based on DWS, VCWB and Waterlab datasets

Parameter	Units	Number of Analyses	5th percentile Raw Water Operational Data	50th percentile Final Water Operational Data	95th percentile Final Water Operational Data	SANS 241: 2015 and DWS/WHO Standards
Physical and aesthetic determinands						
Colour	mg/ℓ as Pt	25	1.00	14.00	497.40 Note1&2	≤ 15
Conductivity	mS/m	235	13.19	16.20	20.69	≤ 170
Total Dissolved Solids	mg/ℓ	69	97.80	128.00	154.94	≤ 1200
Turbidity*	NTU	69	***13.82***	***30.00***	***155.60***	≤ 1
pH	[-]	235	6.46	7.60	8.22	≥ 5 to ≤ 9.7
Suspended Solids at 105°C	mg/ℓ	12	1	9	36	
Chemical determinands - macro-determinands						

Parameter	Units	Number of Analyses	5th percentile Raw Water Operational Data	50th percentile Final Water Operational Data	95th percentile Final Water Operational Data	SANS 241: 2015 and DWS/WHO Standards
Free Chlorine as Cl_2	mg/ℓ	0	N.A	N.A	N.A	≤ 5
Nitrate as NO_3 - N	mg/ℓ	234	0.14	0.50	1.05	≤ 11
Nitrite as NO_2 - N	mg/ℓ	29	0.01	0.01	0.05	≤ 0.9
Sulphate as SO_4^{2-}	mg/ℓ	232	2.00	9.00	20.78	≤ 250
Fluoride as F	mg/ℓ	230	0.05	0.17	0.30	≤ 1.5
Ammonia as N	mg/ℓ	232	0.02	0.05	0.14	≤ 1.5
Chloride as Cl	mg/ℓ	232	1.50	3.70	5.92	≤ 300
Sodium as Na	mg/ℓ	232	4.10	5.70	7.79	≤ 200
Zinc as Zn	mg/ℓ	111	0.00	0.00	0.14	≤ 5
P-Alkalinity	mg/ℓ	21	0.00	5.00	5.00	
Iron as Fe (Dissolved)	mg/ℓ	12	0.03	0.04	0.07	≤ 0.3
Ferrous Iron as Fe2+ (Dissolved)	mg/ℓ	4	0.03	0.03	0.03	≤ 0.3
Manganese as Mn (Dissolved)	mg/ℓ	12	0.03	0.03	0.03	≤ 0.1
Bicarbonate as HCO_3	mg/ℓ	12	98.85	107.00	109.25	
Carbonate as CO_3	mg/ℓ	12	5.00	5.00	5.00	
Hydroxide as OH	mg/ℓ	12	5.00	5.00	5.00	
Chlorite as ClO	mg/ℓ	7	0.00	0.00	0.00	
Bromate as BrO	mg/ℓ	6	0.00	0.00	0.00	
Silica as SiO_2	mg/ℓ	12	12.25	13.50	21.50	
Hydrogen Sulphide	mg/ℓ	12	0.10	0.10	0.10	
Chemical determinands - micro-determinands						
Antimony as Sb	mg/ℓ	16	0.001	0.001	0.020	≤ 0.02
Arsenic as As	mg/ℓ	113	0.001	0.050	0.050 Note 3	≤ 0.01
Barium as Ba	mg/ℓ	87	0.002	0.031	0.081	≤ 0.7
Boron as B	mg/ℓ	100	0.001	0.006	0.040	≤ 2.4
Cadmium as Cd	mg/ℓ	99	0.001	0.003	0.003	≤ 0.003
Chromium as Cr	mg/ℓ	112	0.002	0.004	0.030	≤ 0.05
Copper as Cu	mg/ℓ	112	0.001	0.003	0.022	≤ 2
Cyanide as CN-Free	mg/ℓ	17	0.002	0.070	2.880 Note 4	≤ 0.2
Iron as Fe (Dissolved)	mg/ℓ	163	0.025	0.040	0.071	≤ 0.3
Lead as Pb	mg/ℓ	99	0.008	0.025	0.025 Note 5	≤ 0.01
Manganese as Mn	mg/ℓ	164	0.001	0.020	0.047	≤ 0.1

Parameter	Units	Number of Analyses	5th percentile Raw Water Operational Data	50th percentile Final Water Operational Data	95th percentile Final Water Operational Data	SANS 241: 2015 and DWS/WHO Standards
Mercury as Hg	mg/ℓ	107	0.001	0.001	0.002	≤ 0.006
Nickel as Ni	mg/ℓ	111	0.003	0.010	0.025	≤ 0.07
Selenium as Se	mg/ℓ	17	0.001	0.001	0.020	≤ 0.04
Uranium as U	mg/ℓ	4	0.030	0.030	0.030	≤ 0.03
Aluminium as Al	mg/ℓ	164	0.053	***0.500***	***4.540***	≤ 0.3
Aluminium as Al (Dissolved)	mg/ℓ	12	0.100	0.100	0.116	≤ 0.3
Bromide as Br	mg/ℓ	24	0.040	0.082	0.300	
Silver as Ag	mg/ℓ	3	0.020	0.020	0.090	
Cobalt as Co	mg/ℓ	83	0.010	0.010	0.025	≤ 0.5
Molybdenum as Mo	mg/ℓ	99	0.003	0.003	0.020	
Strontium as Sr	mg/ℓ	13	0.061	0.083	0.096	
Thallium as Tl	mg/ℓ	12	0.001	0.001	0.001	
Vanadium as V	mg/ℓ	111	0.001	0.009	0.025	≤ 1
Chemical determinands - organic determinands						
Total Organic Carbon	mg/ℓ	68	2.52	3.82	5.46	≤ 10
Dissolved Organic Carbon	mg/ℓ	104	1.62	3.20	***17.69***	≤ 10
Chloroform	mg/ℓ	12	0.005	0.005	0.005	≤ 0.3
Bromoform	mg/ℓ	12	0.005	0.005	0.005	≤ 0.1
Dibromochloromethane	mg/ℓ	12	0.002	0.002	0.002	≤ 0.1
Bromodichloromethane	mg/ℓ	12	0.010	0.010	0.010	≤ 0.06
Trihalomethanes as THM	mg/ℓ	0	No data	No data	No data	≤ 0.01
Phenols	mg/ℓ	5	0.01	0.01	0.01	≤ 10
Microbiological determinands						
Escherichia coli	MPN or CFU per 100 mℓ	188	0.00	***3.00***	***31.65***	0
Heterotrophic plate count (HPC)	CFU	220	12.00	121.00	1000.00	≤ 1000
Total coliforms	CFU	231	2.00	***120.00***	***1414.00***	≤ 10
Faecal coliforms	cfu/100mℓ	201	0.00	***3.00***	***27.00***	0
Cryptosporidium species /	count/10L	4	0.00	0.00	0.00	0
Giardia species /	count/10L	4	0.00	0.00	0.00	0
Total Alkalinity	mg $CaCO_3$/ℓ	235	48.09	70.10	88.00	~40-120
Potassium	mg/ℓ	232	0.99	1.43	2.49	≤ 50

Parameter	Units	Number of Analyses	5th percentile Raw Water Operational Data	50th percentile Final Water Operational Data	95th percentile Final Water Operational Data	SANS 241: 2015 and DWS/WHO Standards
Calcium	mg/ℓ	232	14.10	17.96	22.82	≥ 16
Magnesium	mg/ℓ	232	4.80	6.30	8.00	≤ 30
Phosphate PO_4	mg/ℓ	229	0.01	0.03	0.10	
Chlorophyll-a	mg/ℓ	184	0.28	1.25	15.22	≤ 10
Calcium Hardness (calculated from above)	mg/ℓ as $CaCO_3$	241	32.25	44.21	55.55	
Magnesium Hardness (calculated from above)	mg/ℓ as $CaCO_3$	175	15.96	21.16	31.00	
Total Hardness (calculated from above)	mg/ℓ as $CaCO_3$	175	53.70	69.84	84.91	≤ 150
Langelier Index (calculated from above)	-	168	-2.03	-0.72	-0.03	~ 0
Ryznar Index (calculated from above)	-	161	***8.22***	***8.94***	***10.53***	6.5 – 7.0
Calcium Carbonate Precipitation Potential (CCPP) (calculated from above)	mg $CaCO_3$/ℓ		***-3.96***	***-2.68***	***-1.97***	2 to 5
THP GRO C6-C10 & BTEX						
MTBE	mg/ℓ	12	0.0050	0.0050	0.0050	
Tame	mg/ℓ	12	0.0050	0.0050	0.0050	
Benzene	mg/ℓ	12	0.0004	0.0004	0.0004	
Toluene	mg/ℓ	12	0.0010	0.0010	0.0010	
Ethylbenzene	mg/ℓ	12	0.0004	0.0004	0.0004	
m+p-Xylene	mg/ℓ	12	0.0008	0.0008	0.0008	
o-Xylene	mg/ℓ	12	0.0004	0.0004	0.0004	
1,3,5-Trimethylbenzene	mg/ℓ	12	0.0004	0.0004	0.0004	
1,2,4-Trimethyl benzene	mg/ℓ	12	0.0004	0.0004	0.0004	
Naphthalene	mg/ℓ	12	0.0004	0.0004	0.0004	
GRO TPH (C6 – C10)	mg/ℓ	12	0.0100	0.0100	0.0100	
TPH C10-C40		12	0.382	0.382	0.382	
TPH C10-C28		12	0.382	0.382	0.382	
TPH C28-C40		12	0.382	0.382	0.382	
VOC						
Benzene	mg/ℓ	12	0.0010	0.0010	0.0010	
Toluene	mg/ℓ	12	0.0100	0.0100	0.0100	
Ethylbenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
m+p Xylene	mg/ℓ	12	0.0040	0.0040	0.0040	

Parameter	Units	Number of Analyses	5th percentile Raw Water Operational Data	50th percentile Final Water Operational Data	95th percentile Final Water Operational Data	SANS 241: 2015 and DWS/WHO Standards
o-Xylene	mg/ℓ	12	0.0020	0.0020	0.0020	
1,3,5 Trimethyl benzene	mg/ℓ	12	0.0020	0.0020	0.0020	
1,2,4 Trimethyl benzene	mg/ℓ	12	0.0020	0.0020	0.0020	
n Propylbenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
Tertiary Butylbenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
Secondary Butylbenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
n Butylbenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
Isopropylbenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
Styrene	mg/ℓ	12	0.0050	0.0050	0.0050	
4-Isopropyltoluene	mg/ℓ	12	0.0050	0.0050	0.0050	
Bromobenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
Chlorobenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
1,2-Dichlorobenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
1,3 Dichlorobenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
1,4-Dichlorobenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
1,2,3 Trichlorobenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
1,2,4 Trichlorobenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
1,3,5-Trichlorobenzene	mg/ℓ	12	0.0020	0.0020	0.0020	
Naphthalene	mg/ℓ	12	0.0020	0.0020	0.0020	
Carbon Tetrachloride	mg/ℓ	12	0.0050	0.0050	0.0050	
Trichloroethene	mg/ℓ	12	0.0050	0.0050	0.0050	
Dibromomethane	mg/ℓ	12	0.0100	0.0100	0.0100	
Dichloromethane	mg/ℓ	12	0.0500	0.0500	0.0500	
Bromochloromethane	mg/ℓ	12	0.0500	0.0500	0.0500	
1,2 Dibromoethane	mg/ℓ	12	0.0020	0.0020	0.0020	
1,2-Dichloroethane	mg/ℓ	12	0.0100	0.0100	0.0100	
Tetrachloroethene	mg/ℓ	12	0.0020	0.0020	0.0020	
1,1,1-Trichloroethane	mg/ℓ	12	0.0050	0.0050	0.0050	
1,1,2-Trichloroethane	mg/ℓ	12	0.0050	0.0050	0.0050	
Hexachlorobutadiene	mg/ℓ	12	0.0020	0.0020	0.0020	
1,1,1,2-Tetrachloroethane	mg/ℓ	12	0.0100	0.0100	0.0100	
1,1,2,2-Tetrachloroethane	mg/ℓ	12	0.0100	0.0100	0.0100	
2 Chlorotoluene	mg/ℓ	12	0.0020	0.0020	0.0020	

Parameter	Units	Number of Analyses	5th percentile Raw Water Operational Data	50th percentile Final Water Operational Data	95th percentile Final Water Operational Data	SANS 241: 2015 and DWS/WHO Standards
4 Chlorotoluene	mg/ℓ	12	0.0020	0.0020	0.0020	
1,1-Dichloroethene	mg/ℓ	12	0.0100	0.0100	0.0100	
1,1-Dichloroethane	mg/ℓ	12	0.0100	0.0100	0.0100	
cis-1,2-Dichloroethene	mg/ℓ	12	0.0100	0.0100	0.0100	
trans-1,2-Dichloroethene	mg/ℓ	12	0.0100	0.0100	0.0100	
1,2-Dichloropropane	mg/ℓ	12	0.0100	0.0100	0.0100	
1,3-Dichloropropane	mg/ℓ	12	0.0100	0.0100	0.0100	
2,2-Dichloropropane	mg/ℓ	12	0.0100	0.0100	0.0100	
1,2,3 Trichloropropane	mg/ℓ	12	0.0100	0.0100	0.0100	
1,1-Dichloropropene	mg/ℓ	12	0.0050	0.0050	0.0050	
cis-1,3-Dichloropropene	mg/ℓ	12	0.0050	0.0050	0.0050	
trans-1,3-Dichloropropene	mg/ℓ	12	0.0050	0.0050	0.0050	
Dibromooacetic Acid	mg/ℓ	12	0.0002	0.0002	0.0002	
Dibromoacetonitrile	mg/ℓ	12	0.0002	0.0002	0.0002	
Dichloroacetic Acid	mg/ℓ	12	0.0002	0.0002	0.0002	
Chloroacetic Acid	mg/ℓ	12	0.0002	0.0002	0.0002	
Dichloromethane	mg/ℓ	12	0.0002	0.0002	0.0002	
Bromochloroacetic Acid	mg/ℓ	12	0.0002	0.0002	0.0002	
Bromodichloroacetic Acid	mg/ℓ	12	0.0002	0.0002	0.0002	
Chlorodibromoacetic Acid	mg/ℓ	12	0.0002	0.0002	0.0002	
Monobromoacetic Acid	mg/ℓ	12	0.0000	0.0000	0.0000	
Tribromoacetic Acid	mg/ℓ	12	0.0005	0.0005	0.0005	
Chemical Oxygen Demand as O_2 (Total)	mg/ℓ	12	10	15	19	
Dissolved Oxygen as O_2	mg/ℓ	12	7	7	8	
UV Absorbance at 254 nm	cm^{-1}	12	0.0741	0.0741	0.0741	
UV Absorbance at 300 nm	cm^{-1}	12	0.0365	0.0365	0.0365	

Notes:

1 These values seem to be colour values and not true colour.

2 Figures shown in shaded cells do not meet the required standards. Focussed treatment intervention is only deemed necessary if the value is indicated in ***black, bold, and italic*** print.

3 All the results larger than 0.025 mg/ℓ (95 data points) come from DWS data produced before January 1992. These values are taken to denote level of detection values and not actual measured values. There are also 3 data points at 0.02 mg/ℓ from VCWB which are deemed to note detection limits. The balance of data registered results at 0.001 mg/ℓ which suggests that arsenic levels remain below detection limits and do not represent a water quality risk.

4 There are two results that exceed the allowable limit by a significant and improbable margin. It is assumed that the results are reported as mg/ℓ rather than µg/ℓ as would be excepted if the numeric values were to be representative of levels found in natural surface waters. This result is therefore not considered to be representative of a water quality risk.

[5] All lead (Pb) results appear to be reported at detection limits. The 0.025 mg/ℓ data (66 results) are taken from DWS data that was generated before 1990. This result is therefore not considered to be representative of a water quality risk.

The analysis of the raw water quality indicates the following treatment requirements after evaluation and consideration of the errant data:

- Turbidity levels are moderately high and require treatment intervention.
- Aluminium levels are high. The data reflects the total aluminium and therefore includes the non-dissolved fraction which will likely be associated with suspended particles. Removal processes focussing on suspended particles will then also address the aluminium concerns. The dissolved aluminium levels are very low and do not require treatment.
- The data reflects the quality of untreated water, and the microbiological results are therefore not a significant concern. These numbers are expected to reduce significantly when the water is subjected to standard treatment protocols.
- A small number of datapoints reflected very high dissolved organic carbon (DOC) levels. All the high values were however reported prior to 2003. Subsequent reports all indicated DOC levels below the national standard. No specific treatment regimes are included to address organic carbon removal.
- Both the Ryznar index as well as CCPP indicate that the water is aggressive and will require stabilisation.

Based on the available water quality data the water can be described as of very good quality. Turbidity, microbiology, and stability are the only determinands requiring particular attention.

The additional sampling of the water source and analysis for a significantly expanded set of parameters indicated little to no risk associated with chlorophyll-a or contaminants of emerging concern at the proposed treatment plant. Several other determinands which previously showed elevated levels were now confirmed as not being of concern. The high initial values are likely the result of laboratory detection limits exceeding the specified water quality targets.

4.2.2 Potable Water Quality Standards, Regulations, and Guidelines

Treatment objectives for the plant are based on the South African National Standard (SANS 241:2015 - Drinking Water) as well as other international reference standards where SANS does not provide guidance. The international reference standards include the US Environmental Protection Agency (USEPA) guidelines. The reasoning and rational behind the selection of these standards is discussed in the Pre-feasibility Study Report (P WMA 06/D00/00/3423/5). This reasoning remains unchanged.

All process systems will therefore be designed to meet the following codes of practice and criteria as applicable. The applicable design and material codes and specifications are shown in Table 4-2.

Table 4-2: Water treatment process design codes

Specification / Code of practice		Where applicable
SANS:241-1 (2015)	Drinking water Part 1: Microbiological, physical, aesthetic and chemical	Applicable drinking water standard
SANS:241-2 (2015)	Drinking water Part 2: Application of SANS 241-1	Applicable drinking water standard
WASCO (2017)	Water and Sewer Design Guidelines	Water and Sewer Design Guidelines
DWS GNR 813 (2013)	Water Services Act, Regulations Relating to Compulsory National Standards for Process Controllers and Water Services Works	Classification of water treatment works

4.3 Existing Gariep Dam WTP

The Pre-feasibility Study Report (P WMA 06/D00/00/3423/5) discussed the performance of the existing Gariep Dam WTP. The performance of the plant was observed to be good, and the process deemed sufficient to adequately respond to the expected raw water quality received at the plant. The findings are not amended following the incorporation and analysis of the additional water quality data which has been collected after the Pre-feasibility Study Report. The process utilised at the existing Gariep Dam WTP will remain as a baseline proposal for the process to be utilised at the proposed Xhariep WTP.

4.4 Treatment Objectives and Effectiveness

Most of the measurements of treatment effectiveness developed by USEPA are expressed in terms of log removal and performance efficiency. The tables included in subsequent paragraphs use both approaches.

Table 4-3 indicates the water quality objective, possible unit treatment process, process function and treatment targets.

Table 4-3: Summary treatment objectives

Water Quality Objective	Possible Unit Treatment Process	Process function	Target Parameter
pH Correction	Lime dosing or alternative chemical treatment	Adjust pH and stabilise water	CCPP 2 to 5 mg/ℓ
Removal of suspended material (Reduce turbidity)	Horizontal flow sedimentation tanks or vertical flow sedimentation tanks	1a) Removal of settling suspended matter 1b) Removal of pathogens including Giardia and Cryptosporidium 1c) Precipitation of oxidised metals	≤ 1.0 NTU
	Rapid gravity sand filters	2a) Removal of fine suspended matter 2b) Removal of pathogens including Giardia and Cryptosporidium	
Inactivation of pathogens	Chlorination	1) Inactivation of Giardia, bacteria, and viruses	Giardia – 7 to 8 log removal Bacteria – 10 to 11 log removal Viruses – 11 to 12 log removal
Ensure distribution system residual disinfectant	Chlorination	1) Establish a chlorine residual	> 1.0 mg/ℓ
DBP precursor reduction (DOC removal)	1) Clarification 2) Rapid Gravity Sand Filters	1 & 2) Reduce DOC by coagulating dissolved organics - remove with phase separating steps	DOC < 10 THM < 0,005mg/ℓ

It is anticipated that a conventional treatment train will be sufficient to address the treatment requirements while being cost effective in terms of both capital and operating costs.

Conventional treatment normally involves coagulation, flocculation, sedimentation, gravity sand filtration and disinfection. The main treatment processes are briefly discussed below:

- With the turbidity averaging above 10 NTU and exceeding 100 NTU in some instances, it is foreseen that a two-stage phase separation process will be required i.e., sedimentation and rapid gravity sand filtration;
- Disinfection is mandatory. Chlorine dosing is considered for this purpose; and
- Washwater recovery, and solids residual disposal, will be required.

5 Treatment Plant

5.1 Process Selection

A process selection was reported on in the Pre-feasibility Study Report (P WMA 06/D00/00/3423/5). The process selection was based on the guidelines prepared for South African conditions (Van Duuren et al, 1997). The review of updated water quality data did not present any findings that necessitates a deviation from the Pre-feasibility findings and recommendations.

The findings are summarised here for ease of reference:

- Due to the turbidity as well as the large filter area required, the use of slow sand filters would not be suitable in this instance and conventional treatment through coagulation, phase separation and disinfection would be required.
- The water is suitable for flocculation by using either metal based or polymer-based flocculants. In both cases the addition of lime may be required to provide sufficient alkalinity.
- Settling and filtration would be appropriate for phase removal given the moderate to high turbidity profile and the absence of confirmed high concentrations of chlorophyll-a in the abstracted water.
- Stabilisation is required.
- Disinfection is mandatory.
- No “special” water quality challenges were identified in the water quality dataset or at the existing Gariep Dam WTP. Conventional treatment processes are therefore deemed to be appropriate for the new Xhariep WTP. The findings are summarised in Table 5-1.

Table 5-1: List of 'special problems'

Description	Treatment	Applicable
Water Stability	Stabilisation	Treatment required
Iron / Manganese	Oxidation (Chlorine or Potassium Permanganate)	Excessive levels were not noted. Treatment is not required.
Taste & Odour	Activated Carbon	Excessive levels were not noted. Treatment is not required.
Algae	Dissolved Air Flotation / Clarification	Excessive levels were not noted. Treatment is not required.
CECs	Ozone / Activated Carbon	Excessive levels were not noted. Treatment is not required.
Hardness	Ion exchange / high lime softening	Not required
Nitrate	Lime addition/clarification/filtration and chlorination	Not required - implicit in design
Fluoride	Ion exchange	Excessive levels were not noted. Treatment is not required.
Organic carbon	Oxidation / Adsorption / Enhanced Coagulation	Excessive levels were not noted. Treatment is not required.
Colour	Lime addition/clarification/filtration and chlorination	Covered in current strategy

5.2 Alternative Treatment Options

The proposed treatment option can be defined as textbook given the relatively pristine nature of the water. The additional analyses performed did not indicate any need for complex or advanced treatment processes that may be relevant in situations such as:

- Complex water sources that include high percentages of recycled or previously used water; or
- Physical constraints such as limited space availability.

Complications such as these would have required consideration of various advanced treatment practices including membranes.

Consideration was however given to refinement of treatment options as they relate to the selection of reactor design and treatment chemical selection. The considerations applied are discussed under various appropriate headings in the document from here onward.

5.3 Proposed Process Flow

The proposed treatment train for the WTP is as follows:

Table 5-2: Process flow

Description	Treatment	Chemical treatment
Intake	Intake structure with flow metering; rapid mixing and flow distribution	Lime addition for stabilisation Pre-chlorination as pre-oxidation and benthic algae control
Primary phase separation	Flocculation and clarification	Flocculant dosing
Secondary phase separation	Filtration	
Disinfection	Chlorination and retention	Chorine dosing

The basic process flow remains as per the design proposed as part of the Pre-feasibility Study Report (P WMA 06/D00/00/3423/5).

5.4 Treatability Tests

A series of treatability tests were undertaken to guide the chemical treatment option selection as well as assist in determining chemical dosage requirements. The full test report is included in Appendix B.

A short summary of the findings is presented below.

5.4.1 Flocculant Selection and Dosing Rates

The selection of a flocculant influences the process in the following ways:

- The efficacies vary and the design needs to be built around the dosage rates required, and
- The flocculant may by itselves modify the character of the water and this must be considered in the balance of the treatment train design.

It is therefore necessary to understand the overall impact of flocculant selection during the design stage.

Jar tests were undertaken on samples drawn from the abstraction pipelines from the Gariep Dam. The samples were subjected to bench scale tests to determine:

- Preferred flocculants –
    - ferric chloride (metal salt),
    - U3500 (polymer), and
    - PAC3850 (poly-aluminium chloride).
- Dosage rates required, and
- Impact of the selected chemical on the water character.

U3500 was included in the test as this is being used in the existing Gariep Dam WTP. The other two chemicals were selected to represent other flocculant “types”.

The dosage ranges tested for turbidity-focussed performance optimisation are summarised in Table 5-3.

Table 5-3: Flocculant dosage ranges tested with results

Description	Chemical treatment	Lowest turbidity for Settled water	Lowest turbidity for Filtered water
Ferric chloride	2 to 36 mg/ℓ	0.443 NTU (36 mg/ℓ)	0.363 NTU (34 mg/ℓ)
U3500 (polymer)	2 to 24 mg/ℓ	1.87 NTU (6 mg/ℓ)	0.239 NTU (16 mg/ℓ)
PAC3850 (poli-aluminium chloride)	2 to 24 mg/ℓ	1.93 NTU (16 mg/ℓ)	0.258 NTU (8mg/ℓ)

From the analyses performed it was clear that the polymer and the poly-aluminium chloride performed better than the metal salt. All combinations however yielded compliant results.

5.4.2 Stability Investigations

The water quality analysis indicated that the source water was mildly aggressive, and that treatment is required to address this. The addition of lime was considered in this series of tests. The intent of this series of tests was to add enough lime to result in a positive CCPP (+2 mg/ℓ and higher) post inclusion of the flocculants at the selected dosage rates.

Table 5-4: Best performance for lime and flocculant test dosage ranges

Description	Lime dose	Lowest turbidity for Settled water	Lowest turbidity for Filtered water
Ferric chloride	10 mg/ℓ	0.761 NTU (30 mg/ℓ)	0.235 NTU (36 mg/ℓ)
U3500 (polymer)	3.5 mg/ℓ	1.43 NTU (8 mg/ℓ)	0.167 NTU (16 mg/ℓ)
PAC3850 (poli-aluminium chloride)	3.5 mg/ℓ	1.23 NTU (10 mg/ℓ)	0.219 NTU (10 mg/ℓ)

The treatability test concluded that all flocculants delivered good results in combination with lime for the available water samples. U3500 and PAC3850 are however the preferred flocculants based on their lower dose requirements as well as the lower lime dose required to achieve a CCPP of more than 2 mg/ℓ.

Based on the test results it is taken that the average dosage rates to be included in the design are:

- Polymer based flocculant = 10-16 mg/ℓ
- Lime = 3.5-5 mg/ℓ

Further stability assessments were also done using mathematical tools and models. These are discussed in more detail under Section 5.5.4.

5.4.3 Chlorine Demand and Chlorine Decay

Chlorine demand and chlorine decay rates vary from treatment plant to treatment plant due to:

- Variances in raw water quality, and
- Variances in infrastructure design and condition.

The existing Gariep Dam WTP does provide some clues on the chlorine demand, that is the amount of chlorine to be dosed before a chlorine residual is established. Based on records studied at the Gariep WTP the average dosage rate is indicated as 3 mg/ℓ for the period November 2023 to November 2024. While the DWS IRIS (Integrated Regulatory Information System) compliance app[2] indicates that micro

[2] https://ws.dwa.gov.za/iris/mobi_waste.aspx

compliance is good, there is no information available to show the rate at which the chlorine is consumed at the plant and then in the distribution system.

5.4.3.1 Chlorine as Disinfection Option

It is necessary to pause on the selection of chlorine as disinfectant prior to engaging on a discussion of chlorine demand and chlorine decay.

There are several options available to use as disinfectant at the Xhariep WTP. The key requirements are that there will always be a residual presence in the treated water and that the residual is compatible with the disinfection strategies applied to the potable water systems supplying Mangaung, Botshabelo and Thaba Nchu at present. The options are discussed below:

- Chlorine based disinfectants
  The chlorine-based options include chlorine gas (Cl_2), calcium hypochlorite ($Ca(OCl)_2$) and sodium hypochlorite (NaOCl). Larger treatment plants tend to use chlorine gas due to economies of scale. There has been some interest in OSEC (on-site electrolitic chlorination) of late as it permits the user to generate sodium hypochlorite on demand. This approach gained increased local prominence due to a shortage of chlorine gas. Chlorine based disinfectants will align with the current disinfection strategies used in Mangaung which are also chlorine based. Therefore, no special measures will be required to blend water from the different sources if chlorination is used. Chlorine does however decay rapidly in distribution systems and care will have to be taken to address this issue.
- Chloramination
  Chloramination is utilised where long residence times are required in distribution systems. Monochloramines are formed by adding ammonia to a chlorinated system in measured amounts. The formation of dichloramines and trichloramines occur when the ammonia-chlorine balance is incorrect and this can result in poor disinfection, taste and odours. Mixing of chlorinated and chloraminated water is not advised as this will result in the formation of the unwanted compound and as well as possible mutual distruction of disinfectants. The use of cloramines is not recommended due to the complexity of managing the mixing of water sources in Mangaung.
- Advanced oxidation options
  Advanced oxidation using ozone, ultraviolet (UV), or chlorine dioxide is not recommended for the Xhariep treatment site. The advanced oxidation processes are generally expensive and are typically reserved for situations where the raw water quality is poor and treatment of contaminants of concern (CECs) is required. The water quality analyses undertaken as part of this design study indicate that this is not the case at the Xhariep WTP. Ozone and UV furthermore do not leave a residual in the treated water and will have to be followed up with a disinfectant that does so. Chlorine dioxide does leave a residual. The longevity thereof in the distribution system is however not guaranteed and top-up options using additional chlorine dioxide or chlorine (as in the case where the water will blend with other sources in Mangaung), will increase chlorite and chlorate levels for which very strict levels exist in water quality standards. The use of chlorine dioxide is therefore not recommended.

The above suggests that only chlorine-based options remain viable in this application. The sourcing and application of chlorine can be done in various forms and further analysis of the following options should be done as part of the detailed design study.

This analysis is postponed as the market remains in flux with respect to availability of infrastructure and technologies. The analysis will have to focus on both the economy and availability of hardware options when the analysis is done. The options to include are:

- Chlorine gas systems using 1 tonne cylinders – this is the most generic form of gas delivery and is used as a standard in the majority of large plants in the Free State Province,
- Chlorine gas using large multi-ton chlorine freight delivery and storage options – this will result in smaller civil infrastructure and building requirements but the availibility of large tankers may be an issue, and,

- OSEC which will add addition power requirements to the plant.

5.4.3.2 Chlorine Demand

The laboratory tests were conducted to determine the chorine demand as well as the rate at which the chlorine will decay under ideal conditions. The laboratory, after several attempts could not determine the chlorination break point. The results indicated that both free and combined chlorine were present across all dosage ranges. An external opinion was sought from Umgeni Water who routinely also perform such tests. Umgeni Water confirmed that they frequently return similar results. It was advised that a theoretical determination may yield better results. The findings from the theoretical assessment are provided in Table 5-5.

Table 5-5: Theoretical chlorine demand

Demand source	mg/mg	Contaminant P_{50} values	Contaminant P_{95} values	Cl_2 required (median) mg/ℓ	Cl_2 required (max) mg/ℓ
Fe^{2+}	0.630	0.025	0.025	0.016	0.016
Mn^{2+}	1.290	0.025	0.05	0.032	0.065
As	0.990	0.001	0	0.001	0.000
Hg	1.000	0.001	0.002	0.001	0.002
NH_4^+	4.2	0.04	0.15	0.168	0.630
H_2S	8.4	NA	NA		
TOC	0.5	4.17	5.62	2.085	2.810
Chlorine dose required ("Demand")				**2.3**	**3.5**

The analysis indicates the chlorine demand will on average be 2.3 mg/ℓ but can increase to 3.5 mg/ℓ under some conditions. The average demand estimate correlates well with the average dose record from the existing Gariep Dam WTP. The average dose at the existing Gariep Dam WTP will need to be sufficient to allow for a residual in the distribution system. The additional 0.7 mg/ℓ over the calculated chlorine demand value will be sufficient for a small system such as currently serviced by the existing WTP.

5.4.3.3 Chlorine Decay

Chlorine decays in distribution system due to:

- Bulk decay of the water, which depends on the quality of the water.
- Interaction with reservoir structure surfaces and the rate of decay is subject to the condition of the concrete or other construction materials.
- Interaction with pipe walls and this is subject to the condition of the pipes as well as the duration of contact.

The three sources of decay are listed in increasing significance mainly due to the decreasing ratio of water body to contact surface area in the three cases. The first value can be determined in the laboratory while the second decay characteristics can only be determined in a constructed environment due to the significant variances brought about by the type, age and condition of materials used in the distribution systems and then also the duration of contact in each of the various components of the system. It is therefore reasonable to expect chlorine decay rates will change as consumption rates increase and reduces the residence time of water in the system, the growth and control of biofilm in the bulk distribution systems, and as the physical system degrades due to the normal infrastructure aging processes that impact on the condition of the infrastructure.

Three tests were performed in the laboratory to determine the bulk decay coefficient of the source water. The results returned indicated that a reasonable value for the bulk decay coefficient is around 0.03 to 0.04/h.

The decay coefficients for the pipe system cannot be determined in the laboratory nor in the field as the system is not yet constructed. Guidance is taken from work done on existing Rand Water pipelines (Viljoen, Haarhoff, & Joubert, 1997). An average decay coefficient for pipelines of 0.1855/h was derived from data included in the WRC's report Table 6.4. This value is however deemed to be high due to the age and condition of the pipelines. The distribution pipelines for the Xhariep bulk conveyance system are expected to benefit from more modern protection systems and are expected to remain in a pristine condition for the foreseeable time. The decay coefficient for the assessment is therefore taken to be 50% of the WRC value and is assumed to be 0.0928/h.

Decay coefficient information for reservoirs is taken from studies undertaken on Rand Water reservoirs (Van der Walt, 2002). The results reported indicate that the decay coefficients are in the order of 0.04 to 0.05/h on average.

A simplification was adopted in the analysis of decay for Xhariep system due to:

- The duration of water retention in the bulk distribution system reservoirs are short in comparison with its retention in the pipeline system, and
- The decay constants associated with bulk decay in reservoirs are negligible compared to the decay constant adopted for pipelines.

The decay analysis was consequently based on the decay coefficient for pipelines only.

The chlorine decay model used is the first order decay model which is presented below:

$$C_t = C_o.e^{-kt}$$

Where:

- C_t = chlorine concentration (mg/ℓ) at time t
- C_o = chlorine concentration (mg/ℓ) at time 0
- k = first-order chlorine decay rate constant (1/h) and
- t = residence time in the system.

The analysis of expected chlorine decay is presented in Table 5-6. Table 5-6 presents scenarios for the system commencing with a chlorine residual of 2, 4 and 6 mg/ℓ at the potable water pump station at the new Xhariep WTP. The decayed values are presented at various key points in the transfer of the water from the WTP to the receiving reservoir in Mangaung which is expected to be approximately 60 hours after leaving the treatment facility. It is noted from the analysis that the chlorine levels are depleted by the time the water reaches the Booster Pump Station's suction reservoir which is approximately 36 hours after leaving the treatment facility. A booster dose of around 3mg/ℓ at the Booster Pump Station's suction reservoir then allows the water to reach the receiving command reservoir with an acceptable residual level.

Table 5-6: Theoretical chlorine decay at 208 Mℓ/d production rates

Description	Water age (hours)	Chlorine residual at start (mg/ℓ)			
Chlorine booster dose		No boost	No boost	No boost	3mg/ℓ boost at T_3
C_0 (mg/ℓ) - WTP		2	4	6	4
T – 1st command reservoir	12	0.66	1.31	1.97	1.31
T_2	24	0.22	0.43	0.65	0.43
T_3 – Booster pump station	36	0.07	0.14	0.21	3.14
T_4 - 2nd command reservoir	60	0.01	0.02	0.02	0.34
T_5	72	0.00	0.01	0.01	0.11

The analysis indicates that:

- A chlorine residual of around 4 mg/ℓ is required at the end of the WTP, and
- That a 3 mg/ℓ chlorine boost will be required at the booster pump station.

The analysis is based on several assumptions that will only be tested when the system is commissioned. The chlorine dosing system will therefore have to be designed with sufficient flexibility to deliver safe water under varying conditions.

The following must however be noted:

- The calculation is a simplified analysis in order to indicate order of magnitude results. An Epanet model, which is able to integrate more complex dynamics was run and returned comparable results. Both the simplified and Epanet model however are dependent on the selection of accurate decay constants. These remain largely estimates from literature and laboratory tests. Further work will be required to determine more accurate decay constants. These estimates remain subject to system specific variables and the true decay coefficients will only become known once the system is commissioned.
- The models were run at a supply capacity of 208 Mℓ/d. Lower supply capacities will imply longer system retention times and lower residual chlorine levels in the system. Higher supply capacities will mean higher chlorine residual levels and possibly a reduced dependency on the booster chlorination system.

The sizing of the Xhariep WTP chlorine dosing system is possible using the above analysis as input and is presented in Table 5-7.

Table 5-7: Chlorine dosing requirements at the Xhariep WTP

Demand source	Cl_2 required (median) mg/ℓ	Cl_2 required (max) mg/ℓ	Comment
Chlorine dose required for chlorine demand	2.3	3.5	From Table 5-5
Chlorine residual required (mg/ℓ)	4.0	4.0	Table 5-6
Decay constant in reservoir (Assumed)	0.10	0.10	
Duration in reservoir (hr)	1.0	1.0	
Concentration at start of reservoir (mg/ℓ)	4.4	4.4	First order decay
Total chlorine dose design (pre & post) (mg/ℓ)	6.7	7.9	
Primary chlorine dose (% of demand)	100%	75%	
Primary chlorine dose (mg/ℓ)	**2.3**	**2.6**	
Post chlorine dosing (mg/ℓ)	**4.4**	**5.3**	

The dosing system for the Booster Pump Station Reservoir will be required to top up the free chlorine levels. No additional demands will be catered for. The design will therefore be sized to add 3 mg/ℓ chlorine to the flow on average.

5.4.3.4 Total Trihalomethane Production Potential

It is anticipated that high chlorine dosages will be required to ensure that a chlorine residual is retained in the bulk delivery system.

Raw source water was dosed with a single dose to achieve an elevated free chlorine level of 10 mg/ℓ whereafter the water was analysed to determine the potential of trihalomethane (THM5.5.95.5.9) production under these extreme chlorination conditions.

The detail results are included in Appendix B. In summary, and under these worst-case conditions:

- The water formed THMs for all 10 samples.
- Chloroform was found to be the most prevalent THM with 3 of the samples reaching the threshold of the 300 µg/ℓ SANS241 limit. The balance of the results, bar one at 230 µg/ℓ, are below 200 µg/ℓ.
- The second most prevalent THM was bromodichloromethane, which was consistently below the SANS241 threshold of 60 µg/ℓ.

- SANS241 requires the combined trihalomethane ratio to remain below 1. In all cases the ratio ranged between 1.2 and 1.9.

It is concluded from these results that:

- Pre-chlorination, if it is to be practiced, is to be kept at the lowest possible levels to ensure that THM formation is restricted.
- Organic removal must be optimised as part op the plant operations to ensure optimised organic content by the time the water reaches the main chlorination system.
- THM levels must be monitored during the operation of the facility and bulk distribution system as a risk parameter.
- Overall chlorination levels must be kept as low as possible. Therefore, system chlorination boosting is preferred to a bulk chloronation approach at the WTP only. The system will benefit from the relatively slower chlorine degradation rates of low chlorine levels over that of excessively high chlorine levels.

These considerations are carried forward into the proposed disinfection design as presented later in this report.

5.5 Treatment Unit Design

5.5.1 Raw Water Rising Main

Raw water will be transferred from a new raw water pump station to the WTP site. The pump station and rising main design is addressed under the Feasibility Design Report – Pipelines, Pump Stations and Reservoirs (P WMA 06/D00/00/3423/9).

5.5.2 Chemical Dosing Regime

It is anticipated that the following chemical dosing strategies would achieve the desired treatment outcomes:

- pH correction and Stabilisation: Hydrated Lime dosed at the inletworks,
- Flocculant dosed at the entrance to the clarifiers, and
- Chlorine based disinfection to be dosed at the inlet works (pre-chlorination) and after the filters (post chlorination).

5.5.3 Raw Water Receiving Bay

The raw water will be conveyed to the proposed Xhariep WTP through a 2000 mm diameter steel pipeline where it will discharge into the raw water receiving bay. The incoming stream will be cascaded over weir. The water will be pH adjusted, and stability will be addressed at this point.

The incoming stream will be divided into eight equal streams over sharp crested weirs. For Phase 1, four streams will be operational and flowing at 52 Mℓ/d each. For Phase 2, two streams will be operational at a flow of 52 Mℓ/d each. Isolating sluice gates will be provided at this point to shut off one module/unit when required. The future stream, to increase the overall plant capacity to 416 Mℓ/d, will be temporarily closed.

The detailed feasibility design is illustrated in drawing 1002533-2500-DRG-CC-2514 and 2515. The drawings are included in Appendix E.

5.5.4 pH Correction and Stabilisation

5.5.4.1 Treatment Requirement

The raw water supplied to the Xhariep WTP is classified as mildly aggressive. Aggressive water can degrade the cement matrix and concrete aggregates. To mitigate this, pH correction and stabilisation of the water through chemical addition is necessary. The stabilisation chemical will be dosed upstream of the coagulant, at the inlet works. A target calcium carbonate precipitation potential (CCPP) of 2 to 5 mg/ℓ is recommended post inclusion of the coagulant.

5.5.4.2 Options Analysis

An options analysis was performed to identify the most suitable and cost-effective chemical for pH correction and stabilisation. The chemicals evaluated included:

- Hydrated lime (calcium hydroxide)
- Soda ash (sodium carbonate)
- Caustic soda (sodium hydroxide)

Hydrated lime ($Ca(OH)_2$) is a white, powdery substance that is prepared into a slurry before dosing. Lime addition increases CCPP by adding calcium and hydroxide ions, raising the pH and enhancing calcium carbonate precipitation. Additionally, its reaction with carbon dioxide in the water forms bicarbonate and carbonate ions which contributes to alkalinity.

Soda ash (Na_2CO_3), also a white powder commonly dosed as a slurry, increases CCPP by adding carbonate ions which enhance alkalinity. Soda ash, however, does not contribute calcium, limiting its effect to increasing carbonate availability.

Caustic soda (NaOH) is commonly supplied as a concentrated liquid solution (~50 wt.%) and is dosed directly. It rapidly raises pH, thereby indirectly increasing CCPP. The addition of caustic soda, however, does not contribute calcium or carbonate to the water.

The options analysis was conducted for Phase 1 and 2 (312 Mℓ/d) with a target CCPP of 4 mg/ℓ as $CaCO_3$ post coagulant addition. The selected coagulant, Ultrafloc U3500, has minimal impact on pH or alkalinity, so its addition is not expected to affect the stabilisation chemical requirements. Dosage requirements for each stabilisation chemical was determined based on both average and worst-case raw water quality.

Additional requirements for stability and aggression control include (Loewenthal, Ekema, & Marais, 1988):

- Ca and Alkalinity both preferably greater than 50 mg/ℓ as $CaCO_3$ but never less than 30 mg/ℓ as $CaCO_3$; and,
- pH between 7.0 and 9.5.

The estimated average and maximum dose requirements are summarised in Table 5-8. Calcium concentration and alkalinity following stabilisation chemical addition is further shown.

Table 5-8: Chemical requirements to achieve a CCPP target of 4 mg/ℓ

		Lime	Soda Ash	Caustic Soda
		Average (Worst-case)		
Required dose	mg/ℓ	4.95 (29.17)	14.39 (85.36)	5.55 (32.88)
Theoretical chemical requirement	kg/h	75 (445)	219 (1301)	85 (501)
Actual chemical requirement	kg/h	84 (494)	212 (1312)	171 (1011)

		Lime	Soda Ash	Caustic Soda
		Average (Worst-case)		
Calcium (after dosing)	mg/ℓ $CaCO_3$	50.26 (71.52)	43.57 (32.10)	43.57 (32.10)
Alkalinity (after dosing)	mg/ℓ $CaCO_3$	76.09 (86.49)	82.99 (127.68)	76.35 (88.22)
pH (after dosing)	-	8.73 (8.49)	8.72 (8.57)	8.78 (8.79)

Hydrated lime requires the lowest dosage to achieve the target CCPP as it raises the pH and contributes to alkalinity. Additionally, lime is the only chemical that increases the calcium concentration in the water. In contrast, soda ash requires the highest dosage as it has the smallest impact on pH and does not contribute calcium ions. However, as soda ash directly contributes carbonate ions, it results in the greatest increase in alkalinity.

While all resulting alkalinity levels comply with recommendations, only some of the resulting Ca-levels fall in the recommended range. The soda ash and caustic soda-based systems perform poorly in this regard while the lime-based system achieves the required targets. All stabilisation chemicals result in pH levels within the compliance ranges.

Based on the chemical requirements outlined above, the capital costs (CAPEX) and annual ownership costs were estimated for the different stabilisation chemicals and are summarised in Table 5-9 and Table 5-10.

Table 5-9: Estimated CAPEX for stabilisation chemical options

	Hydrated Lime	Soda Ash	Caustic Soda
Storage silos/tanks	R 2 087 000	R 5 048 000	R 1 619 000
Dosing equipment	R 2 217 000	R 5 383 000	R 896 000
Design, installation and commissioning	R 839 000	R 2 594 000	R 755 000
Total CAPEX (Excl. VAT)	**R 4 304 000**	**R 10 431 000**	**R 3 270 000**

Note: Storage silos and tanks were costed based on average dose requirements. Dosing equipment was costed based on maximum dose requirements.

Table 5-10: Estimated annual cost of ownership for stabilisation chemical options

	Hydrated Lime	Soda Ash	Caustic Soda
Annual capital repayment	R 746 216	R 1 808 498	R 566 943
Annual average chemical cost	R 2 808 126	R 15 810 153	R 10 282 486
Annual average electricity cost	R 213 796	R 714 988	R 3 862
Maintenance	R 215 200	R 521 550	R 163 500
Staffing	R 600 000	R 600 000	R 600 000
Total annual cost of ownership (Excl. VAT)	**R 4 584 000**	**R 19 456 000**	**R 11 617 000**

Evidently, caustic soda has the lowest capital expenditure (R3 270 000), followed by hydrated lime (R4 304 000). However, due to its high associated chemical costs, the annual cost of ownership for the caustic soda system is not competitive compared to lime. Hydrated lime has the lowest total annual cost

of ownership, at an estimated R4 584 000. In comparison, the annual cost of ownership for caustic soda is more than twice this amount, while for soda ash, it is more than four times higher.

The additional benefit of Ca^{2+} addition by the lime-based system is noted as an advantage over the competing process alternatives.

Hydrated lime is thus the chosen chemical for pH correction and stabilisation at the proposed Xhariep WTP.

5.5.4.3 Design

The inlet works will provide sufficient mixing energy for hydrated lime dosing, and this will be followed by a baffled channel providing adequate contact time for the lime to dissolve and stabilise the pH prior to coagulation.

The following dosing rates were assumed in the design:

- 30 mg/ℓ maximum, and
- 5 mg/ℓ average.

The actual dosages are expected to vary with changing raw water characteristics that will occur through the different seasons. Regular (once a week) jar tests will be required to optimise chemical dosages. Additional jar tests will be required when there is a noticeable (visibly or chemically) change in water quality.

At least 37 270 kg (± 75 m³) of 90% pure hydrated lime will need to be stored to provide 30 days' storage for the first 208 Mℓ/d phase of the WTP at the average coagulant dosage concentration. Total average consumption at 312 Mℓ/d will increase to 55.9 tonnes per month or (± 112 m³).

The preliminary lime dosing design calculations are indicated in Table 5-11 and the preliminary lime rapid mixing calculations are indicated in Table 5-12.

Table 5-11: Preliminary Lime Dosing Calculations

Parameter	Value	Unit	Remarks/Reference
Phase 1 Flow	208	Mℓ/d	
Phase 2 Flow	114	Mℓ/d	
Maximum dosing rate per Phase	30	mg/ℓ	Based theoretical modelling
	11,180	kg/d	Phase 1: 7,450 kg/d Phase 2: 3,730 kg/d
	508	kg/hr	Over 22-hour operation
Number of dosing units	2	No	Phase 1: 1 duty + 1 standby unit Phase 2: 1 duty + 1 standby unit
Bulk Density of hydrated lime	500	kg/m³	
30-day storage capacity	55,900	kg	Phase 1: 37,300 kg (Two 80 m³ bulk storage silos) (duty+standby) Phase 2: 55,900 kg (total) (Two 80 m³ bulk storage plus one stand by silos) (three total)

Table 5-12: Preliminary Rapid Mixing Calculations

Description	Symbol	Design Capacity	Hydraulic Capacity	Units	Formula/ Comments
Flow Rate (total for plant)	Q_{total}	312,000.00	365,890	m³/day	
Number of streams		6.00	6.00		

Description	Symbol	Design Capacity	Hydraulic Capacity	Units	Formula/ Comments
Flow Rate (per stream)	Q_{stream}	52,000	60,982	m³/day	
Water temperature	˚C		18.00		
Density of the fluid (water)	ρ_{water}		997.46		
Dynamic viscosity	μ_{water}		0.00112400		
Kinematic viscosity	v_{water}		0.00000100		
Total headloss	h_{total}		1000	mm	Hydraulic Mixing (Weir or orifice plate)
Effective Mixing Volume	V		4.95	m³	Q*T
Retention time	T		6.43	sec	
G =	G		1,233	s^{-1}	$((g*h/(v*t)^{0.5}$
G * (T)^0.5 =	GT		24,213		$G * (T)^{0.5}$

The bulk storage silos will be located next to the chemical storage building from where dry lime will be transferred to the day hoppers. The day hoppers, metering feeders and mixing bowls will be installed on the raw water receiving bay with adequate storage capacity to dose the hydrated lime slurry at the first weir of the inlet works structure. Lime slurry will be pumped from the slurry bowls to the dosing point. One dosing point will be provided.

Lime will be dosed in slurry form of maximum 5% concentration and at a maximum dosage of 30 mg/ℓ for the new WTP at 312 Mℓ/d.

To ‘stabilise’ the water, hydrated lime will be dosed to produce a slightly over-saturated water with a positive CCPP (typical 2 – 5 mg/ℓ as $CaCO_3$) and increase the pH, which enhances the oxidation of manganese.

5.5.5 Coagulation, Rapid Mixing and Flow Division

Chemical dosing is purposefully designed to provide flexibility regarding dosing capacity. This is mainly since raw water quality can vary and, given that the chemical dose and raw water quality are directly interlinked, the equipment must provide flexibility in this regard. This flexibility can easily be utilised to make provision for the relatively small increase in plant capacity.

Various chemicals are utilised for the treatment of water for numerous reasons and form an intricate part of the overall treatment process with associated operational costs. Usually, chemicals are added to water for the removal of suspended (e.g., colloids) and dissolved (e.g., chemical softening and removal of colour) particles, disinfection (e.g., chlorine), removal of taste and odour causing constituents (e.g., activated carbon) and stabilisation (lime and/or carbon dioxide).

A new chemical dosing building for the storage of chemicals and to house the new chemical dosing equipment will be required near the rapid mixing and flow division chamber.

Once the water has been stabilised, the ultimate flow of up to 312 Mℓ/d will be split into six modules of 52 Mℓ/d each, in the dividing chamber. Isolating sluice gates will be provided at this point to shut off a module/unit when required. Once flow enters the dividing chamber, the flow splits into equal streams of 52 Mℓ/d. The future streams will be temporarily closed.

The following dosing rates were assumed in this detailed feasibility design:

- 35 mg/ℓ maximum, and
- 12 mg/ℓ average.

The selected flocculant and dosing range is informed by the treatability tests undertaken (refer to Section 5.4.1) as well as the dosage rates reported by the operators of the existing Gariep Dam WTP. The dosing rates at the existing treatment plant varies from 12.3 to 31.3 mg/ℓ.

Regular (once a week) jar tests will be required to optimise chemical dosages once the plant is operational. Additional jar tests will be required when there is a noticeable (visibly or chemically) change in water quality.

The polymer coagulants, in general, consume considerably less alkalinity than hydrolysing metal salts. They are effective over a broader pH range compared to alum and experience shows that they work satisfactorily over any pH range, therefore no pH adjustment will be required for proper coagulation. However, they do not work well in low turbidity waters.

U3500 was selected for this design as a reference coagulant based on the findings of the treatability tests that were undertaken (refer to Section 5.4.1).

- Bulk Coagulant storage will consist of:
  - Six 20,000 ℓ bulk storage tanks (*four for Phase 1*) will be adequate to provide at least 30 days' storage for 312 Mℓ/d at the average coagulant dosage concentration.
  - The required pipework to the dosing pumps will have the necessary flexibility to use any pump from the day tank.
- Coagulant Dosing Equipment will include:
  - Eight single phase variable speed drive (VSD) dosing pumps (6 duty and 2 standby) shall be provided to feed polymer used flocculant from the bulk storage tanks to the dosing points. Phase 1 will require 4 duty pumps and one standby pump to be installed.
  - The dosing pumps are each required to deliver between 12 and 120 ℓ/hour at a pumping head of ±10 m by means of flow paced electronic variable speed controls. Dosing pumps are also stroke adjustable between 10 and 100% of maximum stroke.
  - All pipework is uPVC and delivery lines will be fitted with suitably rated loading valves, pulsation dampeners and flushing lines. A one litre flask will be allowed for on the suction manifold for calibration of the dosing pumps.

The preliminary design calculations for the flocculant dosing system are indicated in

Table 5-13.

Table 5-13: Flocculant dosing system calculations

Parameter	Value	Unit	Remarks/Reference
Flow	312	Mℓ/d	Design capacity of WTP (incl. conveyance loss and summer peak factors)
Maximum dosing rate	35	mg/ℓ	
Density of polymer	1,150	kg/m³	Concentrated U3500
Number of dosing units	9	No	Phase 1: 4 duty + 2 common stand-by (50%)
Maximum delivery of dosing pumps	120.0	ℓ/hr	At 100% Stroke
30-day storage capacity @ avg. dosing rate of 12 mg/ℓ.	131,720	kg	Phase 1: 87,810kg Phase 2: 43,910kg
	120	m³	6 x 20 m³ bulk storage tanks to be provide– - Four required for phase 1, two for phase 2.

Sufficient flash-mixing inducing a G-value > 1000 sec^{-1} is of prime importance to optimize the efficiency of coagulants. This will be provided for at the inlet to the flocculation and clarification system.

Analysis of a traditional weir design for mixing shows that the G-values for a typical design range between 1000 to 1100 sec^{-1} for a receiving chamber of 1.2 x 1.5 m surface and a depth of 1.5 m. The

level difference before and after the weir must be at least 820 mm. In-line flash mixing can also be considered to simplify the design and flocculant dosing.

Allowance will be made to dose a coagulant into the four individual streams of 52 Mℓ/d in Phase 1 as well as the two 52 Mℓ/d streams of Phase 2. Hydraulic flash-mixing will be affected by means of a weir, orifice plate or in-line static mixer with a head loss of at least 0.5 m immediately after the dosing point. Alternatively, the chemical will be dosed into the feed pipe immediately prior to discharging into the division chamber.

5.5.6 Flocculation and Clarification

It should be noted that various types of flocculation and clarification alternatives are available and will need to be evaluated as part of the detailed feasibility study. For the pre-feasibility study, the calculations were based on the sludge blanket (Pulsator Clarifier) with internal flocculation.

This follows high level consideration and comparison of alternatives including horizontal flow clarifiers and clariflocculators. Pulsators were selected based on the following considerations:

- Pulsators can operate at higher rates than clariflocculators and horizontal flow clarifiers which then will yield a smaller footprint. This is advantageous given the large capacity of the plant.
- Horizontal clarifiers of the size required at Xhariep will require complex mechanical moving bridge type desludging equipment. While these have been implemented successfully at Rand Water's Zuikerbosch and Vereeninging WTPs, they do add a level of complexity and maintenance care requirement that may be challenging to provide given the fairly remote location of the Xhariep WTP.
- Rotating bridge type clarifiers (clariflocculators) present the same mechanical maintenance challenges. While the water quality cannot be compared, the Aliwal North WTP and Welbedacht WTP have demonstrated that mechanical failure on the bridge can result in significant challenges to recommissioning once the scrapers become trapped in settled sludge.
- Pulsators have been shown to work well at the Rustfontein and the Welbedacht WTPs. While the mechanical components do require ongoing maintenance and care, there is sufficient local experience with the technology to validate consideration of pulstator clarifiers.
- The pulsators at both Rustfontein and Welbedacht perform well under typical conditions that are experienced in the Free State Province.

The design is therefore based on pulsator technology.

The design features 12 sludge blanket clarifiers (four per 104 Mℓ/d phase) each with a central flocculation column. From the flocculation column the flow diverted into four conduits from which the clarifier will be fed through several pipes with orifices. The excess sludge in the sludge blanket will flow laterally into concentrated pockets and will be removed by hydrostatic pressure through discharge pipes to a central sludge gallery.

Twelve separate sedimentation tanks will be selected to maintain the maximum loading rate of 2.8 m/h when one tank is out of service. Under normal operating conditions this will result in a hydraulic loading rate of 2.52 m/h. By using a length to width ratio of 1:1, each tank surface area was calculated as 420 m². The tank depth was selected as 4.5 m. Launders with submerged holes with a hydraulic load rate of 8 m³/h/m with one tank out of operation result in a total double weir length of 36.95 m or four double weirs of 9.25 m each.

The design calculations for the pulsators are indicated in Table 5-14.

Table 5-14: Sludge Blanket Clarifier (Pulsator) Preliminary Design

Parameter		Value	Unit	Remarks/Reference
INLET CONDITI	Total raw water inflow	312,000	m³/day	Design Capacity of WTP (incl. conveyance loss and summer peak factors) (Nett)
	Water temperature	18	˚ C	

Parameter		Value	Unit	Remarks/Reference
	Density of the fluid (water)	997.79	kg/m³	
	Fluid viscosity	0.00114	cP/100	
	Density of the dried solids	1,005	kg/m³	
	Solids concentration	300	mg/ℓ	Assumed 2 x Turbidity
	Typical settling velocity for polymer flocs	2.52	m/h	
	Δρ	0.00254	kg/m³	
	Number of process units	12		
DIMENSIONAL PARAMETERS	Flow per unit process	0.353	m³/s	
	Surface loading	2.5	m/h	
	Tank Width	22.55	m	
	Tank Length	22.55	m	
	Length: width ratio	1		
	Surface area	508.2	m²	
	Surface loading (check)	2.5	m/h	
	Tank depth	4.5	m	
	Width:depth ratio	5.01		
	Wetted perimeter	31.5	m	
	Cross sectional area	101.4	m²	
	Average cross flow velocity	0.00348	m/s	
WEIR SIZING	Total weir length required @ 6m³/m/h	52.94	m	
	Total weir length required @ 8m³/m/h (one tank o/s)	36.95	m	
	Flow per meter	7.2	m³/m/h	
	Number of weirs across width	4		
	Pipe size of weir @ 0.5m/s	0.47		
	Theoretical retention time	1.80	hr	
KPI's	Reynolds number	11,143		
	Froude number	3.84E-07		
	Densimetric Froude number	0.35654		
	Fd^2	0.127		

The flow characteristics of the sedimentation tank are estimated using the Reynolds number, Froude numbers and Densimetric Froude number. The use of the Reynolds number is limited to establish if turbulent flow can be expected or not while the Froude number relates the average tank velocity to the gravitational acceleration. The Densimetric Froude number gives an indication of the tank's stability. If the ratio is less than unity, the gravity effects will dominate the momentum forces. In this case, the Densimetric Froude number is significantly below unity.

The detailed feasibility design is illustrated in drawing 1002533-2500-DRG-CC-2518 & 2519. The drawings are included in Appendix E.

5.5.7 Rapid Gravity Sand Filtration

A total of 30 rapid gravity sand filters will be provided i.e., 20 for Phase 1 and 10 for Phase 2 of the works with a combined filter area of 2,541 m² for a full stream of 312 Mℓ/d. This arrangement will produce a filtering rate of 6.00 m/hr with 30 filters in operation, and 6.67 m/hr when three filters are out of service.

The incoming flow will be equally divided on the inlet side to the filters by inlet pipes while the outlet valves will allow filter water to waste on a time cycle and will allow a slow start operation.

Each filter will be backwashed independently, first with a combination of air at a rate of 50 m/hr and water at 17 m/hr, then with water only at a rate of 34 m/hr.

The minimum water level will be maintained by a fixed outlet weir. A 200 mm deep false floor will be provided for a nozzle system.

Provision was made in the design for 1000 mm deep filter media. The filter media will be made up of sand. The sand should have a uniformity coefficient (UC) < 1.4 and must have an effective grain size of 0.9 mm. Limits will also be placed on the over and under size fractions.

Each filter will be fully automated and equipped with pressure sensors (one mounted above the media to measure head loss and one mounted above the filter outlet to measure flow rate) and on-line turbidity meters.

The filter washing will be automatic, initiated either when the pressure level in a filter reaches a pre-set level or when a filter has completed a pre-set run length. Alternatively, it can be initiated manually. Table 5-15 and Table 5-16 show the filtration bed and filter design calculations.

Table 5-15: Filtration Bed Fluidization and Expansion

Parameter	Value	Unit	Remarks/Reference
Bed Expansion	1	%	
Bed Depth	1.0	m	
Porosity	0.42	-	
Density	2,650	kg/m³	
D_{10}	0.90	mm	
T	18	˚C	
Rho (water)	999.13	kg/m³	
Viscosity (water)	1.447	10^{-6} m²/s	
Le	1.00	m	
Ee	0.43	m	
B	694.69		
Kv	112.00		
Ki	2.25		
Re	8.36		
Minimum Fluidisation Velocity	31.34	m/h	
	8.70	mm/s	
L/d ratio	1111	%	

Table 5-16: Preliminary Filter Design

Parameter	Value	Unit	Remarks/Reference
Flow rate	365.9	m³/day	Operational 22 of 24 hours and 5% treatment loss

Parameter	Value	Unit	Remarks/Reference
	4.23	m³/s	
	15,245	m³/h	
Number of filter units	30		
Capacity per filter unit	12.20	Mℓ/d	
	508.18	m³/h	
Filtration rate	6.00	m³/m²/h	
Required filter area	84.70	m²	Required filter area
Filter bed Length	18.02	m	Filter bed Length
Filter bed Width	4.70	m	Filter bed Width
Provided Filter Area	84.70	m²	Provided Filter Area
Total filter area	2,541	m²	
Filtration rate	6.00	m³/m²/h	
Filtration capacity (net)	365.9	Mℓ/d	
Filtration rate with 3 filters O/S	6.67	m³/m²/h	
Backwash rate	17 and 34	m³/m²/h	
	1,440 and 2,880	m³/h	
Max velocity in washwater header	2.5	m/s	
Backwash pipe size (diameter)	650	mm	

The hydraulic gradeline of the plant dictates that the filter block must be elevated above ground level to ensure that expensive earthworks are avoided while the net positive suction head (NPSH) requirements of the high lift pumps are satisfied. This allows for the provision of a storage sump under the filter block from where backwash water and other non-potable service water can be drawn.

The detailed feasibility design is illustrated in drawing 1002533-2500-DRG-CC-2522 and 2523, which are included in Appendix E.

5.5.8 Washwater Disposal

5.5.8.1 Treatment Requirement

The optimal operation of the Rapid Gravity Sand Filters (RGSF) relies on frequent backwashing to remove accumulated particles and restore filter performance and efficiency. This essential maintenance process requires a high flowrate of water over a short time, resulting in the generation of substantial volume of spent washwater, as illustrated in Table 5-17. Consequently, it is crucial to design an effective system for managing and disposing of the washwater generated.

Table 5-17: Washwater generated during RGSF Backwash

Parameter	Value	Unit	Remarks/Reference
Backwash Stage 1 (Low rate) Duration	15	min	
Backwash Stage 2 (High rate) Duration	5	min	
Backwash Stage 1 (Low rate) Flowrate	17	m/hr	
Backwash Stage 2 (High rate) Flowrate	34	m/hr	
Volume of washwater generated per filter	600	m³	

Parameter	Value	Unit	Remarks/Reference
Total volume of washwater generated	18000	m^3	per day to wash all 30 filters during the Complete Phase
% water used for backwash	5.4%	-	assuming single wash per filter per day

5.5.8.2 Options Analysis

Four approaches typically considered for wasted washwater handling/disposal are as follows (AWWA & ASCE, 2012):

- Direct discharge to a stream or adjacent body of water,
- Discharge to sanitary sewer system,
- Equalization and recycling within the main treatment process, and
- Treatment of washwater by concentrating the solids through either sedimentation or thickening.

Managing a daily wasted washwater volume of 18 Mℓ/d presents significant challenges. The proposed location of the Xhariep WTP, along with environmental constraints, prevent the direct discharge of the wasted washwater into natural waterways or a sanitary sewer system. Opting for an equalization and recycling approach would necessitate the construction of large equalization basins, i.e. 2 equalization basins with a diameter of 50 m and water depth of 3 m each, to accommodate the volume. Similarly, if further treatment of the wasted washwater is pursued prior to disposal, robust thickening and/or dewatering systems will be required to process the substantial volume effectively.

5.5.8.3 Design

Upon investigation of the typical approaches for handling and disposal of wasted washwater, it was decided that the wasted washwater from the filters would be directed to the sludge lagoons that will be constructed adjacent to the WTP for the sludge management. This approach enables the sludge lagoons to function as a combined system for both sludge and wasted washwater handling across the entire WTP. In this setup, the solids from the wasted washwater will settle within the lagoons, while the excess water will be allowed to drain into the stormwater system through a proposed outlet pipe, recycled back to the inlet of the works and allowed to simply evaporate. This would require the periodic removal of sediment from the lagoons to maintain their functionality.

The detailed feasibility design of the sludge lagoons is detailed in Section 5.5.11 of this report.

5.5.9 Disinfection

5.5.9.1 Treatment Requirement

The Xhariep WTP process train includes two chlorine dosing points:

- At the inlet works (pre-chlorination)
- In the clearwater storage tank feed manifold (post-chlorination)

Pre-chlorination is essential to prevent biofilm formation in the conveyance system. Post-chlorination ensures effective disinfection of the treated water and maintains the required chlorine residual levels until the booster station. The dosing requirements of the system are summarised in Table 5-18.

Table 5-18: Chlorine disinfection chemical requirements

Parameter	Unit	Cl_2 required (median)	Cl_2 required (maximum)
Pre-chlorination dose	mg/ℓ	2.3	2.6

Parameter	Unit	Cl_2 required (median)	Cl_2 required (maximum)
Post-chlorination dose	mg/ℓ	4.4	5.3
Total chlorine dose	**mg/ℓ**	**6.7**	**7.9**

5.5.9.2 Options Analysis

Chlorine gas and onsite sodium hypochlorite generation (OSEC) were investigated as potential disinfection systems.

Gaseous chlorination is widely used in water treatment plants for disinfection, making its design and operation well established and understood. However, this system is considered a hazardous installation and requires specialised transportation, handling, storage and equipment. The SANS 10298 standard has specifically been devised to mitigate against the risk of chlorine gas leaks through outlining stringent safety measures to safeguard both the onsite personnel and nearby public.

OSEC generates sodium hypochlorite through the electrolysis of a brine solution. The brine solution is prepared by dissolving salt (sodium chloride) into a stream of softened water. The generated sodium hypochlorite solution has relatively low free available chlorine concentrations (< 0.8%). The application of OSEC eliminates the safety concerns and special training inherent with the handling and storage of chlorine gas and commercial strength sodium hypochlorite (12 -15%). OSEC does, however, present its own challenges. Hydrogen gas is produced as a by-product and if present in concentrations above 4%, it is a flammable/explosive gas that can also cause an oxygen deficient environment. For this reason, it must be safely vented from the process. Moreover, although sodium hypochlorite has the same functions as chlorine gas in terms of formation of HOCl and OCl- in water, chlorine gas which acts as an acid (pH < 2) decreases the pH of the water while sodium hypochlorite tends to be more alkaline (pH 11~13) and increases the pH of the water. This may impact disinfection efficiency, given its dependence on pH.

The options analysis was conducted for Phase 1 and 2 (312 Mℓ/d). Chlorine gas was assumed to be supplied in 1-ton tanks and salt for OSEC supplied in 1-ton bags. To meet the dosage requirements specified in Table 5-18, the system requires an average chlorine gas flowrate of 99 kg/h, with a maximum flowrate of 116 kg/h. For OSEC, the required salt flowrate is 293 kg/h on average, with a maximum flowrate of 346 kg/h.

A financial evaluation of the two disinfection systems was conducted. The capital costs (CAPEX) and total annual cost of ownership for each system are summarised in Table 5-19 and Table 5-20.

Table 5-19: Estimated CAPEX for disinfection system options

	Chlorine Gas	OSEC
Preliminary & General	R 7 030 000	R 13 907 000
Civil Work	R 13 043 000	R 16 206 000
Mechanical Work	R 11 545 000	R 33 500 000
EC&I Work	R 4 041 000	R 11 725 000
Total CAPEX (Excl. VAT)	**R 35 659 000**	**R 75 338 000**

Table 5-20: Estimated annual cost of ownership for disinfection system options

	Chlorine Gas	OSEC
Annual capital repayment	R 6 182,285	R 13 061 719
Annual average chemical cost	R 22 225,099	R 4 263 341
Annual average electricity cost	R 30 793	R 4 704 634
Maintenance	R 940 425	R 2 213 400
Staffing	R 600 000	R 600 000

	Chlorine Gas	OSEC
Total annual cost of ownership (Excl. VAT)	**R 29 979 000**	**R 24 844 000**

Evidently, the CAPEX, and consequently the annual capital repayment, for the gaseous chlorine disinfection system is lower than for OSEC. However, due to the significantly higher chemical costs associated with chlorine gas, the total annual cost of ownership for the gaseous chlorine disinfection system exceeds that of the OSEC system. As a result, the total annual cost of ownership for gaseous chlorine (R 29 979 000) is 21% higher than that of OSEC (R 24 844 000).

Due to the operational familiarity with chlorine gas and its simple design compared to the more complex OSEC alternative, chlorine gas has been selected as the preferred disinfection method, despite its higher total annual cost of ownership. The implementation of the chlorine gas system reduces the learning curve for operators and minimises potential challenges during implementation. This decision can be reassessed in the detailed design phase. The further analysis of chlorination systems must also consider chlorine gas using large multi-ton chlorine freight delivery and storage options – this will result in smaller civil infrastructure and building requirements, but the availability of large tankers may present a logistical challenge.

5.5.9.3 Design

5.5.9.3.1 Chlorination at the WTP

The fundamental design inputs for the chlorination system are discussed in Section 5.4.3.

Chlorine gas was proposed for disinfection with an estimated maximum dosage of 7.9 mg/ℓ chlorine required to maintain a 4.0 mg/ℓ residual at the outlet of the treated water tank at full production capacity.

To support phasing of the development of the WTP, two chlorination facilities are planned for the fully developed site. The first will service the 208 Mℓ/d requirements of Phase 1 while the second will cater for the 104 Mℓ/d requirements for Phase 2 and 3 each.

At a maximum dosage of 7.9 mg/ℓ and ultimate flow rate of 10,164 m³/hr for Phase 1 at the inlet works and 9,502 m³/hr for Phase 1 at the clearwater tank, the mass dosing rate of chlorine required will be a total of 77.2 kg/hr or 1853 kg/d. This will require a total of 52 one-tonne chlorine cylinders per month, and around 14 cylinders per manifold.

Assuming chlorinators of 20 kg/hr are used then:

- 2 duty and 1 standby unit will be required for pre-chlorination, and
- 3 duty and 1 standby unit will be required for post-chlorination.

This will yield a total dosing capacity of 40kg for pre-chlorination and 60kg/hr for post chlorination. The total of chlorinator capacity of 100 kg/hr will exceed the overall reliable abstraction rates of the chlorine drum manifold under cold conditions. This can be resolved by reducing the capacity of the pre-chlorination chlorinators to 10 kg/hr and installing 3 duty units. This will however impact on the interchangeability of the units. It is therefore recommended that this issue be considered further during detailed design development when the plant operators can state their preference. The consideration must include further discussion on OSEC as per the findings of Section 5.5.9.2.

The detailed feasibility design is illustrated in drawing 1002533-2500-DRG-CC-2520 and 2521. The drawing is included in Appendix E.

5.5.9.3.2 Booster Chlorination at the Booster Pump Station Reservoir

The fundamental design inputs for the booster chlorination system are discussed in Section 5.4.3.

Chlorine gas was proposed to increase the free chlorine level by an average of 3.0 mg/ℓ to achieve an available free chlorine level of 0.3-0.35 mg/ℓ at the handover point to the Mangaung bulk distribution system.

To ensure there is sufficient dosing capacity a 4.0 mg/ℓ dosing facility will be provided at the booster pump station site.

At a maximum dosage of 4.0 mg/ℓ and ultimate flow rate of 312 Mℓ/d for Phase 1 and 2 the mass dosing rate of chlorine required will be a total of 52 kg/hr or 1248 kg/d. This will require a total of 21 one tonne chlorine cylinders per month, and around 9 cylinders per manifold.

Assuming chlorinators of 20 kg/hr are used then:

- 3 duty and 1 standby unit will be required.

This will yield a total dosing capacity of 60 kg/hr for top-up chlorination. The total of chlorinator capacity is not expected to exceed the overall reliable abstraction rates of the chlorine drum manifold which is estimated to be 61.2 kg/hr.

The detailed feasibility design is illustrated in drawing 1002533-2500-DRG-CC-2522 and 2523. The drawings are included in Appendix E.

5.5.10 Clearwater Storage

Two independent storage units are envisaged for the full site development. The breakdown is as follows:

- 1 reservoir will serve the first 208 Mℓ/d Phase 1; and;
- Another reservoir will serve the second Phase 104 Mℓ/d WTP. This reservoir can be constructed to meet the requirement of only Phase 2 or can be sized to cater for both Phase 2 and Phase 3. This decision is best left for the detail design development stages of the Phase 2 module.

Table 5-21 indicates that a CT-value of 104 mg.min/ℓ will be required for a 3-log inactivation of Giardia Cysts when chlorine is used. Assuming a residual chlorine value of 4.0 mg/ℓ, the estimated contact time required is 26 minutes. The CT value for bacteria and viruses is between 6 and 7 (Table 5-22) which then confirms the above retention time as adequate for the main microbiological concerns. A minimum storage volume of 4,097 m³ is then required for disinfection.

Table 5-21: CT Values for Inactivation of Giardia Cysts (US Environmental Protection Agency, April 1999)

Disinfectant	Inactivation (mg · min/L)					
	0.5-log	1-log	1.5-log	2-log	2.5-log	3-log
Chlorine [1]	17	35	52	69	87	104
Chloramine [2]	310	615	930	1 230	1 540	1 850
Chlorine Dioxide [3]	4	7.7	12	15	19	23
Ozone [3]	0.23	0.48	0.72	0.95	1.2	1.43

CT values were obtained from AWWA, 1991

1. Values are based on a free chlorine residual less than or equal to 0.4mg/ℓ, temperature of 10°C, and a pH of 7.
2. Values are based on a temperature of 10°C and a pH in the rant of 6 to 9.
3. Values are based on a temperature of 10°C and a pH of 6 to 9.

Table 5-22: CT Values for Inactivation of Bacteria and Viruses (US Environmental Protection Agency, April 1999)

Disinfectant	Inactivation (mg · min/ℓ)			
	Bacteria		Viruses	
	2-log	4-log	2-log	4-log
Chlorine	0.1 – 0.2	10 - 12	2.5 – 3.5	6 - 7

Disinfectant	Inactivation (mg · min/ℓ)			
	Bacteria		Viruses	
	2-log	4-log	2-log	4-log
Chlorine Dioxide	8 - 10	50 - 70	2 - 4	12 - 20
Ozone	3 - 4	N/A	0.3 – 0.5	0.6 – 1.0

The storage volume dedicated to disinfection is separated from the high lift pump balancing storage volume by a high-level weir which then guarantees the retention time is achieved. The compartments of the reservoir can be drained using bypass pipes which can be opened to facilitate draining and cleaning of the reservoir.

A provision of 0.5 hrs of pumping time for the high lift pumps has been provided in the pump balancing compartment of the reservoir, resulting in a volume of 4,727 m³. This will allow enough time to adjust pump flow rates should production rates in the WTP change.

This results in a minimum reservoir capacity of 8,824 m³ to which an additional 20% operational buffer capacity is added to accommodate dead storage volumes and mandatory low operating levels as may be required for the high lift and service water pumps. This results in a storage facility of 10.6 Mℓ which is partitioned as follows:

- Partition 1 – Constant head with a volume of 2.65 Mℓ dedicated to chlorination only. The minimum residence time in this partition will be 16.8 minutes at maximum plant capacity.
- Partition 2 – Constant head with a volume of 2.65 Mℓ dedicated to chlorination and to serve as a source tank for chlorinated water to be used on site. It will not be subject to draw-down from the high lift pumps. The residence time in this partition will be 16.8 minutes at maximum plant capacity.
- Partition 3 – Variable level balancing tank to supply the high lift pumps. The partition will have a full supply volume of 5.3 Mℓ. The partition will have a residence time of 33 minutes at full production capacity.
- All partitions will be baffled.

The detailed feasibility design is illustrated in drawing 1002533-2500-DRG-CC-2524 and 2525. The drawings are included in Appendix E.

5.5.11 Solids Handling and Disposal

5.5.11.1 Treatment Requirement

The sludge handling system is designed to accommodate the full plant hydraulic capacity (416 Mℓ/d) assuming 10% (worst-case scenario) of the overall plant capacity will be wasted as sludge from the pulsators and wasted washwater from the filters. The average solids concentration of the inlet stream to the sludge lagoons was estimated at 68 mg/ℓ based on the average turbidity of 30 NTU, coagulant and lime dosing of 10 mg/ℓ and 5 mg/ℓ, respectively. For an average daily flow of 416 000 m³/day and based on the above-mentioned assumptions, approximately 9 930 tons of solids will be removed by the treatment plant over a 1-year period. Additionally, the coagulant sludges typically achieve a concentration of about 10% solids in sludge lagoons (AWWA, American Water Works Association Water Quality and Treatment A Handbook on Drinking Water, 2000). However, in this Study, the highest overall compacted concentration of 20% was targeted at an estimated sludge density of 1,500 kg/m³.

5.5.11.2 Options Analysis

Five methods of disposal are typically considered for process waste (AWWA, 2000):

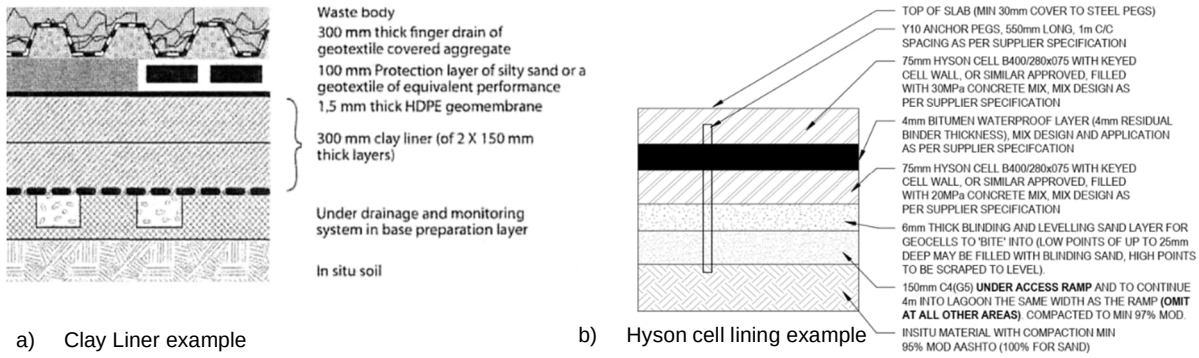
- Discharge to natural waterway – will not receive regulatoty approval,
- Discharge to sanitary sewer system – not viable as an option,

- Discharge to permanent/dewatering lagoons,
- Burial in a landfill after dewatering/drying – Not viable given the volumes of wet sludge but can be considered for the dewatered sludge, and
- Re-use of all or a portion of the wastes – this remains a long term ambition but will require dewatering.

Due to sufficient land available at the Xhariep WTP, sludge lagoons were considered as well-suited for storing, thickening, dewatering and drying the sludge generated during the coagulation and sedimentation processes as well as from filter backwash. This nonmechanical sludge handling option is highly cost-effective; however, periodic cleaning, repairs and maintenance of the sludge lagoons are necessary to ensure their continued functionality.

Sludge lagoons are generally earthen basins constructed either by building a berm on the ground surface or excavating a large basin in the ground. In most cases, sludge lagoons required a protective lining to meet Environmental Impact Assessment (EIA) requirements and prevent leakage into the groundwater. Additionally, this lining must be durable to withstand potential damage from equipment used to remove dried sludge. Several lining options are available among which three options listed below were further investigated in this study:

- **Clay liner**: A three-layer system comprised of a bottom layer of 30 cm of compacted clay with a low hydraulic conductivity, an intermediate impermeable synthetic membrane (1.25 to 2.5 mm thick HDPE) and a final granular layer of about 30 cm deep (Mackenzie L. Davis, 2020)
- **Hyson cell lining**: A three-layer system comprised of a bottom layer of 75 mm of hyson cell filled with 20MPa concrete mix, an intermediate 4 mm bitumen waterproof layer and a final top layer 75 mm of hyson cell filled with 30MPa concrete mix.
- **Reinforced concrete lining**: A three-layer system comprised of a bottom layer of 75 mm of reinforced concrete layer, an intermediate 4 mm bitumen waterproof layer and a final top layer 75 mm of reinforced concrete layer.



a) Clay Liner example

b) Hyson cell lining example

Figure 5-1: Sludge lagoon linings

Sludge lagoons generally operate in a cyclic process consisting of three stages: filling, drying, emptying. This cycle is repeated until the lagoon is full. A subsequent drying period is for additional thickening and dewatering before the dried sludge is removed. It was assumed that each stage of the cycle has an equal duration.

For clay-lined lagoons, a 12-month storage period was considered, while for Hyson cell and reinforced concrete-lined lagoons, a 6-month storage period was assumed. The longer period for clay lined ponds have to do with the significant damage to the liner typically caused by the sludge clearing process. A lower clearing frequency will also reduce the frequency of damage and repair.

Based on these durations, the required lagoon storage volumes are at least 33,100 m³ for clay-lined lagoons and 16,600 m³ for lagoons with Hyson cell or reinforced concrete linings as shown in Table 5-23.

Table 5-23: Estimations of sludge lagoons volume and dry solids content

Description	Unit	Sludge lagoon lining		
		Clay liner	Hyson cell lining	Reinforced concrete lining
Storage duration	months	12	6	6
Volume of sludge in lagoons before drying period	m^3	33 100	16 600	16 600
Dry solids content after drying period	tonne	9 930	4 970	4 970

A financial evaluation of the three-sludge lagoon lining options was conducted. The capital costs (CAPEX) and the annual OPEX for each option are summarised in Table 5-24 and Table 5-25.

Table 5-24: Estimated CAPEX for Sludge lagoon options

Description	Estimated CAPEX for sludge lagoon options		
	Clay liner	Hyson cell lining	Reinforced concrete lining
Preliminary and General	R4 450 000	R44 810 000	R51 450 000
Earthworks	R47 800 000	R25 420 000	R25 420 000
Civil works	R127 200 000	R141 720 000	R168 290 000
Mechanical works	R12 090 000	R12 090 000	R12 090 000
EC&I works	R4 240 000	R4 240 000	R4 240 000
Total CAPEX (excl. VAT)	**R195 780 000**	**R228 280 000**	**R261 490 000**

The estimated costs of the mechanical and electrical, control and instrumentation (EC&I) works for all three options are identical as they encompass the expenses for the supernatant recycle pump station and associated valves. Additionally, the earthworks costs, including excavation and disposal, are the same for both Hyson cell and reinforced concrete lined lagoons. However, the total CAPEX varies among the options due to the variations in materials of construction costs. The 6-month storage reinforced concrete lining lagoon has a total CAPEX (R261 490 000) that is 15% higher than the total CAPEX of the 6-month storage Hyson cell lining lagoon (R228 280 000) and 36% higher than the 12-month storage clay-lined lagoon (R195 780 000).

Table 5-25: Estimated Annual OPEX for sludge lagoon options

Description	Estimated Annual OPEX for sludge lagoon options		
	Clay liner	Hyson cell lining	Reinforced concrete lining
Electricity	R2 980 000	R2 980 000	R2 980 000
Sludge removal	R10 010 000	R10 010 000	R10 010 000
Lagoons cleaning and repair	R8 470 000	R1 620 000	R940 400
Maintenance	R2 470 000	R1 620 000	R1 140 000
Labour	R720 000	R720 000	R720 000
Total OPEX (excl. VAT)	**R24 450 000**	**R16 950 000**	**R15 800 000**
Sludge handling and disposal system cost (Amortised @ 20 years)	R25 400 000	R29 610 000	R33 920 000
Total annual cost of ownership (excl. VAT)	**R50 050 000**	**R46 560 000**	**R49 720 000**

The operational costs associated with electricity to power the supernatant recycle pump station, removal of sludge and labour are identical for all lagoon options, as they are expected to perform similarly in these aspects. However, significant differences in cleaning, repair and maintenance costs are observed, which influence the total OPEX. The reinforced concrete-lined lagoon option has the lowest total OPEX,

followed closely by the Hyson cell lined lagoon option. This is attributed to their durability, which requires minimal maintenance and repairs over their lifecycle compared to the clay lined lagoons.

Additionally, the amortisation of capital was estimated as 11.5% p.a. of the total CAPEX (excl. VAT) at 20 years to determine the total annual cost of ownership of each option. As a result, the total annual cost of ownership of the Hyson cell-lined lagoon option (R46 560 000 p.a.) is 7% lower than the clay lined lagoons (R50 050 000 p.a.) and 6.4% lower than that reinforced concrete-lined lagoons (R49 720 000 p.a.).

5.5.11.3 Design

The Hyson cell-lined sludge lagoons were proposed for the sludge handling and disposal at the Xhariep WTP.

At least four lagoons divided into two sections, each lagoon with a six-month storage capacity would be required, one for drying sludge and three more for receiving sludge. Sludge from the clarifiers and filter wash water will discharge into one of the four sludge lagoons, thus allowing cleaning of the one, and redundancy from two more lagoons as presented in Figure 5-2.

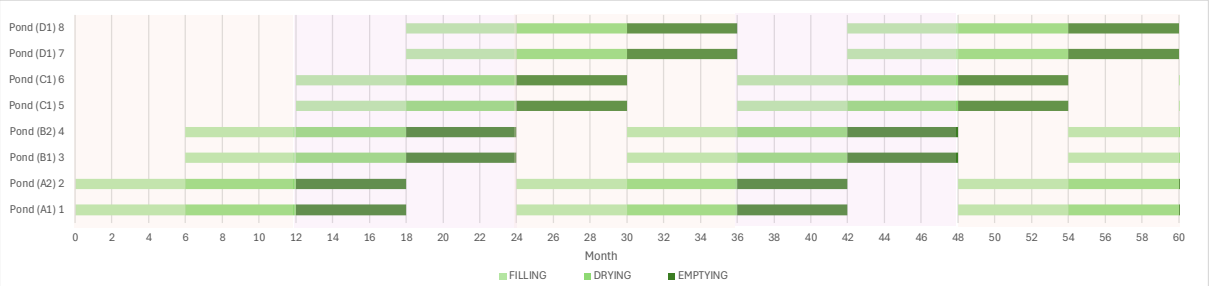


Figure 5-2: Sludge lagoon operation cycle

Table 5-26 shows the sludge production and storage calculations.

Table 5-26: Sludge Production and Storage Requirements

Parameter	Based on raw water quality (1% Solids)	Units
Average suspended solids	54.00	mg/ℓ
Coagulant (U3500) added	10.00	mg/ℓ
Lime added	5.00	mg/ℓ
Average production rate	400	Mℓ/d
Average mass dried sludge produced	27 200	kg/d
Dried sludge produced per year	9 928 000	kg
Dried sludge produced over 2 years	19 856 000	kg
Dried solids density	1 500	kg/m³
Volume of un-thickened sludge produced over 1 year	14 599 600	m³
Final solids content		
Sludge thickened after evaporation (Solids Content)	20%	
Bulk density of 20% solids Sludge	1,320.00	kg/m³
Mass of thickened sludge	136 000	kg/d
	4 136 700	kg/month
	49 640 000	kg/year
Volume of sludge in lagoon (after drying)	90.7	m³/day
	2 760	m³/month

Parameter	Based on raw water quality (1% Solids)	Units
	33 100	m³/year
Filling period (months)	6	No
Volume of sludge in lagoon (before drying)	16 600	m³
Dry solids content	4 964 000	kg
Area required	23 165	m²
Length / Width	4	
Width of lagoon	76	
Length of Lagoon	304	
Volume of water to remove	7 283 270	m³
Evaporation based on area	185	mm

The detailed feasibility design is illustrated in drawing 1002533-2500-DRG-CC-2550, 2551 and 2552. The drawings are included in Appendix E.

Supernatant from the lagoons will be collected in a central chamber and discharged into the supernatant sumps downstream of the lagoons where it will be recycled back to the inlet works through the supernatant recycle pump stations or diverted to stormwater.

Table 5-27 shows the preliminary design details of the supernatant sumps and pump stations.

Table 5-27: Preliminary design details of the supernatant sump and pump station

Parameter	Value	Units	Remarks/ References
Supernatant sumps			
Total supernatant flowrate	1250	m³/h	Assuming 75% recovery of overall waste stream
Retention time	0.5	hr	
Total storage volume required	750	m³	with 20% safety factor
Number of sumps	2	No	
Sump volume	375	m³	
Water depth	3.00	m	
Sump freeboard	1.00	m	
Total sump hight	4.00	m	
Sump area	188	m²	
Length to Width ratio	2.00	-	
Width	7.00	m	
Length	14.0	m	
Supernatant Recycle Pump station			
Type of pumps	Submersible	-	
Number of pumps installed	4	No	
Number of duty pumps	4	No	
Number of standby pumps	2	No	
Flowrate per pumps	625	m³/h	

The initial 208 Mℓ/d first phase will require the construction of at least two ponds, one supernatant sump and the installation of two submersible pumps. One additional pond and sump will have to be added per 104 Mℓ/d expansion.

5.6 On-site Piping and Water Conveyance

Table 5-28 provides the information on major process unit interconnecting pipework.

Table 5-28: On-site piping and water conveyance detail

Pipe description	Material	Diameter	Joint system	Flow velocity	Number of pipes
Raw water pipe to inlet works	Coated mild steel	2000 mm	Welded pipes, flexible couplings and restraining flange adapters	1.769 m/s	Phase 1: x1
Inlet works to Pulsator feed pipes	Coated mild steel	850 mm	Welded pipes and flexible couplings	1.365 m/s	Phase 1: x4 Phase 2: x2 Phase 3: x1
Pulsator outlet to filter inlet	Coated mild steel	First section 1200 mm	Welded pipes and flexible couplings	1.236 m/s	Phase 1: x1 Phase 2&3: x1
		Last section 1525 mm	Welded pipes and flexible couplings	1.522 m/s	Phase 1: x1 Phase 2&3: x1
Filter outlet to Reservoir	Coated mild steel	Direct filter outlet 1200 mm	Welded pipes and flexible couplings.	1.236 m/s	Phase 1: x1 Phase 2&3: x1
	Coated mild steel	Combined pipe to reservoir 1600 mm	Welded pipes and flexible couplings	1.381 m/s	Phase 1: x1 Phase 2&3: x1

5.7 Ancillary Infrastructure

5.7.1 Power Supply

Power to the High Lift Pump Station and WTP site will be supplied from the Eskom 132 kV Ruigtevallei - Valley Dora line.

This will require 30 meters of line to loop in and loop at the site. The 132 kV switching station will require two incomer bays, two feeder bays and bus-section bay. This outdoor yard will need to be built to Eskom standards and become the property of Eskom once completed. The layout of this yard can only be finalised once application has been made to Eskom and an Eskom design team has been appointed.

In addition, two 30 MVA 132/11 kV transformers will be required to ensure firm supply to the site.

An 11 kV brick-built substation will be required to supply the High Lift Pump Station and WTP individually at 11 kV.

5.7.2 Chemical Dosing and Handling

All chemicals proposed for the plant and the associated dosing and storage requirements shall be proposed to the Employer's Agent and Employer for approval during the construction phase of the project. The detail design of the systems shall be in line with the principles and requirements established in this detailed feasibility study.

Where indicated, secondary chemical dosing shall be allowed for in all civil design infrastructure, should the secondary chemical dosing equipment not be provided in Phase 1.

The WTP shall be able to accommodate storage for each chemical for a minimum period of 30 days of the WTP at average chemical consumption rates.

The Contractor shall account for all water and ambient temperatures that may affect chemical strength, mixing kinetics, make up of chemicals and dosing.

Chemical pump shall be positive displacement piston diaphragm pumps (typical for chemical dosing) to control dose rate.

5.7.3 Service and Fire Water

Service water shall be drawn from the reservoir and pumped to elevated water tanks which can provide the necessary service water and fire water needs to the plant via gravity at the required pressure. The elevated tanks may need to be positioned elsewhere to sustain the necessary downstream required pressure.

A pumped service water system may also be considered for distribution around the plant, however, this is a less preferred option compared to the simpler elevated tank configuration.

The filter backwash system shall be separate from the service water system.

The service water pump station may be housed in the filter backwash building.

5.7.4 Wastewater Treatment Works

A small wastewater treatment works (WWTW) shall be designed and constructed to serve all the buildings within the WTP area and the staff accommodation area.

A percolation-based system cannot be considered due to the geology of the WTP site. The alternative treatment options then include:

- A pond based system is attractive in that it offers passive treatment at low maintenance cost and effort. The oxidation pond will have to be situated away from the washwater recovery system to avoid direct of accidental contamination of the water in the treatment system. Ideally the ponds must be sited to the north of the WTP.
- Alternatively a package plant can be considered. A package plant will require ongoing operation and maintenance effort but its closed nature will assist preventing cross-contamination via avian or other routes.

The recommendation for this site is the oxidation pond system on the condition that it can be sited north of the WTP failing which an RBC (rotating biological contactor) type design can be considered for a package plant.

The effluent from the wastewater treatment facility must meet the applicable DWS discharge limits (DWS, 2013).

The required treatment capacity is anticipated to be low. Assuming a total of 40 persons active on site daily, each discharging 60 ℓ/c/d to the treatment facility, then a treatment capacity of 2.4 m³/day is required.

All workplace wash flows, and chemically contaminated water, shall not be discharged to the sanitation system and shall not be discharged to the stormwater management system but shall be retained and treated in place.

6 Civil Design and Building Requirements

6.1 Philosophy of Design

The concept (preliminary) design of the Xhariep WTP, including the layout and the configuration of the infrastructure, takes account of the following considerations, which will be developed further during the detailed design phase:

- The configuration of the plant to suit the terrain on each site.
- The hydraulic profile and the inter-relation of this to the site terrain.
- The geotechnical conditions, with consideration of
  - suitable founding conditions.
  - what is reasonably achievable in terms of excavation; and
  - minimisation of fill.
- The minimisation of chemical dosing pipeline lengths.
- Allowance for the approach road.
- Importantly, an operator-centric design that provides:
  - easy access to areas that require routine operator input and checking.
  - “Operation corridors” that flow in such a way between process units that routine operation monitoring can be achieved via a simple route walked through the plant; and
  - well-designed open-plan rest areas for operators (such as the canteen), that do not isolate them from the plant operations but are instead designed so that critical areas remain in sight, with the aim of keeping these under the attention of operators.

6.2 Structural Design of Concrete Elements

Water-retaining structures will be designed in terms of BS 8007 and any supporting specifications (e.g. in-house specifications) for water-containing structures, which is largely an adaptation of the British Specification. Concrete for water-retaining structures shall be class 35 MPa/19mm concrete and shall have a cement/water ratio not less than 2.2 and a cement content of 380 kg/m^3. Cement for water-retaining structures shall be type CEM II B-V with fly ash extender in accordance with SANS 1491: Part II.

The nominal concrete cover to reinforcement shall be 50 mm, unless otherwise specified on the drawings with a minimum cover of 40 mm in terms of BS 8007. The use of concrete cover blocks in water-retaining structures, will be supported.

The detail structural (reinforcing) design of the reinforced concrete elements will be executed as part of the detailed design process. However, for costing purposes, an estimated allowance ranging between 100 and 180 kg steel per cubic meter of concrete was made, depending on the type of structure.

Structural concrete for non-water-retaining structures has been designed in terms of SANS 1200, as amended, and shall be either class 25MPa/19mm or 35MPa/19mm depending on the application and as shown on the drawings.

6.3 Applicable Statutory and Regulatory Requirements

Structural design will be carried out in compliance with the SANS 10400: “Code of Practice for the application of the National Building Regulations”, using the following standards:

- Water retaining and excluding elements will be designed in accordance with BS8007:1987, using the British design codes for structural concrete design (BS8110-1 1997), modified by CIRIA C660 – Early-age thermal crack control in concrete.
- Water retaining structures classified as 'Tightness Class 1' in terms of EN 1992-3 provisions for achieving tightness class.
- Non-water-retaining buildings and structures will be designed using SANS 10162:1 (steel) and SANS 10100:1 (concrete).
- Minimum loadings given in SANS 10160 Parts 1 to 3 will be used unless otherwise specified below.
- Seismic design will be carried out in accordance with SANS 10160 Part 4 unless otherwise specified.

6.4 General

The following design failure methods are considered in each section of the works:

- Overall stability against sliding (Factor of Safety (FOS) = 1.2) and overturning (FOS = 1.5).
- Overall stability against uplift (buoyancy) (FOS = 1.1).
- Ultimate limit state design of elements.
- Typical serviceability (including crack-width) design of elements.

6.5 Water Retaining Structures

6.5.1 Description of Structures

The following structures will be water retaining:

- Inlet works,
- Chambers,
- Pulsator tanks,
- Filter basins and filtered water sump,
- All storage reservoirs,
- All sumps and tanks,
- Pump stations, and
- Solids handling ponds.

6.5.2 Site Specific Considerations

The geology of the site was investigated. A good founding surface will need to have a minimum bearing pressure of at least 250 kPa. However, the entire structure will need to be founded on homogenous material. This will result in structures founded on either hard material or constructed platforms.

Refer to Report P WMA 06/D00/00/3423/7 (Geological and Materials Investigations Report) for a detailed assessment of the geological conditions encountered on the treatment site.

6.5.3 Overall Stability Criteria

The structures will be designed to resist two loading scenarios:

- Resist internal hydrostatic loads, and
- Resist external backfill loads with saturated water table.

In the case of an empty tank, the reinforced concrete raft footing will be designed to resist uplift forces due to groundwater pressures where appropriate.

For conventional loading (internal hydrostatic loads), no backfill will be assumed as is the case in water tightness testing.

6.5.4 Ultimate Limit State (ULS) Design Load Cases

Two load cases will be considered for ULS design:

- Overspill case – areas where water is stored/processed are filled up with water to the highest possible level. No backfill is assumed for this case.
- Empty case – tank is empty and backfill up to finished ground level is assumed. The water table is assumed to be at the same level as the backfill for this case.
- Slabs and beams will be designed to resist vertical loads (permanent and variable).

6.5.5 Serviceability Limit State (SLS) design load cases

SLS design procedure will comprise designing “watertight” elements for maximum allowable crack-width for the overspill case in accordance with classification ‘Tightness Class 1’ of EN 1992-3, and by considering early-age thermal cracking.

Slabs and beams to be designed to not exceed the SLS maximum criteria for deflections.

6.6 Building Work

In terms of the process requirements, the following buildings will be designed in accordance with the general architectural prescriptions and all in accordance with SANS 10400 and relevant Particular Specifications:

- Office building (Drawing no 1002533-2500-DRG-CC-2512 & 2513)
- Workshop building (Drawing no 1002533-2500-DRG-C-2510 & 2511)
- Chemical storage and dosing control building (Drawing no 1002533-2500-DRG-C-2516 & 2517)
- Guard house (Drawing no 1002533-2500-DRG-C-2529)
- Pulsator top structures (Drawing no 1002533-2500-DRG-C-2518 & 2519)
- Filter gallery top structure (Drawing no 1002533-2500-DRG-C-2522 & 2523)
- Chlorine dosing and storage building (Drawing no 1002533-2500-DRG-C-2520 & 2521)

6.6.1 Office Building

A building will be provided for administrative functions and ablution facilities at the Xhariep WTP. In terms of administration requirements, provision has been made for the following:

- Operator offices (2No)
- Common Room
- Laboratory Room
- Meeting room (8-10 seater)
- Telemetry, Control and Server Room
- Kitchen
- Male and Female Toilets with storage lockers and showers
- Storeroom
- Minimum of 4 No covered parking bays linked to internal access road.

The walls will be enclosed with approved facebrick on the outside in stretcher bond, inside stockbrick with smooth plaster. The roof construction shall be galvanized profiled steel sheeting on factory manufactured timber trusses.

Doors will be standard wooden doors and all windows standard residential type windows. All ceiling material will be fibre reinforced cement covered with pink insulation. The reinforced concrete floor will be covered with a steel floated screed.

6.6.2 Workshops

A building will be provided for administrative and maintenance functions at the Xhariep WTP and to serve as a regional hub for maintenance on the Xhariep bulk water infrastructure including the raw water pump station, pipelines and command reservoirs. There will also be sufficient facilities provided for plant and maintenance labour. In terms of administration requirements, provision has been made for the following:

- Management offices (2No)
- Stores (3No) and stores contol office
- Large open workshop space
- Small secured workshop space (2No)
- Meeting room (8-10 seater)
- Admin work desk space
- Kitchen and common room
- Filing and general purpose rooms
- Male and Female Toilets with storage lockers and showers
- Storeroom
- Minimum of 4 No covered parking bays linked to internal access road.

The walls will be enclosed with approved facebrick on the outside in stretcher bond, inside stockbrick with smooth plaster. The roof construction shall be galvanized profiled steel sheeting on factory manufactured steel trusses.

Doors will be standard wooden doors and all windows standard residential type windows. Large doors will be steel roller shutter type with manual chain operation. All ceiling material will be fibre reinforced cement covered with pink insulation. The reinforced concrete floor will be covered with a steel floated screed.

6.6.3 Chemical Storage and Dosing Control Building

A building will be provided for administrative and control functions of chemical dosing at the Xhariep WTP.

There will also be sufficient facilities provided for plant and maintenance labour. In terms of administration requirements, provision has been made for the following:

- Management offices (2No)
- Chemical storage volumes
- Chemical dosage control spaces
- Male and Female Toilets with storage lockers and showers
- Storeroom

The walls will be enclosed with approved facebrick on the outside in stretcher bond, inside stockbrick with smooth plaster. The roof construction shall be galvanized profiled steel sheeting on factory manufactured steel trusses.

Doors will be standard wooden doors and all windows standard residential type windows. Large doors will be steel roller shutter type with manual chain operation. All ceiling material will be fibre reinforced cement covered with pink insulation. The reinforced concrete floor will be covered with a steel floated screed.

6.6.4 Guard House

A guard house will be provided at the entrance of the WTP with a toilet which will be connected to the common sewer reticulation system for the Office Building and the guard house.

There shall be enough space to house two guards at any time.

Brickwalls on the outside will be facebrick in stretcher bond, inside stockbrick with smooth plaster, painted. All windows standard fixed steel louvres with insect gauze backing.

Concrete floors shall be steel floated.

6.6.5 Pulsator Top Structures

A building will be provided on the pulsators to house and control the pulsator equipment.

Brickwalls on the outside will be facebrick in stretcher bond, inside stockbrick with smooth plaster, painted. All windows standard fixed steel louvres with insect gauze backing. Doors will be standard wooden doors.

The roof will be constructed using reinforced concrete. Concrete floors shall be steel floated.

6.6.6 Filter Gallery Top Structures

The filter gallery top-structure will serve as an operations and observation platform from where filter control can be directed.

Brickwalls on the outside will be facebrick in stretcher bond, inside stockbrick with smooth plaster, painted. All windows standard fixed steel louvres with insect gauze backing. Doors will be standard wooden doors.

The roof will be constructed using reinforced concrete. Concrete floors shall be steel floated.

6.6.7 Chlorine Storage and Dosing Building

A building for the storage and dosing of chlorine has been designed as shown on drawing no 1002533-2500-DRG-C-2520 & 2521. The preliminary position of the building will be next to the chlorine contact tank as shown on the relevant layout drawings.

The building will be designed in terms of the acceptable safety regulations whereby any major chlorine gas leak is contained inside the building and then released under controlled conditions to a scrubber unit.

The roof of the storage area shall be a reinforced concrete frame (to support the I-beam required for chlorine delivery purposes) and shall be covered by galvanised sheeting. The floor shall be power floated concrete protection by an approved self-levelling acid resistant epoxy.

The walls will be enclosed with approved facebrick on the outside in stretcher bond, to suit the existing buildings aesthetically, inside stockbrick with smooth plaster.

6.6.8 Pump Stations

Brickwalls on the outside will be facebrick in stretcher bond, inside stockbrick with smooth plaster, painted. The roof structure shall be constructed with reinforced concrete.

Access doors will be standard transformer room doors with louvres and maintenance access will be roller shutter doors. All windows standard fixed steel louvres with insect gauze backing.

The roof structure shall be constructed with structural steel portal frames bolted to the concrete floor covered by galvanised sheet metal fixed to cold formed steel purlins.

Concrete floors shall be steel floated.

6.7 Site Services

6.7.1 Interconnecting Process Pipework

Given the geotechnical characteristics of the treatment site, the bulk of the interconnecting process pipework will be steel. All above ground pipework shall be supported on pedestals. Connections between above ground and underground pipework shall make provision for expansion and movement. Long lengths of above ground pipework will include flexible jointing to accommodate heat induced expansion and shrinkage.

Underground interconnecting pipework between process structures will be steel. All steel pipes and fittings underground will be coated to provide the required corrosion protection.

Some PVC piping will be considered in protected and shielded environments. PVC to steel pipe connections will be flange adaptors.

Pipework between the chemical dosing shed and relevant process structure will predominately be surface mounted smaller diameter steel pipes, providing easy access and early detection of any leaks and preventing contamination of soils or working areas.

Pipe routing considers minimising the length of pipe, installing pipes in the same trench, making use of service corridors, avoiding clashes of pipes, and avoiding the excessive use of bends and fittings.

6.7.2 Service Water Supply

Water will be required for domestic purposes at the Admin Building, Chemical Storage Building, Workshop, Chlorine stores and the Guard House, for firefighting purposes, for chemical dosing processes as well as for providing wash water at strategic points around the site.

A water distribution ring main will distribute service water around the site take offs to all water supply points within the WTP boundary. The maximum pressure in the pipeline will be 90 m with a minimum pressure of 24 m.

A local elevated storage reservoir will be constructed.

Where possible pipes have been routed to follow service corridors and generate a ring feed. Pipes will be installed underground (where possible) with a minimum cover of 1.0 m to pipes. All pipes will be HDPE PE 100 PN 16 to SANS 4427.

Above ground pipe sections will be constructed using galvanised pipe.

6.7.3 Bulk Earthworks for Structure Platforms

Site clearance should be limited to the areas affected by the works. The organic rich topsoil at the site should be stripped and stockpiled for landscaping and re-vegetation purposes.

The fill required underneath all structures will be done with G7 material compacted to 95% of modified AASHTO density with the final 150 mm of fill to be G5 material compacted to 95% of modified AASHTO density.

The side slopes of all cut and fill embankments will be done at 1: 2 (*Vertical: Horizontal*).

6.7.4 Access Roads

The access road will be surfaced with precast concrete interlocking paving blocks with kerbs, edge beams or side drains as edge restraints. Stormwater drainage will be collected on the side of the road and discharged onto the surrounding natural ground. Where the access road crosses a stream or storm gulleys a portal culvert with in- and outlet structures will be constructed.

The internal roads will provide access for delivery and maintenance vehicles to new plant infrastructure. The geometric design of the road will take the turning movement of these vehicles into account.

Design Standards used in the design of the roads and parking area are:

- Guidelines for Human Settlement Planning and Design, CSIR, 2000
- UTG 10: Guidelines for the Geometric Design of Commercial and Industrial Local Streets
- UTG 2: Structural Design of Segmental Block Pavement for Southern Africa
- TRH 14: Guidelines for Road Construction Materials

6.7.5 Horizontal and Vertical Alignment

The following considerations were made for the geometric design:

- A design speed of 40 km/h within the WTP was used.
- A single road cross fall of 2% was designed for drainage purposes.
- Outlet chutes at the low side of the road for stormwater drainage.
- The use of the road verges by other services such as sewer, water and electrical services; and
- Safe access to site within acceptable grades.

6.7.6 Pavement Design Considerations

Traffic loading and subgrade conditions of the site are the major considerations for the structural pavement design. The design traffic loading considerations were based on the following assumptions shown in Table 6-1.

Table 6-1: Pavement Design Considerations

Road	Design traffic	Example
Access road	Normal E80 loads:	30 m³ chemical delivery truck: - Five axle artic (6x4 TT + tandem axle ST) - Gross 43,000 kg - Tare 16,250 kg - Payload up to 26,750 kg
		30 m³ chemical delivery truck: - Six axle artic (6x4 TT + trigem axle ST) - Gross 47,000 kg - Tare 17,250 kg - Payload up to 29,480 kg
		Most common delivery or service vehicle: - Thee axle rigid - Gross 24,000 kg - Tare 8,660 kg - Payload up to 15,340 kg
Internal loads	Normal E80 loads	See access road detail
High lift pump station	Normal E80 loads	See access road detail
	Heavy plant	20-25 ton mobile crane

Road	Design traffic	Example
Workshop	Normal E80 loads	See access road detail
	Heavy plant	20-25 ton mobile crane

6.7.7 Pavement Structure Selection

The following pavement structure for the access roads are proposed:

- 80 mm interlocking paving blocks (Type S-A, Class 35)
- 20 mm bedding sand
- 150 mm C4 stabilised subbase – G5/G6 material before stabilisation using 4.5% cement for costing purposes
- Roadbed preparation using impact compaction (100% of vibratory hammer compaction, 1m depth)

The pavement for heavy traffic should at least provide for 3 million 8-ton axles. For a similar loading the following concrete pavement solution can be considered inside the facility where a more durable surfacing is required:

- 200 mm plain jointed concrete (4.8MPa flexural strength, max slab length 4 m with sawcut/key joints, REF311 steel mesh in odd, shaped slabs)
- 150 mm C4 stabilised subbase as above
- Roadbed preparation using impact compaction as above

6.7.8 Sewerage

Domestic wastewater on the site will be directed to the wastewater treatment facility. Depending on the outcomes of the detailed design study a collection sump and pump station may be required. The diameter and slope of the discharge pipes from these buildings are designed to obtain the minimum self-cleansing velocity of 0,7 m/s. The discharge pipe will be a heavy-duty solid wall class 34 uPVC sewer pipe in accordance with SANS 791.

6.7.9 Stormwater Drainage

The final surfaces around new structures will be sloped to drain stormwater away from structures and buildings. The floor levels of buildings will be raised at least 170 to 300 mm above the final surfaced level. The paved internal roads will act as a stormwater carriage way sloping in a southerly and westerly direction, discharging stormwater onto the surrounding areas. Erosion control measures will be applied at these discharge points.

6.7.10 Fencing

A new perimeter security fencing around the water treatment plant will be constructed. The specifications for the fence will match the standard specification adopted for the overall project.

6.7.11 Telephone and Data

It is anticipated that communications on the WTP site will be facilitated by the cellular network and through wireless technology. Although no telephone line, data line or IT network connection will be installed now, allowance will be made in the offices area to accommodate this telecommunication infrastructure in future should the owner or operator require it to be installed. A 19” server or Wi-Fi router can typically be installed in a network server room in future.

The site will be serviced via local on-site data network.

Power skirting in the administration building will be of the double volume power skirting type to make allowance for reticulation of data and telephone cabling in future.

6.7.12 Building Electrical

Surface-mounted three phase socket outlets will be installed in the machine room area. All other single-phase socket outlets will be flush mounted as far as possible. Power skirting will be used in the office area where possible, to ensure flexibility for potential future changes.

Interior lighting will be ceiling mounted and automatically switched on and off with motion sensors. Exterior lighting will be controlled by means of a day/night switch.

Street and/or area lighting will also assist to increase security at the Works by lighting the entrances and perimeter. No high mast lighting will be used.

Low level and indirect lighting solutions will be used as far as possible to minimise light pollution at the WTP.

All light fittings will be specified to meet the industrial lighting requirements and be energy efficient. LED fittings are recommended to keep maintenance to a minimum.

6.8 Building Wet Services

6.8.1 Domestic Water Supply

Domestic water will be supplied from the site reticulation network to connection points at the following buildings:

- Office building, workshops, high-lift pump, etc. – serving occupant amenities.
- Guard House – serving occupant amenities.
- Chemical storage and chlorine dosing building – serving eye wash.

The building connections will be provided with isolation valves. Additionally, the administration and guard house buildings will be provided with water meter stations.

Water will be supplied from the building connections to the various user points.

6.8.2 Sanitary Drainage

Drainage from the administration building and guard house will be collected from the various sanitary fixtures and routed to a common connection point outside the building for onward drainage to the sewer reticulation system. All sanitary equipment will be fitted with appropriate equipment traps, integral traps for the water closets and urinal, bottle traps for the wash hand basins and rubber p-traps for the sink units.

Waste drainage from the wash hand basins and sinks will collect to an overflow gulley located outside the buildings. Soil drainage from the water closets and urinal will be collected to a stack with vent pipe extending to above the roof level. Gulley and stack discharge will be routed together to a common connection point to the site infrastructure.

6.8.3 Building fire services

Provision of water for fire-fighting purposes will comply with the requirements of the SANS code of practise 10090 – Community Protection against Fire.

Fire protection equipment will be provided to the various buildings according to the requirements of SANS 10400 Part T: Fire Protection.

All buildings will be provided with fire extinguishers.

The site will be provided with site fire hydrants located on site to cover all buildings within a reach of 45 m from a fire hydrant.

Water supply to the hydrants as well as to the hose reels located in the office building will be provided by the water reticulation system.

Minimum dynamic pressure required at each hydrant and hose reel is 30 m i.e., 3 Bar.

Fire signage will be provided to indicate the positions of all fire extinguishers and fire hose reels. Directional fire signage will also be provided to indicate evacuation routes from the office building.

7 Mechanical Works

Mechanical installations for the WTP will consist of specified equipment supplied, installed, and commissioned by specialist suppliers/sub-contractors in collaboration with electrical and instrumentation specialists. Mechanical equipment has been selected based on the specific process requirements.

7.1 Design Criteria

7.1.1 Reference Documents, Standards and Specifications

The following standards, specifications and guidelines which apply to the design of pump stations, pipework and valve installations will be used. It is noted that this list is not exhaustive:

- ANSI/HI 9.8-1998 Pump Intake Design.
- ANSI/HI 9.6.6-2009 Rotodynamic Pumps for Pump Piping.
- AWWA Manual M11 Steel Pipe – A Guide for Design and Installation.
- SANS 62-1:2013 Steel pipes – Part 1: Pipes suitable for threading and of nominal size not exceeding
  150 mm.
- SANS 719:2011 Electric welded low carbon steel pipes for aqueous fluids (large bore).
- SANS 1123:2011 Pipe flanges.
- SANS 664-1:2011 Wedge gate and resilient seal valves for waterworks Part 1: General.
- SANS 664-2:2011 Wedge gate and resilient seal valves for waterworks Part 2: Wedge gate valves.
- SANS 664-3:2011 Wedge gate and resilient seal valves for waterworks Part 3: Resilient seal valves.
- BS 5155:1984 Specification for butterfly valves.
- SANS 1849:2008 Butterfly valves for general purposes.
- BS 5153:1974 Specification for cast iron check valves for general purpose.
- SANS 1551:2008 Check valves (flanged and wafer types).
- SANS 676:2010 Reinforce concrete pressure pipes.
- SANS 677:2010 Concrete non-pressure pipes.
- SANS 4427:2008 Plastic piping systems – Polyethylene (PE) pipes and fittings for water supply.
- SANS 966 – 2013: Components of pressure pipe systems – Part 1: Unplasticized polyvinyl chloride (PVC-U) pressure pipe systems.
- DIN EN 1091:1997 Vacuum sewerage systems outside buildings.
- DWA-A 116-1:2006 Special sewerage systems – Part 1: Vacuum sewerage systems outside buildings.
- TT 481/11 Waterborne Sanitation Design Guide, Water Research Commission South Africa (WRC).
- TT 482/11 Waterborne Sanitation Operations and Maintenance Guide, Water Research Commission South Africa (WRC); and,
- Other relevant international standards deemed appropriate by the design engineers.

Other relevant Utilities Standards, specifications, and statutory requirements as well as relevant design manuals of various services and suppliers will be consulted.

7.1.2 Pipelines

7.1.2.1 Pipe Material

All mild steel pipes and fittings/specials will be fabricated with the following material grades.

- Pipes:
  - SANS 719 : Steel Grades C
  - SANS 1431 : Steel Grades 300 WA and 350 WA
  - API 5L : Steel Grades X42, X46, X52, X56 and X60
  - EN 10025-2 : Steel Grade S355JR + AR (where specified for specials)
- Specials /fittings:
  - 150 mm Ø and smaller to be manufactured with pipe conforming to SANS 62 (heavy duty) or ASTM Schedule 40 (seamless pipes) to suit specified pressures.
  - Larger than 150 mm Ø shall be manufactured from pipes complying with the specifications above.

7.1.2.2 Pipe Joint System

The jointing system that will be used for the distinct types of pipe material is shown in the table below.

Table 7-1: Pipe Jointing

Pipe Material	Jointing Preference	Comment
uPVC	Spigot and socket	
HDPE (Diameter > DN110)	Buttwelding	
HDPE (Diameter ≤ DN110)	Compression fittings	
Steel	Flanged	Applicable to pipe specials

Joining pipelines to dissimilar material i.e., steel to uPVC will be as indicated on the drawings but will conform to the connection details shown in the table below.

Table 7-2: Pipe connection details

Connection Type	Connection Detail
HDPE to steel	HDPE Stub flange to steel flange
uPVC to steel	Flange adaptor to steel flange

7.1.2.3 Flow Velocity in Pipelines

The minimum self-cleansing full-bore velocity for conventional sewer applications is 0.6 to 0.7 m/s.

For the design of the WTP raw water and potable pipelines 0.7 m/s was used as the minimum and 2.5 m/s as the maximum, with a preferred velocity of 1 – 1.5 m/s.

7.1.3 System Losses

7.1.3.1 Friction Losses

Friction losses in the pipeline will be calculated using the Darcy-Weisbach formula. Table 7-3 contains Darcy-Weisbach friction co-efficient values for different pipe materials based on pipe condition and age.

The secondary losses will be calculated based on the type of fitting and couplings.

Table 7-3: Darcy -Weisbach friction co-efficient values for different pipe materials

Lining type	Condition	Ks (mm)
Steel pipeline **Epoxy lining**	Smooth (new) Average (25 years old) Rough (50 years old)	0.03 0.06 0.15
Ductile Iron pipeline **Cement mortar lining**	Smooth (new) Average (25 years old) Rough (50 years old)	0.15 0.30 0.60
HDPE pipeline	Smooth (new) Average (25 years old) Rough (50 years old)	0.03 0.06 0.15
PVC	Smooth (new) Average (25 years old) Rough (50 years old)	0.06 0.09 0.15

7.1.3.2 Minor Losses

Minor losses through transitions, bends, valves, etc will be calculated in accordance with USBR and other publications. Table 7-4 contains minor head loss coefficients (k_L) that will be used in design.

Table 7-4: Minor head loss coefficient

Fitting Type	Coefficient k_L	Fitting Type	Coefficient k_L
Entrances		**Bends**	
Sharp edged	0.50	11.25º	0.03
Rounded	0.25	22.5º	0.05
Bell mouth	0.05	30º	0.07
Foot valve	2.50	45º	0.09
Strainer	2.50	60º	0.10
Re-entrant	0.80	90º	0.13
Exits		**Reducers**	
Sharp edged	1.00	Concentric/Eccentric	0.50
Bell Mouth	0.20	Flowmeter	0.00
Valves		**Tees**	
Gate valve	0.20	In-line	0.30
Check valve	2.00	Branch	0.75
Stopcock valve	10.00	**Junctions**	
Butterfly valve	0.30	30º	0.40
Globe valve	10.00	45º	0.60
Ball valve	0.05	90º	0.80

7.1.4 Pipe Supports

All above ground pipes require pipe supports. The following design parameters shall apply:

- All pipe supports shall be upward thrusting. The pipe shall lay on top of the support.

- No pipe shall be held in position by any clamping mechanism with the pipe above the clamping mechanism. The pipe will show no downward movement if the clamping mechanism is released.
- This will generally take the form of U-bolts or flat bars and angle or channel-iron brackets and supports bolted to the adjacent building steelwork during and after completion of pipe installation.
- Vertical piping shall be supported at each floor using half couplers/clamps each capable of carrying the full mass of the pipe via their frictional characteristics. These clamps must be used when removing gravitational forces from a joint.
- Pipe supports will be provided close to all heavy items such as valves of size DN300 and larger.
- Low carbon steel supports shall be fabricated from heavy duty hot rolled steel sections. The complete assembly shall be hot dip galvanised after all fabrication is completed. Welds shall be continuous “all round”; i.e. no crevices.
- Where appropriate, 3 mm thick neoprene strips shall be placed between pipes and supports or clamps to protect the paintwork and to limit corrosion.
- Where roller or sliding supports are used to accommodate movement, suitable wear blocks shall be fixed to the pipe to prevent damage.

7.1.5 Couplings

Flexible couplings e.g., Klamflex, Viking Johnson or equal approved will be manufactured from hot rolled asymmetric steel T sections with a profiled rolled steel sleeve and accommodated with an EPDM gasket.

7.1.6 Flanges

All flanges will comply with the requirements of SANS 1123 and drilled to Table 1000/3, 1000/4 or 1000/8 for steel plate flanges for welding, steel screwed boss flanges or steel plate blank flanges respectively. Table 1600/3, 1600/4 or 1600/8 will also be used where required. All flanges will be equal to higher than the maximum design pressure of the pipeline on which they are installed.

All flanges will be flat face with gaskets cut to fit the full face of the flange.

7.1.7 Bolts and Nuts

All bolts and nuts will be according to SABS 135 or SANS 1700.

7.1.8 Fittings/specials for PVC pipes

Where available, fittings/specials for PVC pipes will be cast iron or ductile iron with spigot and socket rubber ring joints. All fittings/specials will adhere to the relevant requirements of SANS.

7.1.9 Corrosion Protection

Steel pipes, fittings and fasteners will be hot dip galvanised to SANS 121 (Heavy duty). Where indicated in the design, pipework will be specified to be lined and coated. Coating will be applicable for the installation type, product water / chemical transferred and connection type.

7.1.10 Air Valve and Scour Valve Installations

Once the pipeline route has been finalised, air valve sizes and positions will be determined for the longitudinal pipeline sections. Either of the utility programmes developed by VENT-O-MAT or ARI will

be used for this purpose. The sizing and positioning of air valves will be based on the rate at which air will be introduced or expelled from the pipeline, taking account of the following:

- Filling conditions
- Dewatering conditions
- Pipe rupture
- Normal operating conditions
- Surge / water hammer conditions
- The differential pressure across air valves during air intake will be limited to 3.5 m

Scour installations will be provided at all low points along the pipeline profile, but not if they fall inside a stream. Scour installations, in combination with inline isolating valves, will be sized to allow any section of the pipeline to be drained within a maximum of 8 hours.

Scour installations will be designed to ensure that the maximum scour velocity in the pipeline is between 0.4-0.5 m/s and the maximum velocity through the scour outlet does not exceed 6 m/s.

7.1.11 Valves

Valves will be designed and/or selected to meet the following requirements:

7.1.11.1 Gate Valves

- Gate valves shall be constructed in accordance with SANS 664.
- All gate valves shall be the Resilient Seal Gate Valves (RSV), other than for scours and within pump stations where wedge gate types will be used.
- Gate valves will be non-rising spindle type in the chambers or underground and rising spindle type in pump stations provided with a handwheel or cap top as appropriate.
- Supporting feet will be fitted on all valves of sizes 300 mm and larger unless otherwise specified.

7.1.11.2 Air Valves

- Air valves will be of the vacuum break type, of compact single chamber design, in addition to incorporating an anti-shock feature when located within the pump stations.
- Valves shall be fitted with ¼” BSP test cocks where required.

7.1.11.3 Non-return Valves

- Non-return valves will conform with the requirements of BS 5153 or SANS 1551, shall be swing check type, and shall be flanged and drilled to SANS 1123 unless otherwise noted.
- The valves will be suitable for either horizontal or vertical mounting with the angle of the door ensuring that closure starts at the point where forward flow declines.
- Valves shall provide drip-tight closure.

7.1.11.4 Butterfly Valves

- Butterfly valves will conform to the requirements of BS 5155: 1984 and shall be cast iron solid body drilled off-centre for downstream dismantling.
- Butterfly valves will be clockwise closing when viewed from above.
- Operation shall be by means of a spring loaded, quarter-turn ratchet hand lever.

7.1.12 Pump Station Design Criteria (excl. High-Lift Pump Station)

The design criteria for the pump stations associated with the WTP, but excluding the high-lift pump station (refer to P WMA 06/D00/00/3423/9), have been compiled to meet the following requirements:

7.1.12.1 System Hydraulics

The pump station will be designed to have sufficient capacity for pumping instantaneous peaks.

Pump stations will be designed to operate under the full range of projected system hydraulic conditions. The System will be designed to prevent pumps from operating for extended periods beyond the pump manufacturers recommended normal operating ranges. Start / stop cycles will be in accordance with the motor manufacturers' recommendation.

7.1.12.2 Surge Analysis

Hydraulic surges and transients (water hammer) will be determined during the detailed design of pump stations and rising mains and the design of all relevant components shall take these pressures into consideration.

7.1.12.3 Pump Duty and Number of Pumps

Pump stations will be designed to accommodate peak flows as mentioned previously. Pumps and rising mains will be designed with 20% additional peak flow capacity.

All pump sets are fixed speed except when specified otherwise (e.g. where it is required to accommodate varying flow ranges).

7.1.12.4 Pump Intake

Pump intake will be sized for volumetric demand in accordance with American National Standard for Pump Intake Design ANSI/HI 9.8-1998.

Minimum submergence on the pump intake in the suction tank / reservoir will be designed in accordance with ANSI/HI 9.8-1998.

7.1.12.5 Pump Station Layout

The pump station layout will be designed to accommodate adequate space for routine operation and maintenance as well as a safe working environment.

Hoisting equipment will be provided in pump stations where equipment cannot be handled by hand, with sufficient vertical space to lift and move the equipment safely to the outside of the pump station building.

Where dry wells are located below ground level, a sump pump and dewatering pump will be installed.

7.1.12.6 Hoisting Equipment

The sub-structure and superstructure will be designed to ensure the installation and removal of equipment can be done with minimal effort. This may require provision for access hatches, lifting hooks, hoisting systems, roller shutter doors etc.

7.1.12.7 Ventilation

The pump station will be designed in such a way to ensure sufficient movement of fresh air by a suitable ventilation system preventing damage to mechanical and electrical equipment due to overheating. All sumps will also be well ventilated to prevent build-up of dangerous gasses.

7.1.12.8 Valves

Provision will be made for suitable isolation, non-return, air, scour and control valves as required by the design.

The type of non-return valves will be selected based on surges and transients and suitable for use with the liquid conveyed.

Isolation and non-return valves will be installed above the natural ground level or in a separate dry chamber next to a wet sump.

7.1.12.9 Pipework

All pipework within the pump station will be flanged or welded.

The class of pipes and associated flanges will suit the design pressure (including surge and transient) with a minimum design pressure of 10 bar.

The bellmouth suction from a wet well or sump will be sized to have a velocity less than 1.0 m/s.

Suction inlets will be designed to prevent formation of vortexes.

The velocity in suction pipes will not exceed 1.5 m/s.

The velocity in delivery pipes will not exceed 2.5 m/s.

Restrained flexible couplings will be provided between the isolating valve and the pump on the suction pipe and between the pump and the non-return valve on the delivery pipe.

Suction and delivery pipework will be supported at 1.5 m intervals (maximum) and all changes in direction.

A pressure gauge will be installed on the suction and discharge side of each pump installed in a dry well. The range of discharge gauges will be adequate to measure the shutoff head on the pump.

7.1.12.10 Sump Level Control

The level control mechanism will be an ultrasonic level controller, together with a backup float mechanism. The ultrasonic sensing devices will be in the sump of the pump station where it will not be affected by flows entering the sump or by the suction of the pumps.

7.1.12.11 Flow Meters

Clamp-on ultrasonic flow meters or full-bore electromagnetic flow (EMF) meters will be installed on delivery manifolds of pump stations.

Flow meter installations will make provision for straight pipe sections upstream and downstream of the meter to ensure the required meter accuracy. The length of these straight pipe sections will be in accordance with the meter manufacturer’s specifications/guidelines.

7.2 Mechanical Equipment List

Mechanical equipment lists for the WTP is provided in **Appendix F**. The equipment selections, power ratings and capacities are preliminary, and will be finalized during detailed design. A summary of the estimated power consumptions required for Phase 1 (208 Mℓ/d) and Phase 1 and 2 (312 Mℓ/d) is shown in Table 7-5.

Table 7-5: Summary of the estimated energy consumption required at the Xhariep WTP for Phase 1 and 2

			Phase 1		Phase 2		Phase 1 & 2	
		Unit	Absorbed power	Rated power	Absorbed power	Rated power	Absorbed power	Rated power
1	**Inlet works**	kW	24	32	0	0	24	32
2	**Flocculation and coagulation**	kW	72	92	36	46	108	138
3	**Rapid gravity sand filters**	kW	183	256	183	256	365	512
4	**Clear water storage**	kW	2	2	1	2	2	3
5	**Chemical dosing**	kW	101	133	47	71	148	204
6	**Residual handling**	kW	89	120	79	110	167	230
7	**Service water**	kW	3	5	3	4	6	9
8	**Service buildings**	kW	25	25	0	0	25	25
	PLANT TOTAL	**kW**	**501**	**664**	**351**	**489**	**852**	**1152**

8 Electrical Works

The preliminary electrical design is covered in the following sections, while aspects related to control and instrumentation are covered in the Electronic, Control and Instrumentation section. The design life of electrical equipment is typically 15 to 20 years.

8.1 Scope of Work

- Electricity Supply (from High Lift Pump Station)
- Diesel Powered Generator Set
- LV Switchgear and Control-gear Assemblies
- LV Chemical dosing control panels
- Small power and lighting distribution boards
- Area lighting outdoor kiosks
- Field Control Stations
- LV Cables
- Cable Support Systems
- Wiring and Outlets
- Lighting
- Street and Area Lighting
- Earthing
- Lightning Protection
- LV Electric Motors
- LV Electric Valve Actuators
- Testing (FAT, SAT) and commissioning of the electrical installation
- Certificates of compliance
- As-built drawings
- Operation and maintenance manuals
- Training
- Spares

8.2 Design Approach

The design approach for the electrical works is to achieve the following:

- Design a simple and practical low voltage (LV) installation allowing for easy and convenient operation and maintenance.
- Design a LV electrical system that can supply power to and control the electrical equipment of the WTP.
- Design a LV system that complies with the relevant specifications and standards for LV installations.
- Allow spare capacity to accommodate future extension and or modifications of the WTP.
- Safe design to ensure equipment and persons are adequately protected from possible faults and electrical hazards.

8.3 Design Basis

The electrical system will be designed within the following constraints:

8.3.1 Standards and Specifications

The WTP electrical system will be designed to comply with the following specifications:

- The applicable SANS Standards for electrical installations
- The Occupational Health and Safety Act 1993.
- DWS Standard Specifications for electrical installations, where available.
- Project-Specific Engineering Standards for electrical installations, where required to augment DWS standards.

8.3.2 Voltage Drop

The maximum allowable voltage drops for the design will be as follows:

- 5% from transformer LV terminals to equipment terminals for steady state operation.
- 15% from transformer LV terminals to motor terminals for direct-on-line motor starting.

8.3.3 Harmonics

The maximum allowable total voltage harmonic distortions for the design are:

- 8% at the LV MCC busbars.

8.3.4 Equipment Specifications

- Equipment and materials which will be installed on the plant must be able to operate in the environment.
- Equipment must be IP rated to levels suitable to the area of installation. Electrical equipment installed outside will have a minimum IP rating of 65.

8.3.5 Health and Safety

In general, the electrical installation will be designed in accordance with SANS 10142-1 (LV) and General Machinery Regulations to ensure that people and property are protected from hazards that can arise from the operation of the electrical installation under both normal and faulty conditions. The following health and safety measures will be taken:

- All electrical equipment will be equipped with overload protection.
- All submerged electrical equipment will be equipped with earth leakage protection.
- All protection devices and electrical equipment will be sized to meet the anticipated fault levels on the system.
- All electrical equipment, electrically driven equipment and accessible extraneous conductive surfaces will be bonded to earth.
- All electrically driven equipment will be provided with an E-stop or field switch disconnector within arm’s length of the equipment.

8.4 Design Criteria

8.4.1 Electrical Supply

The supply authority in the area is Eskom.

The bulk electrical supply to the site will be handled as a consideration under the scheme Feasibility Design Report (P WMA 06/D00/00/3423/9).

An electrical receiving and switch yard has been provided on the treatment site next to the high lift pump station as indicated on drawing 1002533-2500-DRG-CC-2502.

The WTP will be supplied from the site's medium voltage (MV) network by means of 11/0.4 kV step-down transformers. For redundancy, two transformers will be provided, each sized to handle the full Phase 1 load.

When Phase 2 is constructed in future, another set of step-down transformers need to be installed.

The anticipated load for Phase 1 is 630 kVA, while Phase 2 will add another 450 kVA.

8.4.2 Backup Power

Backup power will be provided to the WTP by means of a diesel-powered generator set, which will be an indoor set sized for providing all essential loads. Essential loads will include small power, lighting, building security systems, plant control systems, instrumentation, electrically actuated valves and sluice gates, solenoid valves, disinfection systems, service water and sump pumps. The plant can be safely shut down during a power outage, but water cannot be treated. The anticipated generator size for essential loads of Phase 1 is about 200kVA.

The diesel generator set will be equipped with a fuel tank sized with the capacity to supply 24-hours of continual operation of essential equipment. In the case of a power failure there will be an automatic changeover to generator power.

8.4.3 LV Switchgear and Control Gear Assemblies

A main motor control centre (MCC) will be provided to supply the WTP. The panel will be near the equipment using the majority of the power (backwash pumps and blowers) to reduce voltage drops in the cables.

This panel will enable two transformer feeds and a backup power supply with automatic changeover.

The motor control centres will be built to the specifications shown in Table 8-1.

Table 8-1: Motor Control Centre Specifications

Description	Specification
Colour	B26 (Electric Orange)
Material of Manufacture	2 mm Mild Steel / AluZinc
Epoxy Powder Coating	Yes
Ingress (Closed doors)	IP 44
Method of Installation	Floor standing
Access	Front and rear
Cable entry	Bottom
Form of internal separation	3b / 4a

Smaller local MCCs or chemical dosing control panels will be built to the specifications shown in Table 8-2.

Table 8-2: Smaller Motor Control Centre Panel Specifications

Description	Specification
Colour	B26 (Electric Orange)
Material of Manufacture	2 mm Mild Steel / AluZinc
Epoxy Powder Coating	Yes

Description	Specification
Ingress (Closed doors)	IP 44 (IP54 if located in dusty environments like powder based chemical dosing)
Method of Installation	Mounted on stand or wall mounted depending on location
Access	Front
Cable entry	Bottom
Form of internal separation	1

The power and lighting distribution boards will be built to the specifications shown in Table 8-3.

Table 8-3: Power and Lighting Distribution Board Specifications

Description	Specification
Colour	B26 (Electric Orange), White in the administration building
Material of Manufacture	1.6 mm Mild Steel
Epoxy Powder Coating	Yes
Ingress (Closed doors)	IP 44
Method of Installation	Flush
Access	Front
Cable entry	Top and Bottom
Form of internal separation	1

The street and area lighting kiosks will be built to the specifications shown in Table 8-4.

Table 8-4: Street and Lighting Kiosks Specifications

Description	Specification
Colour	Green
Material of Manufacture	2 mm GRP
Epoxy Powder Coating	Yes
Ingress (Closed doors)	IP 65
Method of Installation	Plinth mounted
Access	Front
Cable entry	Bottom
Form of internal separation	1

8.4.4 Field Control Stations

Field E-stop/start stations will be installed within arm's reach of equipment where possible. The field E-stops will be equipped with a start push button and emergency stop push button.

Equipment with a local control panel e.g., the dosing station will not be equipped with dedicated field control stations. The control panels will be equipped with emergency stop and start push buttons.

8.4.5 LV Cables

LV multicore cables will be copper conductor, PVC insulated cables with steel wire armouring. All cables will be labelled.

Electrical cables will be sized for current carrying capacity, maximum allowable volt drop, installation method and derating factors in accordance with SANS 10142.

The cable sizes will be restricted within the range of 4C x 2.5 mm² to 4C x 185 mm² to allow for the most practical installation.

Single core, aluminium wire armoured, cable will be used where the use of 4C x 185 mm² cable is not practicable to achieve the required current handling capabilities.

8.4.6 Cable Support Systems

Hot dipped galvanized steel cable ladders and trays (mesh) will be provided to support cables.

Conduits that are installed in concrete or brickwork will be PVC.

Surface conduits (if required) will be hot dipped galvanized steel with PVC end caps.

Cables installed in cable trenches will be secured to cable ladders.

8.4.7 Wiring and Outlets

The administration building will be equipped for power skirting for future flexibility and a combination of standard (white) and dedicated (red) socket outlets.

Industrial buildings will be equipped with single phase and 3 phase power outlets as required. Each will be connected to the supply distribution board (DB) using house wire sized to meet the current and voltage drop requirements.

8.4.8 Lighting

Light emitting diode (LED) lighting suited for industrial areas will be provided in all buildings. Motion sensors will be used to ensure lights are not kept on unnecessarily.

8.4.9 Area Lighting

Pole mounted LED streetlights will be provided throughout the site. Where practicable, area lighting will be mounted on building exteriors.

8.4.10 Earthing

Earthing and bonding will be provided as a protection measure for persons and equipment from fault or surge currents. Earthing and bonding will be provided as follows:

- A copper earth electrode will be installed in the building foundations and at step-down transformers to dissipate fault currents into the ground.
- All accessible extraneous conductive parts of electrical equipment/electrically driven equipment will be bonded to earth.

8.4.11 Lightning Protection

High risk buildings will be equipped with lightning protection system for the safety of equipment and persons.

8.4.12 LV Electric Motors

Motors rated above 40 kW (blower and backwash pumps) will have a positive temperature coefficient (PTC) embedded in the stator winding (just one phase). This will be hardwired to the MCC starter for protection.

The motors will be started via variable frequency converters (VFCs), soft starters or direct online as required by the process design and motor starting requirements. The VFCs and soft starters shall be equipped with a fieldbus or Ethernet interface for connection to the automation system.

8.4.13 LV Electric Valve Actuators

All site valves requiring automatic operation will be motorized.

8.4.14 Installation, Testing and Training

All Factory Acceptance Tests (FATs) will be attended by the client and engineer.

Comprehensive training and operation manuals will be provided for the required staff.

9 Electronic Control and Instrumentation

The preliminary design for the electronic control and instrumentation is discussed in this section. The design life of electronic equipment is typically 10 to 15 years.

9.1 Scope of Work

- Programmable Logic Controller (PLC)
- SCADA
- Field instrumentation
- Testing (FAT, SAT) and commissioning of the electrical installation
- As-built drawings
- Operation and maintenance manuals
- Training
- Required spares

9.2 Design Overview

Figure 9-1 shows a high-level electronic system layout of the WTP with the basis of the design discussed in this section.

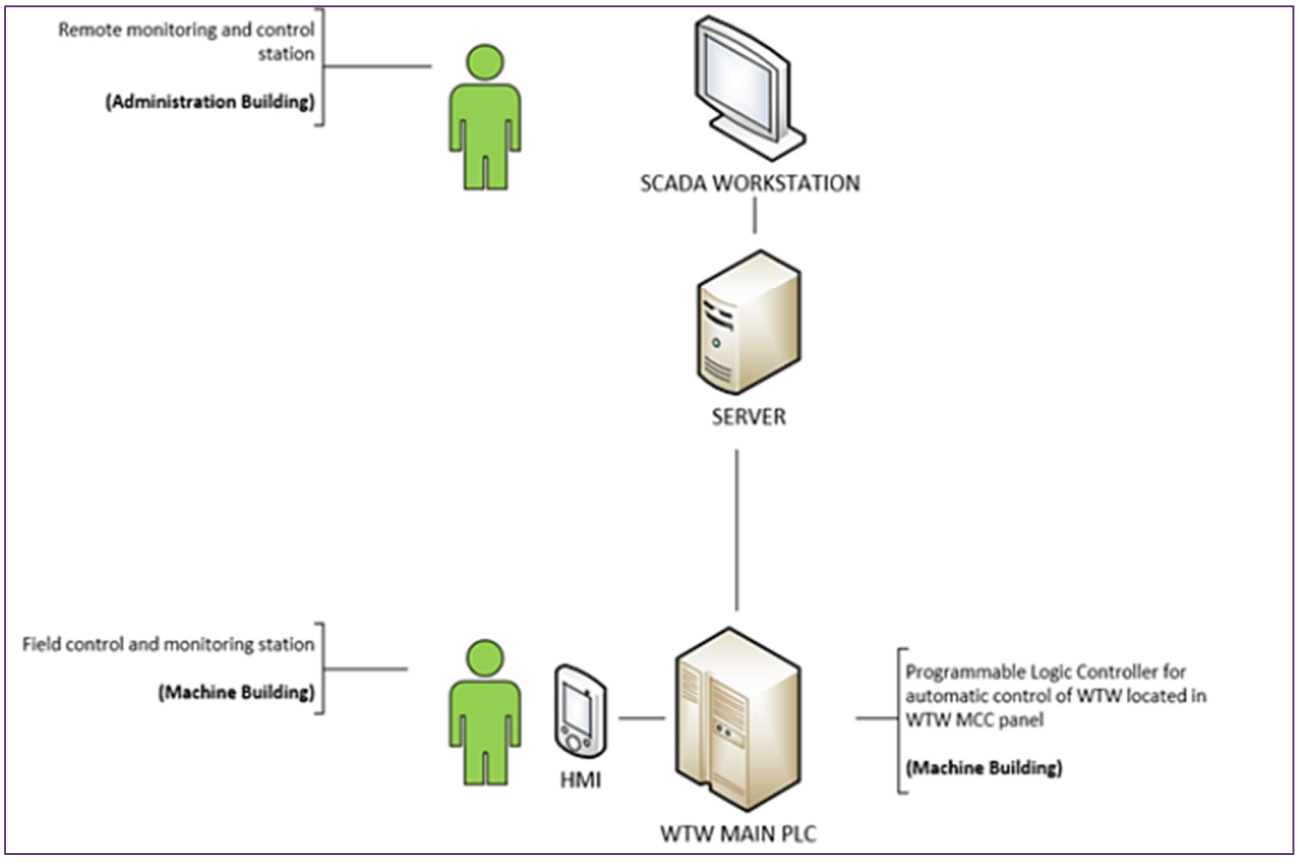


Figure 9-1: Typical WTP Electronic Control System Overview

9.3 Design Approach

The design approach for the electronic works is to achieve the following:

- Design a central control system for the WTP allowing for easy and convenient operation.
- The installation can be controlled and monitored remotely from the administration building SCADA, the Xhariep scheme remote command center or in the field at the Human Machine Interfaces (HMI) at various possible locations, like filters and dosing systems.
- Allow spare capacity to accommodate future extension and or modifications of the WTP.

9.4 Design basis

The electronic system will be designed within the following constraints:

9.4.1 Standards and Specifications

The WTP electronic control system will be designed to be compliant with the following specifications:

- The Occupational Health and Safety Act 1993.
- DWS Standard Specificationss for electrical installations, where available.
- Project-Specific Engineering Standards for electrical installations, where required to augment DWS standards.
- ISO Standards on equipment manufacture and instrument calibrations
- ISA Standards on nomenclature

9.4.2 System Voltages

System voltages will be designed as follows:

- 230 VAC (voltage alternating current) for MCC contactor coils and MCC controls.
- 24 VDC (voltage direct current) for PLC.
- 230 VAC UPS supply.
- 230 VAC/24 VDC for uninterrupted power supply (UPS) to instrumentation power as required.
- 24 VDC for solenoid blocks.
- 24 VDC for digital inputs and outputs.
- 4 – 20mA current for analogue instruments.

9.4.3 Communication

Serial data communication will be used where applicable to minimize the number of cables required for the installation. There will be no use of wireless connections for the installation. All connections will be hardwired.

Connections of equipment to the PLC will be as follows:

- PLC to Soft Starters: Ethernet
- PLC to VFC: Ethernet
- PLC to HMI: Ethernet or Fieldbus
- PLC to Remote IO: Ethernet or Modbus
- PLC to Generator controller: Ethernet or Modbus
- PLC to SCADA: Ethernet
- Fieldbus communication to analogue field instruments will not be required.

9.4.4 Equipment Specifications

- Equipment and materials which will be installed on the plant must be able to operate in the environment.

- Equipment must be IP rated to levels suitable to the area of installation. Electrical and electronic equipment installed outside will have a minimum IP rating of 65.
- Due to procurement being done in the public sector realm, specific OEMs for control equipment will be selected by the Contractor during tender.

9.4.5 Health and Safety

In general, the electronic installation will be designed in accordance with the IET Electrical wiring regulations (LV) and to ensure that people and property are protected from hazards that can arise from the operation of an electronic installation under both normal and fault conditions. The following health and safety measures are highlighted:

- Electronic designs will be subjected to a risk assessment.
- All electronic equipment will be earthed.
- All electronic equipment installed outside will be surge protected.
- The control system will have password protected access at various levels ensuring that changes made to the system are by authorized personnel only.

9.5 Design Criteria

9.5.1 Functional Design Specification

The Contractor will provide a detailed control system functional design specification (FDS). This document will detail the control architecture, control philosophy, HMI and SCADA mimics, equipment etc. that will make up the automation system.

9.5.2 Programmable Logic Controllers

A central Programmable Logic Controller (PLC) will be installed in the WTP MCC located at the filter plant's equipment room. This PLC will be programmed for the automatic control of all equipment on the site supplied from separate MCCs. Remote input/output (IO) will be located around the plant and communicate back to the PLC's CPU through a fibre optic cable ring network.

The installation can be switched into manual mode in which case the operator takes control of the system or specific equipment. In manual mode the PLC will continue to monitor the installation in the background. Safety measures will be hardwired in the MCCs to ensure that equipment is not operated outside of the safe margins.

9.5.3 Human Machine Interface

A human machine interface (HMI) touch screen will be installed at each filter and each dosing system station. The primary function of the HMI will be localized plant monitoring and control and allowing the authorized operators to change parameters.

9.5.4 SCADA

A SCADA station for monitoring and controlling of the WTP will be installed in the Administration building. The SCADA will come complete with a rack mounted server (in a server room), historian server, UPS, a printer, one desktop computer, two 50" wall mounted screens, two 23" monitors, a mouse and keyboard. The SCADA will provide the following functionalities:

- Report generation. The SCADA will be equipped with a reporting feature and will provide the following functionalities in the form a screen display, downloadable file, as well as printable hard copies:
  - Daily reports
  - Monthly reports
  - Yearly reports
  - Alarm and disturbance reports
  - Maintenance reports
  - On demand query reports
- Process visualizations. The process visualization feature will provide the following functionality:
  - Dynamic process symbols (i.e., images and mimics). The mimics will be based on the works and the piping and instrumentation diagrams (P&IDs).
  - Display of trend curves from historic data.
  - Display of trend curves on real time basis.
  - Display of operator alerts, messages, alarms, and events.
- Trending (historic and on-line). This function will allow live and historic trends of analogue or calculated values. Each stored value will be the instantaneous or average values of a number of samples, depending on the desired resolution.
- Operator command interface. Process commands, set points and parameter changes will be allowed via SCADA faceplates and will include:
  - Control system set points.
  - Switching drives on/off, opening and closing of actuated valves etc.
  - Acknowledgement of error and alarm messages.
- Operator access security. The system will have multi-level password protection whereby different levels of operators will be granted different operational authorizations

9.5.5 Cables

The following cables will be used:

- Control cables: 600/1000V multicore 1.5 mm² standard copper conductors or PVC-insulated cables with galvanized steel wire armoring and PVC serving.
- Instrumentation cables: either twisted pair, 1.5 mm² or triad 1.5 mm² standard copper conductors, individually and overall screened, PVC-insulated with galvanized steel wire armoring and PVC serving. Multi-pair cables will be used to group the instrument signals of the field instrumentation in an area and relay them to the PLC via an instrumentation junction box.
- Fibre Optic Cable: Multimode 62.5/125 µm.

9.5.6 Earthing and Bonding

All electronic equipment will be connected to a comprehensive earthing system consisting of separate instrument earths and protective earths.

All cable trays carrying cables for electronic equipment will be bonded to earth.

10 Operation, Maintenance and Asset Management

10.1 Operational Procedures and Operator Duties

This section of the report reviews operational procedures and duties that need to be considered and incorporated into the detail design. These can be considered as part of a Hazard and Operability (HAZOP) study and possibly a Hazard Analysis and Critical Control Point (HACCP) study.

10.1.1 Visual Observation

Although control parameters do provide sufficient information for the satisfactory operation of a potable water treatment works, visual observation of each unit process, as well as general plant appearance, are equally important.

The process controller must be on the alert for changes in the physical appearance of a process and be able to relate these changes to its performance. Much may be learned from simple, but perceptive sensory observation of process features.

By combining careful observation with experience, the process controller can determine what is happening in the plant and make any adjustments that may be necessary. After consulting with the Senior process controller, observation can also direct the process controller towards undertaking more specific control tests that will indicate process demands and determine the type and extent of the control adjustments needed.

Keeping a record of visual observations under good as well as poor operating conditions is just as important as analytical recording and can be an effective control aid to ensure a high-quality product.

There are more visual aids that a process controller can use to help control the plant than is generally realised.

All personnel should be made to understand that a clean and well operated plant is a happy plant and a happy environment to work in.

10.1.2 Monitoring Instrumentation

Monitoring instrumentation is mainly used to detect and prevent process failure and, ultimately, to protect personnel and equipment.

It is also needed to obtain data to serve as a record of plant performance. In addition, using monitoring instrumentation, operating personnel, maintenance, and plant down-time may be minimized.

10.1.3 Sampling Points

Sampling points throughout the works should be clearly marked. Sampling and control frequency must be such that a key parameter can be prevented from going out of control. A sampling, readout and analysis programme should be compiled daily.

In considering a control strategy, a distinction should be made between control strategies for individual processes and an overall strategy for the plant. The strategy should be aimed at obtaining a reliable, fail-safe potable treatment system.

A product assurance programme must be developed to aid the process controller in keeping the control parameters strictly within their limits. The sampling and monitoring strategy should align with the requirements of SANS 241:2015.

10.1.4 Records

It is very important to assess the running and maintenance costs of the various processes at the works and records should be kept so that:

- Figures may be extracted to analyse running costs.
- The works may be run at optimum efficiency.
- They may be used as a guide in solving current problems.

The information taken daily should be recorded on working forms which in turn can then be recorded on weekly or monthly summary forms. The laboratory technician should also use special forms for recording laboratory tests to check quantities of chemicals, etc.

There are seven types of records that must be kept:

- Hourly Records
- Shift Records
- Daily Records
- Weekly Reports
- Monthly Reports
- Monthly Records
- SCADA records (when installed)

The hourly record's primary purpose is to control the plant, optimise operations and check water quality. Shift records are kept enabling the operator to control operations during his/her shift. Daily records are kept enabling the monitoring of costs and consumption.

Some records are kept on an ad hoc basis to control personnel and visitors as well as maintenance records.

10.2 Human Resources Required

The required number and classification of plant and personnel at a specific treatment plant is based on the classification of the treatment plant, as outlined in the latest Regulation 3630, in terms of section 26 read in conjunction with section 12A of the Water Act (Act 54 of 1956).

For this report, a preliminary plant classification is completed and can be found in Table 10-1. Based on the plant classification, the minimum legal requirement for staffing is provided. It is noted that this is not a matter of discretion. The nature of the treatment works, raw water quality and condition of the plant will determine the functional staffing requirement, which is generally higher than the minimum legal requirement.

Table 10-1: Preliminary plant classification (Regulation 3630)

Technology	Unit Process	Control Elements	Maximum
Population supplied		>250 000	4
Infrastructure	Design Capacity in kilolitres per day (kl/d)	> 25 000	10
	Versus peak day	Design = peak day use	1
	Final water storage capacity	<36 hours during peak	2
	Installed power (kilowatts of installed power to operate)	>1000 kW	10
Operating Procedures	Raw water flow rate	controlled variation with automatic adjustments	2
	Raw water quality	Seasonal adjustments needed in procedures	1
	Chemical dosing	+1 flocculation chemical with pH control	8

Operating Process	Desludging	Automatic fixed schedule of desludging	3
	Filter Backwash	Optimised filter backwash	5
	Settling Process	Controlled process (sludge blanket)	5
	Stabilisation	pH correction with automatic dosing	1
	Filtration	Rapid Filters	5
	Disinfection	Dosing with chlorine gas, ultraviolet or ozone	3
Control Processes	Recirculation/Backwash recovery	With separate settling tanks	3
	Sludge handling	Sludge lagoons	3
	Water Losses	Distribution	4
	Water Management	Different reservoirs	2
	Pumping	Raw, Final and other pumping	6
	Level	SCADA	5
	Maintenance	Specialised maintenance by process controller	2
	Lab services Analytical services	Reading with instrumentation by process	2
	Lab services Analytical services	Full lab service on site but not done by process controller, although still a management function	3
	Lab services Analytical services	Chemical analysis done by process controller	4
	Lab services Analytical services	Jar tests to maintain optimum dosing by process controller (more than 2x daily)	5
	Administration	Process control systems in place (SCADA/HMI/Similar)	5
Regulation 3630 plant scoring			**104**
Regulation 3630 plant classification			**Class A**

The required registration compliance in terms of Regulation 3630 and actual operational resources employed at the works are shown in Table 10-2. Note that the operations and maintenance support services will be subject to the plant equipment installed and condition of the plant in future. The personnel can form part of current operations and maintenance structures, serving multiple treatment and distribution infrastructures. It is however recommended that, with the remoteness of the treatment plant from major population centres, that operations and maintenance staff be dedicated to the treatment works.

Table 10-2: Required Operational Resources for Treatment Facilities

Works Class	Class of Process Controller per Shift	Class of Process Controller for Supervision	Operations and Maintenance Support Services Requirements
E	Class I	Class V [1]	These personnel must be always available. May be in house or outsourced. 1 Electrician, 2 civil, 3 Mechanical, and 4 Instrumentation Technician
D	Class II	Class V [1]	
C	Class III	Class V [1]	
B	Class IV	Class V	
A	Class IV	Class V	
Note:			

1. Does not have to be at the works full time

According to Section 9 of the Basic Conditions of Employment Act, No. 75 of 1997, workers may work a maximum of 8 ordinary hours per day, for 5 or more days a week, working a maximum of 45 hours a week.

If the employee agrees in writing, it is also possible for an employee to work a compressed working week of 12 hours a day, as stipulated in Section 11 of the Basic Conditions of Employment Act (RSA, 1997). These employees may not work more than 5 days a week. Table 10-3 summarises two options for shift operation of the works operating at design capacity. The plant can be run at design capacity for shorter periods to achieve lower overall throughput over reduced time periods.

Table 10-3: Shift Work Considerations per WTP

Option	Shift (Hours)	Shifts/ Week	People/ shift	Shifts/ person/ week	Teams Rotating/ week	Potential Hours/ week	Max. Paid Overtime/ Person/ week
1	8	21	6	5	5	40	10
2	12	14	6	4	4	48	10

10.3 Human Resource Requirements

The estimated staff to be employed at the Xhariep WTP is documented in Table 10-4. The staff will include process controllers and staff responsible for the maintenance of the overall plant.

Phase 2, scheduled for implementation 10 years after Phase 1, is expected to require additional staff including 4 process controllers, 4 general labourers and 2 cleaners.

Table 10-4: Estimated staff employed at the Xhariep WTP

Description	Estimated Staff Employed		
	Ultimate plant capacity 312 Mℓ/d	Phase 1 208 Mℓ/d	Phase 2 +104 Mℓ/d
Process controllers (8-hour shifts)	12	8	4
Shift supervisors	4	4	-
Superintendent	1	1	-
General labourers	16	12	4
Mechanical foreman	2	2	-
Electrical foreman	2	2	-
Mechanical & Electrical technician	8	8	-
Receptionist	1	1	-
Cleaners	8	6	2
TOTAL	**54**	**44**	**10**

10.4 Water Safety Planning (WSP)

According to the World Health Organisation (WHO), the most effective means of consistently ensuring the safety of a water supply is through using a **comprehensive risk assessment** and **risk management approach** that encompasses all steps in the supply.

It is important that this plan remains a **living document** which will continually develop over time as the needs and circumstances of the water system changes. It is further important that the document is used

for planning, operations and budgeting purposes. Only then will the plan truly fulfil its function, which is to safeguard drinking water at each step along the process.

The procedure for compiling a WSP is based on the WHO Water Safety Plan Manual, as stipulated in the Blue Drop Requirements for Water Safety Planning. The methodology will closely follow the WHO guidelines as described above as well as follow the processes depicted in Figure 10-1.

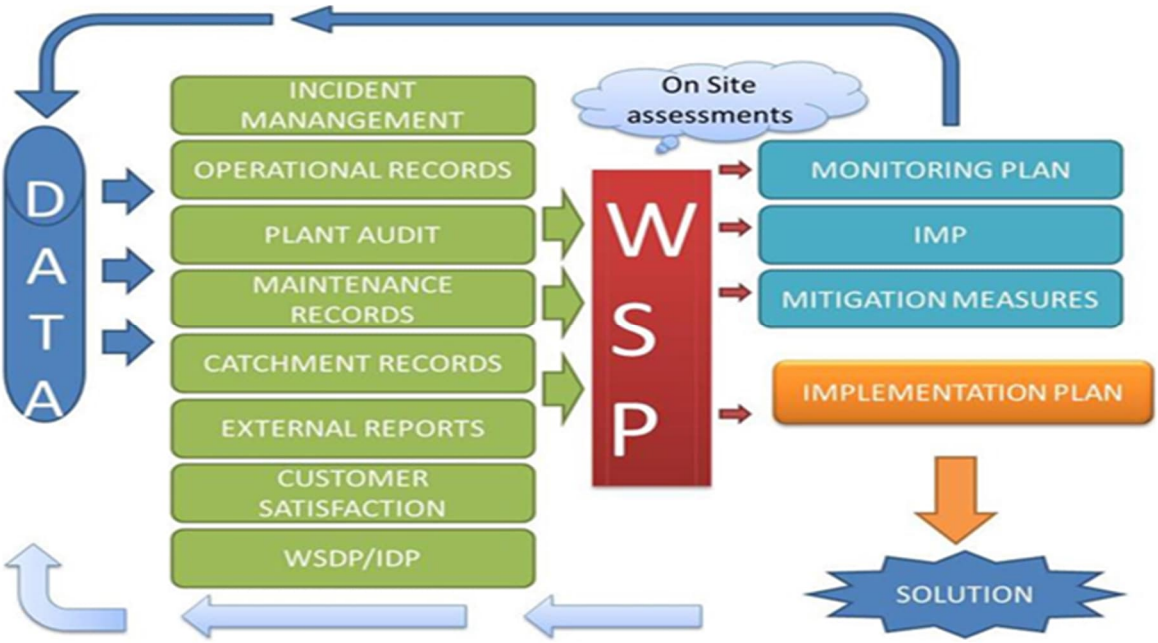


Figure 10-1: The Water Safety Planning Process (Ceronio, Krouwkamp, Borland, Coetzee, & van der Merwe-Botha, 2018)

10.5 Proposed Operational Strategy

For sustainable operation of any potable system, a variety of operational and control aspects must be managed to ensure smooth running of the works, adequate monitoring of processes and activities, maintenance of plant, and control using appropriate measures to ensure a compliant product is sustainably delivered.

To achieve effective management of operations, the Client should be able to achieve the following but not limited to the benefits listed below (Van Vuuren & van Dijk, 2011):

- Should be able to ensure that their facilities and equipment are available as intended.
- Will have high reliability of equipment and facilities per the intended design.
- Will be able to maintain the value of infrastructure and equipment.
- Full use of the system over the intended design life and possible extended service life.
- Will be able to collect accurate Information to plan proper operation and maintenance tasks for budget purposes.
- Would be able to achieve reduced capital and operational costs as planned maintenance and repairs are much more cost effective than reactive maintenance.

A successful operation and maintenance programme can have certain limitations due to cost, availability of trained maintenance staff and staff motivation to expand the programme. However, the benefits by far out way the limitations, therefore the Client should undertake to implement their preventative/planned maintenance as the first step to preventing major system problems, disruption of supply and improving the sustainability of their system and service delivery to consumers.

The necessity for consistent fail-safe removal of the substances not required in the final water makes it imperative to have step by step operation and control procedures to enable the operating and

maintenance personnel to maintain stringent plant control. This can be achieved by setting performance objectives for all aspects of the treatment system. This should be defined with a maximum number of safety barriers built into the system to prevent short-term failure of any process or of the system.

The necessary procedures and programs should be in place to enable the Client to achieve the optimum operational performance of the water treatment infrastructure. The following should be considered when compiling the operational strategy:

- Guideline policies
- Quality management and monitoring
- Performance monitoring
- Chemical control
- Energy management program
- Asset management system

11 Financial Considerations

11.1 Introduction

This section provides an indication of the capital and operational costs for the 312 Mℓ/day (Complete Phase), 208 Mℓ/day (Phase 1) and additional 104 Mℓ/day (Phase 2) WTPs. The general philosophy to determine the capital cost estimate was to use tendered rates from previous projects with similar scope to price the respective infrastructure components.

The following Xhariep WTP items are priced separately:

- Civil works,
- Mechanical equipment,
- Electrical equipment,
- Electronic Control and Instrumentation and Supervisory Control and Data Acquisition (SCADA) system

The proposed Xhariep WTP was assessed for the following specific financial criteria:

- Capital expenditure, and,
- Operation and maintenance costs.

11.2 Preliminary Capital Expenditure Estimate

The capital expenditure (CAPEX) estimate was prepared based on historical data collected from plants of a similar nature and technology level and is summarised in Table 11-1.

The assumptions used for the capital costing were as follows:

- Unit costs (civil, process and mechanical, electrical, and electronic) for process units were adopted from projects of a similar nature in terms of process technology, process size and hydraulic capacity.
- Capital cost estimates for civil works, process and mechanical equipment, electrical and electronic equiment based on dated quotes were escalated at 8% per annum (p.a.) to allow for market related inflation.
- Civil works preliminary and general expenses were based on 25%, while the mechanical, electrical and electronic work preliminary and general expenses were based on 30%.
- Foreign exchange adjustment was calculated for all options for specific mechanical and electrical components that may be imported. Exchange rates at the time of tender and at the time of order were considered and the resultant foreign exchange adjustment was determined.
- Allowance for foreign exchange variation of 5% per annum (p.a.) were assumed for the construction period.
- Contract Price adjustment of 7% per annum (p.a.) were assumed for the construction period.
- Contingencies of 15% were assumed to account for unforeseen items.
- Professional Fees were calculated based on ECSA 2021 Fee Scales gazetted on 26 March 2021 for each scenario based on the CAPEX and engineering discipline.
- Site Supervision was not included as part of the CAPEX
- Cost estimates can be assumed to be at an accuracy of 25 – 30% as part of detailed feasibility studies, which should improve to 10 – 15% at the end of the detailed design phase.

Table 11-1: Estimated Capital Expenditure for the Xhariep WTP

Description	Estimated CAPEX		
	Complete Phase 312 Mℓ/d [1]	Phase 1 208 Mℓ/d [2]	Phase 2 +104 Mℓ/d [3]
Preliminary and General	**R 619 300 000**	**R 463 060 000**	**R 323 230 000**
Civil Contractor P&G	R 452 900 000	R 356 410 000	R 209 230 000
Mechanical Contractor P&G	R 162 830 000	R 104 360 000	R 111 550 000
Electrical Contractor P&G	R 3 570 000	R 2 290 000	R 2 450 000
Electronic Contractor P&G	R 2 140 000	R 1 380 000	R 1 470 000
Civil works	**R 1 811 570 000**	**R 1 425 630 000**	**R 836 900 000**
General	R 3 600 000	R 3 600 000	R 3 600 000
Water retaining structures (filters, sumps, channels)	R 684 420 000	R 473 210 000	R 456 030 000
Sludge Lagoons	R 188 030 000	R 188 030 000	-
Buildings	R 206 750 000	R 194 100 000	R 27 330 000
Site Clearance and Bulk earthworks	R 80 230 000	R 53 490 000	R 57 730 000
Stormwater	R 40 230 000	R 28 170 000	R 26 040 000
Access Road	R 228 780 000	R 228 780 000	-
Internal Road Works and Paving	R 103 010 000	R 72 110 000	R 66 720 000
Landscaping and Irrigation	R 41 740 000	R 33 400 000	R 18 010 000
Fencing	R 29 920 000	R 29 920 000	-
Interconnecting Pipework	R 138 600 000	R 69 300 000	R 149 620 000
Miscellaneous	R 66 260 000	R 51 520 000	R 31 820 000
Mechanical works	**R 542 740 000**	**R 347 860 000**	**R 371 830 000**
Inlet Works (pH and Stabilisation)	R 5 120 000	R 3 720 000	R 5 720 000
Coagulation	R 9 890 000	R 6 600 000	R 7 120 000
Flocculation and Clarification	R 176 970 000	R 108 870 000	R 117 510 000
Rapid Gravity Sand Filtration	R 76 520 000	R 36 140 000	R 48 130 000
Disinfection	R 17 250 000	R 14 660 000	R 11 880 000
Sludge and Washwater Handling	R 13 460 000	R 14 660 000	R 11 880 000
Service Water Pump Station	R 1 270 000	R 1 000 000	R 1 430 000
HVAC	R 1 590 000	R 1 260 000	R 470 000
Forced Ventilation	R 5 290 000	R 5 290 000	-
Others (Sewage system, Ducting, Welding steel pipeline)	R 186 040 000	R 124 030 000	R 133 880 000
Miscellaneous	R 49 340 000	R 31 630 000	R 33 810 000
Electrical works	**R 11 880 000**	**R 7 610 000**	**R 8 140 000**
Bulk power supply	R 1 793 000	R 1 149 000	R 1 229 000
MV electrical work	R 4 932 000	R 3 159 000	R 3 379 000
LV electrical work	R 5 156 000	R 3 303 000	R 3 533 000
Electronic works	**R 7 130 000**	**R 4 570 000**	**R 4 890 000**
SCADA & telemetry	R 2 781 000	R 1 783 000	R 1 908 000
Instrumentation	R 4 100 000	R 2 628 000	R 2 812 000

Description	Estimated CAPEX		
	Complete Phase 312 Mℓ/d [1]	**Phase 1 208 Mℓ/d [2]**	**Phase 2 +104 Mℓ/d [3]**
Building electronic & security	R 250 000	R 160 000	R 172 000
Subtotal capital cost (excl. VAT)	**R 2 992 620 000**	**R 2 248 730 000**	**R 1 544 990 000**
Contract Price Adjustment (CPA) @7% p.a.	R 673 470 000	R 506 070 000	R 347 690 000
Allowance for foreign exchange variation @ 5% p.a.	R 577 870 000	R 434 230 000	R 298 340 000
Contingency @ 15%	R 636 600 000	R 478 360 000	R 328 660 000
Project cost (excl. VAT)	**R 4 880 560 000**	**R 3 667 390 000**	**R 2 519 680 000**
Professional fees (excl. VAT)	**R 311 240 000**	**R 233 870 000**	**R 160 680 000**
Engineering design fees @8%	R239 410 000	R179 900 000	R123 600 000
Disbursements and recoverable costs	R 71 830 000	R 53 970 000	R 37 080 000
Total project cost (excl. VAT)	**R 5 191 800 000**	**R 3 901 260 000**	**R 2 680 360 000**
Cost per mega Liter (R/Mℓ)	R 16 650 000	R 18 760 000	R 25 780 000

Notes:
1 Cost Estimate Base Date – November 2025.
2 Cost Estimate Base Date – November 2025
3 Cost estimate Base Date – November 2035 (assumed implementation 10 years after Phase 1).

11.3 Operation and Maintenance Cost

A design for a WTP is highly dependent on the operation and maintenance requirements, which in turn are based on the operational complexity of the infrastructure installed and the process technology implemented. The requirements of the Client, technical skills of staff and ability of the Client to maintain the infrastructure are also key aspects to be considered.

In addition to comparing the capital costs, it is also worthwhile to compare the costs over the project lifecycle for the different options including the capital costs as well as the operation and maintenance costs (particularly electricity) of the WTP. The following assumptions were made for estimation of the operation and maintenance costs:

- Maintenance costs were based on the type of structure, mechanical or electrical component. This was done as a percentage of the CAPEX and/or capital replacement cost (CRC).
- Electricity costs were estimated by using a rate of electricity of R1.44/kWh and the estimated average energy consumption of the different options.
- Chemical costs were obtained from suppliers and dosing rates were calculated based on accepted principles.
- Labour costs were estimted based on the estimated number of personnel required for the operation of the Xhariep WTP at the different options.
- Sludge disposal costs included the cost for sludge removal after drying, sludge lagoons repair and cleaning after sludge removal.

11.3.1 Estimated Maintenance Cost

The annual maintenance costs are estimated as a percentage of the CRC of the specific components as shown in Table 11-2.

Table 11-2: Estimated annual maintenance cost as a function of CRC for the Xhariep WTP

Description	Maintenance	Value (% of total)	Annual maintenance cost		
			Complete Phase 312 Mℓ/d [1]	Phase 1 208 Mℓ/d [2]	Phase 2 +104 Mℓ/d [3]
Civil	0.75% of CRC	63%	R 37 600 000	R 29 020 000	R 18 070 000
Sludge lagoons	2.0% of CRC	5%	R 3 770 000	R 2 510 000	R 1 260 000
Mechanical	2.25% of CRC	22%	R 12 220 000	R 7 830 000	R 8 370 000
Electrical	3.0% of CRC	7%	R 4 420 000	R 3 230 000	R 2 360 000
C&I	3.0% of CRC	3%	R 1 570 000	R 1 140 000	R 850 000
Total			**R 59 580 000**	**R 43 730 000**	**R 30 910 000**

Notes:
1 Estimated maintenance cost required for first year of plant operation are based on 2025 Costs.
2 Estimated maintenance cost required for first year of plant operation are based on 2035 Costs

11.3.2 Estimated Operational Cost

11.3.2.1 Human Resources Cost

The cost of staff employed at the proposed WTP was calculated based on the level of Plant Manager, Supervisor, Process Controller, and maintenance required for each option. The salary estimates were escalated accordingly and based on industry accepted monthly/annual salaries for suitably qualified personnel. Note that these are first order estimates only and have been derived from previous projects of a similar nature and size.

The costs documented in Table 11-3 represents a summary of the approximate annual salaries for a WTP employing the same conventional treatment processes and were scaled to suit the capacity of the Xhariep WTP.

Table 11-3: Approximate annual staffing costs for the Xhariep WTP

Description	R/Month	Number [3]	Annual staffing cost		
			Complete Phase 312 Mℓ/d [1]	Phase 1 208 Mℓ/d [1]	Phase 2 +104 Mℓ/d [2]
Operators (8-hour shifts)	R 35 000	12	R 5 040 000	R 3 360 000	R 3 720 000
Shift supervisors	R 45 000	4	R 2 160 000	R 2 160 000	-
Superintendent	R 75 000	1	R 900 000	R 900 000	-
General labourers	R 20 000	16	R 3 840 000	R 2 880 000	R 2 160 000
Mechanical foreman	R 40 000	2	R 960 000	R 960 000	-
Electrical foreman	R 40 000	2	R 960 000	R 960 000	-
Mechanical and electrical technician	R 25 000	8	R 2 400 000	R 2 400 000	-
Receptionist	R 20 000	1	R 240 000	R 240 000	-
Cleaners	R 8 000	8	R 960 000	R 576 000	R 840 000
Total		**54**	**R 17 460 000**	**R 14 440 000**	**R 6 720 000**

Notes:
1 Estimated Operational cost required for first year of plant operation are based on 2025 Costs.
2 Estimated Operational cost required for first year of plant operation are based on 2035 Costs.
At the implementation of Phase 2, additional staff will be required (4 operators, 4 general workers and 2 cleaners)
3 Total staff number after implementation of complete Phase.

11.3.2.2 Other Operational Costs

The other operational costs include energy cost, chemicals and sludge disposal costs. The energy cost was estimated based on the estimated mechanical load of the Xhariep WTP with a blended energy tariff

of R 1.44/kWh while the chemical and sludge disposal costs were estimated based on approximate current chemical costs and estimated usage rates. It should be noted that these costs will increase gradually as the flow to the plant increases until the design horizon.

The other operational costs are shown in Table 11-4 for the first year of operation of the works.

Table 11-4: Estimated other Annual Operational Costs for the Xhariep WTP

Description	Estimated Additional Annual Operating Cost		
	Complete Phase 312 Mℓ/d [1]	Phase 1 208 Mℓ/d [2]	Phase 2 +104 Mℓ/d [3]
Energy	R 47 670 000	R 30 510 000	R 55 770 000
Chemicals	R 71 590 000	R 47 730 000	R 34 360 000
Sludge Disposal	R 13 940 000	R 9 300 000	R 10 020 000
TOTAL	**R 133 200 000**	**R 87 540 000**	**R 100 150 000**

Notes:
1 Estimated other operational cost required for first year of plant operation based on 2025 Costs
2 Estimated other operational cost required for first year of plant operation based on 2035 Costs

11.3.2.3 Summary

The estimated operation and maintenance budget required for the first year of operation is summarised in Table 11-5, showing an estimated minimum O&M budget requirement.

The amortisation of capital was estimated as 11.5% p.a. of the plant civils, mechanical, electrical and C&I costs (Total Capital Cost, excl. VAT) at 20 years to determine the total annual cost of ownership.

Table 11-5: Estimated Annual Operation and Maintenance Budget for the Xhariep WTP

Description	Estimated Annual Maintenance and Operating Budget		
	Complete Phase 312 Mℓ/d [1]	Phase 1 208 Mℓ/d [2]	Phase 2 +104 Mℓ/d [3]
Maintenance	R 59 580 000	R 43 730 000	R 30 910 000
Labour	R 17 460 000	R 14 440 000	R 6 720 000
Energy	R 47 670 000	R 30 510 000	R 55 770 000
Chemicals	R 71 590 000	R 47 730 000	R 34 360 000
Sludge Disposal	R 13 940 000	R 9 300 000	R 10 020 000
TOTAL OPEX (Excl. VAT)	**R 210 240 000**	**R145 710 000**	**R 137 780 000**
Plant Cost (Amortised @ 20 years)	R 633 040 000	R 475 680 000	R 326 820 000
TOTAL ANNUAL COST OF OWNERSHIP (Excl. VAT)	**R 843 280 000**	**R 621 390 000**	**R 464 600 000**

Notes:
1 Estimated operation and maintenance budget required for first year of plant operation based on 2025 Costs
2 Estimated operation and maintenance budget required for first year of plant operation based on 2035 Costs

12 Environmental and Social Requirements

The environmental and social requirements for the project have been evaluated along with those of the overall Xhariep Pipeline Project. Aspects that are relevant to the treatment site are addressed in the following reports:

- P WMA 06/D00/00/3423/3 - Stakeholder Management Report
- P WMA 06/D00/00/3423/10 - Socio-Economic Impact Assessment Report
- P WMA 06/D00/00/3423/13 - Environmental Scoping Report
- P WMA 06/D00/00/3423/14 - Public Participation Report
- P WMA 06/D00/00/3423/15 - EIA Report with specialist studies

13 Regulatory Requirements

13.1 Technical Resource Availability

The following technical resource availability aspects as shown in Table 13-1 have been addressed as part of the Detailed Feasibility Design of the Xhariep WTP.

Table 13-1: Technical Resource Availability

Technical Resource Availability	Comment
Has a water license with adequate allocation for all uses been approved?	No. The application must be done by the system owner. DWS, together with relevant municipalities must still decide who the implementing agent and owner of the supply system will be. This decision will only be made once the detailed feasibility study has been completed. The WUL application will therefore take place as part of the detailed design phase of the project commences.
Have all land and property rights issues been addressed (land acquisition & servitudes)	Refer report: P WMA 06/D00/00/3423/12 Land Matters
Landowner Consent	Refer reports: P WMA 06/D00/00/3423/12 Land Matters P WMA 06/D00/00/3423/14 Public Participation Report
Rural Land Tenure System	Refer reports: P WMA 06/D00/00/3423/12 Land Matters P WMA 06/D00/00/3423/14 Public Participation Report
Land Ownership	Refer reports: P WMA 06/D00/00/3423/12 Land Matters P WMA 06/D00/00/3423/14 Public Participation Report

13.2 Pertinent Legislation

All regulatory requirements related to the project are addressed in the various sub-reports to the project.

Report Index	Report Name	DWS Number
10	Socio-Economic Impact Assessment Report	P WMA 06/D00/00/3423/10
12	Land Matters	P WMA 06/D00/00/3423/12
13	Environmental Scoping Report	P WMA 06/D00/00/3423/13
14	Public Participation Report	P WMA 06/D00/00/3423/14
15	EIA Report with specialist studies	P WMA 06/D00/00/3423/15

14 Institutional Arrangements

Refer to the Socio-Economic Impact Assessment & Legal, Institutional and Financing Report (Report P WMA 06/D00/00/3423/11) on any matters related to institutional arrangements regarding the ownership and operation of the WTP.

15 Conclusions and Recommendations

The Xhariep Water Treatment Plant (WTP) is required to deliver potable water to beneficiaries of the Scheme 1B1(A) option as defined in the Pre-feasibility Study Report (Report P WMA 06/D00/00/3423/5). This report deals with the detailed feasibility design of the WTP only. The feasibility design report the for abstraction of raw water, the conveyance thereof to the WTP and the distribution of the treated water is presented in Report P WMA 06/D00/00/3423/9.

The required plant capacity is 312 Mℓ/d. The site planning however provides for an additional 104 Mℓ/d to facilitate future plant expansion. The total planned site capacity is therefore 416 Mℓ/d. The sizing horizon for the WTP is 30 years.

The design of the WTP is based on the establishment of two clusters of treatment infrastructure, each consisting of two semi-independent trains of 104 Mℓ/d each. Each cluster then has a capacity of 208 Mℓ/d. It is anticipated that the site will be developed to deliver 208 Mℓ/d at first and then to be augmented with a further 104 Mℓ/d around 10 years later at which time the capacity of the WTP will be 312 Mℓ/d. The further provision of 104 Mℓ/d is not scheduled at present but will allow for consideration of delivery to the south of the proposed WTP as well as further distribution into the southern Free State Province. The plant design will reach the target daily production capacity in 22 hours per day.

The placement of the WTW remains as finalised during the pre-feasibility study report. The site is located to the immediate east of the N1-highway and approximately 5 km north of the Xhariep Town. Access to the site will be by exiting to the north from the R701. The site is not currently being utilized for any intensive agricultural or other activities. The site elevation is located between 1280 and 1300 m above mean sea level (AMSL).

A stand-out feature of the site is that it is underlain by rock at shallow depth. Most trail pits encountered rock at less than 1m depth with an average of around 0.5m. There is not sufficient soft material to allow for the excavation of pipe trenches for the main process pipelines. The design therefore requires that most of the main structures, treatment reactors and pipelines be constructed and installed above ground to reduce the cost of excavation and to avoid the requirement for excessive pumping between process units.

Raw water will be sourced from Gariep Dam. An analysis of available and newly generated water quality data indicates the following treatment requirements after evaluation and consideration of the errant data:

- Turbidity levels are moderately high and require treatment intervention.
- Total aluminium levels are high. The dissolved aluminium levels are very low and do not require treatment. The non-dissolved fraction will be removed along with general turbidity if care is taken not to re-dissolve the aluminium through extensive pH manipulation.
- The microbiological indicators will be removed adequately through normal disinfection protocols. No positive results were noted for chlorine resistant cysts or oocysts in any of the water qualty data sets.
- A small number of datapoints reflected very high dissolved organic carbon (DOC) levels. All the high values were however reported prior to 2003. Subsequent reports all indicated DOC levels below the national standard. No specific treatment regimes are included to address organic carbon removal.
- Both the Ryznar index as well as CCPP indicate that the water is aggressive and will require stabilisation.
- The additional sampling of the water source and analysis for a significantly expanded set of parameters indicated little to no risk associated with chlorophyll-a or contaminants of emerging concern at the proposed treatment plant.
- Some historical data sets indicate a number of determinands are present at levels of concern. The high initial values are likely the result of laboratory detection limits exceeding the specified water quality targets.The latest data sets indicate that these values, when appropriately analysed, are below levels of concern.

The water can be described as of good quality. Turbidity, microbiology, and stability are the only determinands requiring particular attention. Conventional flocculation, settling and filtration is proposed. A comparable process is currently successfully employed at the Gariep Dam WTW. The new Xhariep WTW will additionally focus on stabilisation and a suitable disinfection strategy.

The treatment technology proposed for the Xhariep WTP can be described as conventional:

- Flocculation and clarification will take place in a pulsator clarifier. The proposed design is based on a loading rate of 2.5 m/h which is conservative for pulsators but will be appropriate for the occasional turbidity peaks that may exceed 200 NTU in extreme cases. A total of 12 separate pulsators will be required to deliver 312 Mℓ/d. The modular design will allow for diversion of flow to the remaining units if a unit is to be removed from operation for maintenance purposes.
- The rapid gravity sand filters are designed for deep penetration of floc into the filter bed. The filter beds are 1 m deep and the effective media size (d_{10}) is 0.9 mm. The filter will be cleaned using a combined air and water scour to facilitate collapse pulsing which will be followed by a water rinse. A total of 30 filters, with a surface area of 84.7 m^2 each, are required to deliver 312 Mℓ/d. The filter loading rate is 6 m/hr with all 30 filters operational and 6.67 m/hr if three filters have been removed from operation for cleaning. Backwash water will be drawn from a storage reservoir provided below the filters.

Laboratory tests indicate that the preferred flocculant for treatment of the source water is a poli-aluminium chloride flocculant. The average design dosage of 12 mg/ℓ and maximum of 35 mg/ℓ are informed by laboratory tests as well as current operational experience at the existing Gariep Dam WTP.

Water quality data and laboratory tests indicate that stabilisation is required to achieve the required CCPP target of 2 to 5 mg/ℓ. An options analysis indicates that hydrated lime at around 5 to 10 mg/ℓ is the most economical approach to stabilisation.

A chlorine demand study indicated a single chlorine dose at the treatment plant would not be sufficient to sustain chlorine levels in the transfer system. Chloramination cannot be considered as Mangaung does not presently receive chloraminated water from its other sources and the mixing of chloraminated and non-chloraminated water cannot be permitted. The system will therefore be chlorinated with a booster injection of chlorine at the Booster Pump Station at which time the water will have been in the transfer system for around 48 hours. Chlorine decay models indicate that this approach will result in a chlorine residual being present in the water when it reaches the receiving reservoirs in Mangaung. A comparison of chlorination systems indicated that chlorine gas systems are more advantageous than on-site chlorine generation systems. This report is based on the use of 1 tonne chlorine gas drums. More economical gas delivery approaches may be available, but this can only be confirmed following direct negotiation with chlorine gas suppliers.

Main disinfection will take place in the on-site storage reservoir. The CT-requirement for Giardia, Cryptosporidium as well as viruses will be satisfied. The design further aims to maintain a chlorine residual up to when the water reaches the booster station. The total chlorine dose at the WTP is estimated to be in the order of 6.7 mg/ℓ on average and 7.9 mg/ℓ at maximum. The dosage requirement at the booster pump station is estimated to be 3 mg/ℓ. The chlorine dosing requirements are high and suggest that trihalomethane production may be a risk. Laboratory tests indicate a marginal risk for this albeit at higher chlorine dosages and on untreated water. Trihalomethanes will have to be monitored as a risk determinand once the WTP is in operation.

The storage reservoir make provision for another 30 minutes of storage for high lift pump balancing purposes. This is anticipated to be sufficient to allow for smooth operation of the high lift pumps. The high lift pumping station design is handled as part of the Feasibility Design Report – Pipelines, Pump Stations and Reservoirs (Report P WMA 06/D00/00/3423/9).

Treatment residuals will be thickened in sludge ponds. Mechanical thickening was not considered as an alternative due to the additional operational complexity that this brings to a WTP as well as the fact that sufficient land is available to allow for consideration of the low cost and effort alternative of ponds.

Pond supernatant will be returned to the inlet works to ensure efficient use of the water resource. A Hyson cell lined pond was found to be most cost effective.

The following support buildings have been included in the feasibility design:

- Administration and control building with a laboratory, meeting rooms, control offices and staff facilities;
- A maintance workshop with workshop floor area supported by overhead cranes, stores areas, offices, meeting rooms and facilities for maintenance personnel; and
- Chemical storage areas for bulk chemical storage and housing of dosing equipment. Chlorine is stored and controlled from separate facilities that can be developed in a phased manner.

All structures, services and installed plant shall be designed and constructed to meet DWS standards as well as the WTP owner's standards where these exceed the requirement of DWS.

The mechanical equipment lists for the WTP are provided in **Appendix F**. The equipment selections, power ratings and capacities are preliminary, and will be finalized during the detailed design phase. A summary of the estimated power consumptions required for Phase 1 (208 Mℓ/d) and Phase 1 and 2 (312 Mℓ/d) is shown in the table below. The table excludes the high lift pumping station which is included in Report P WMA 06/D00/00/3423/9.

Summary of the estimated energy consumption required at the Xhariep WTP for Phase 1 and 2 (excluding high lift pumping station)

			Phase 1		Phase 2		Phase 1 & 2	
		Unit	Absorbed power	Rated power	Absorbed power	Rated power	Absorbed power	Rated power
1	**Inlet works**	kW	24	32	0	0	24	32
2	**Flocculation and coagulation**	kW	72	92	36	46	108	138
3	**Rapid gravity sand filters**	kW	183	256	183	256	365	512
4	**Clear water storage**	kW	2	2	1	2	2	3
5	**Chemical dosing**	kW	101	133	47	71	148	204
6	**Residual handling**	kW	89	120	79	110	167	230
7	**Service water**	kW	3	5	3	4	6	9
8	**Service buildings**	kW	25	25	0	0	25	25
	PLANT TOTAL	**kW**	**501**	**664**	**351**	**489**	**852**	**1152**

The design approach for the electronic works shall achieve the following:

- Centralised control of the WTP allowing for easy and convenient operation.
- The installation can be controlled and monitored remotely from the administration building SCADA, the Xhariep scheme remote command center or in the field at the Human Machine Interfaces (HMI) at various possible locations, like filters and dosing systems.

The estimated expenditure to complete the design and construct the WTP was prepared of based on historical data collected from plants of a similar nature and technology level. The estimated design and construction costs come to the following:

Description	Estimated CAPEX		
	Complete Phase 312 Mℓ/d [1]	Phase 1 208 Mℓ/d [2]	Phase 2 +104 Mℓ/d [3]
Preliminary and General	**R 619 300 000**	**R 463 060 000**	**R 323 230 000**
Civil works	**R 1 811 570 000**	**R 1 425 630 000**	**R 836 900 000**

Description	Estimated CAPEX		
	Complete Phase 312 Mℓ/d [1]	**Phase 1 208 Mℓ/d [2]**	**Phase 2 +104 Mℓ/d [3]**
Mechanical works	**R 542 740 000**	**R 347 860 000**	**R 371 830 000**
Electronic works	**R 7 130 000**	**R 4 570 000**	**R 4 890 000**
Subtotal capital cost (excl. VAT)	**R 2 992 620 000**	**R 2 248 730 000**	**R 1 544 990 000**
Contract Price Adjustment (CPA) @7% p.a.	R 673 470 000	R 506 070 000	R 347 690 000
Allowance for foreign exchange variation @ 5% p.a.	R 577 870 000	R 434 230 000	R 298 340 000
Contingency @ 15%	R 636 600 000	R 478 360 000	R 328 660 000
Project cost (excl. VAT)	**R 4 880 560 000**	**R 3 667 390 000**	**R 2 519 680 000**
Professional fees (excl. VAT)	**R 311 240 000**	**R 233 870 000**	**R 160 680 000**
Total project cost (excl. VAT)	**R 5 191 800 000**	**R 3 901 260 000**	**R 2 680 360 000**
Cost per mega Liter (R/Mℓ)	R 16 650 000	R 18 760 000	R 25 780 000

Notes:
1 Cost Estimate Base Date – November 2025.
2 Cost Estimate Base Date – November 2025
3 Cost estimate Base Date – November 2035 (assumed implementation 10 years after Phase 1).

The annual cost of ownership was estimated based on the estimate costs for maintenance, staffing, energy, chemicals and sludge disposal. The ownership cost estimate is summarized in the table below.

Description	Estimated Annual Maintenance and Operating Budget		
	Complete Phase 312 Mℓ/d [1]	**Phase 1 208 Mℓ/d [2]**	**Phase 2 +104 Mℓ/d [3]**
Maintenance	R 59 580 000	R 43 730 000	R 30 910 000
Labour	R 17 460 000	R 14 440 000	R 6 720 000
Energy	R 47 670 000	R 30 510 000	R 55 770 000
Chemicals	R 71 590 000	R 47 730 000	R 34 360 000
Sludge Disposal	R 13 940 000	R 9 300 000	R 10 020 000
TOTAL OPEX (Excl. VAT)	**R 210 240 000**	**R145 710 000**	**R 137 780 000**
Plant Cost (Amortised @ 20 years)	R 633 040 000	R 475 680 000	R 326 820 000
TOTAL ANNUAL COST OF OWNERSHIP (Excl. VAT)	**R 843 280 000**	**R 621 390 000**	**R 464 600 000**

Notes:
1 Estimated operation and maintenance budget required for first year of plant operation based on 2025 Costs
2 Estimated operation and maintenance budget required for first year of plant operation based on 2035 Costs

The environmental and social requirements for the project have been evaluated along with those of the overall Xhariep Pipeline Project. Issues that are relevant to the treatment site are addressed in companion reports under this project. The same applies to regulatory requirements and institutional arrangements as they pertain to this project.

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Appendix A: Raw Water Quality Data

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Project number: 1000 **Report number:** 135467 **Order number:**

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Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-18258
Date\Time Sampled			N/A
pH - Value @ 25 ºC	A	WLAB065	8.1
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	19.7
Total Dissolved Solids @ 180°C	A	WLAB003	150
Suspended Solids at 105°C	A	WLAB004	31
Colour in PtCo Units	A	WLAB006	10
Turbidity in N.T.U	A	WLAB005	20
Total Alkalinity as $CaCO_3$	A	WLAB007	88
P-Alkalinity as $CaCO_3$	A	WLAB023	<5
Bicarbonate as HCO_3	A	WLAB023	107
Carbonate as CO_3	A	WLAB023	<5
Hydroxide Alkalinity as $CaCO_3$	A	WLAB023	<5
Total Hardness as $CaCO_3$	A	WLAB051	79
Calcium Hardness as $CaCO_3$	A	WLAB051	48
Magnesium Hardness as $CaCO_3$	A	WLAB051	31
Chloride as Cl	A	WLAB046	5
Sulphate as SO_4	A	WLAB046	10
Fluoride as F	A	WLAB014	0.2
Nitrate as N	A	WLAB046	<0.1
Nitrite as N	A	WLAB046	<0.05
Bromide as Br	S	---	0.3
Silica as SiO_2	N	WLAB046	17.0
Ortho Phosphate as P	A	WLAB046	0.1
Total Cyanide as CN	S	---	<0.07
Hydrogen Sulfide	S	---	<0.1
Total Organic Carbon as C	A	WLAB060	2.6
Dibromooacetic Acid	S	---	<0.0002
Dibromoacetonitrile	S	---	<0.0002



J. Ngobeza - Chemical Technical Signatory



E. Nkabinde - Chemical & Microbiological Technical Signatory

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Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-18258
Date\Time Sampled			N/A
Dichloroacetic Acid	S	---	<0.0002
Chloroacetic Acid	S	---	<0.0002
Dichloromethane	S	---	<0.0002
Bromochloroacetic Acid	S	---	<0.0002
Bromodichloroacetic Acid	S	---	<0.0002
Chlorodibromoacetic Acid	S	---	<0.0002
Dissolved Organic Carbon as C	A	WLAB060	2.3
Monobromoacetic Acid	S	---	<0.00001
Tribromoacetic Acid	S	---	<0.0005
Chemical Oxygen Demand as O_2 (Total)	A	WLAB018	39
Dissolved Oxygen as O_2	N	WLAB040	9.3
UV Absorbance at 254 nm	S	---	0.0640
UV Absorbance at 300 nm	S	---	0.0253
Chloroform as $CHCl_3$	S	---	<0.005
Bromoform as $CHBr_3$	S	---	<0.005
Dibromochloromethane as $CHBr_2Cl$	S	---	<0.002
Bromodichloromethane as $CHBrCl_2$	S	---	<0.010
Chlorophyll-a (µg/ℓ)	N	WLAB033	4
Total Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	980
Faecal Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	<1
Heterotrophic Plate Count (cfu/1 mℓ)	A	WLAB021	33
Free and Saline Ammonia as N	A	WLAB046	<0.1
Sodium as Na	A	WLAB015	8
Potassium as K	A	WLAB015	1.5
Calcium as Ca	A	WLAB015	19
Magnesium as Mg	A	WLAB015	8
Aluminium as Al	A	WLAB015	0.341
Aluminium as Al (Dissolved)	A	WLAB015	<0.100

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Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-18258
Date\Time Sampled			N/A
Antimony as Sb	A	WLAB050	0.003
Arsenic as As	A	WLAB050	<0.001
Barium as Ba	A	WLAB015	0.030
Total Chromium as Cr	A	WLAB015	<0.025
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	0.018
Iron as Fe	A	WLAB015	0.256
Iron as Fe (Dissolved)	A	WLAB015	<0.025
Manganese as Mn	A	WLAB015	<0.025
Manganese as Mn (Dissolved)	A	WLAB015	<0.025
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Selenium as Se	A	WLAB050	<0.001
Strontium as Sr	N	WLAB015	0.093
Thallium as Tl	N	WLAB050	<0.001
Vanadium as V	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	<0.025
% Anion-Cation Balance	N	---	96.7
TPH GRO C6-C10 & BTEX	S	---	See Below
TPH C10-C40	S	---	<0.382
TPH C10-C28	S	---	<0.382
TPH C28-C40	S	---	<0.382
Volatile Organic Compounds (VOCs)	S	---	See Below



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TPH GRO C6-C10 & BTEX

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-18258
Date\Time Sampled			N/A
MTBE	S	---	<0.005
Tame	S	---	<0.005
Benzene	S	---	<0.0004
Toluene	S	---	<0.001
Ethylbenzene	S	---	<0.0004
m+p-Xylene	S	---	<0.0008
o-Xylene	S	---	<0.0004
1,3,5-Trimethylbenzene	S	---	<0.0004
1,2,4-Trimethyl benzene	S	---	<0.0004
Naphthalene	S	---	<0.0004
GRO TPH (C6 – C10)	S	---	<0.010



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VOC

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-18258
Date\Time Sampled			N/A
Benzene	S	---	<0.001
Toluene	S	---	<0.010
Ethylbenzene	S	---	<0.002
m+p Xylene	S	---	<0.004
o-Xylene	S	---	<0.002
1,3,5 Trimethyl benzene	S	---	<0.002
1,2,4 Trimethyl benzene	S	---	<0.002
n Propylbenzene	S	---	<0.002
Tertiary Butylbenzene	S	---	<0.002
Secondary Butylbenzene	S	---	<0.002
n Butylbenzene	S	---	<0.002
Isopropylbenzene	S	---	<0.002
Styrene	S	---	<0.005
4-Isopropyltoluene	S	---	<0.005
Bromobenzene	S	---	<0.002
Chlorobenzene	S	---	<0.002
1,2-Dichlorobenzene	S	---	<0.002
1,3 Dichlorobenzene	S	---	<0.002
1,4-Dichlorobenzene	S	---	<0.002
1,2,3 Trichlorobenzene	S	---	<0.002
1,2,4 Trichlorobenzene	S	---	<0.002
1,3,5-Trichlorobenzene	S	---	<0.002
Naphthalene	S	---	<0.002
Bromoform	S	---	<0.005
Chloroform	S	---	<0.005
Carbon Tetrachloride	S	---	<0.005
Trichloroethene	S	---	<0.005



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Sampled by: Waterlab

WATERLAB (Pty) Ltd

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CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-08-21 **Date completed:** 2024-09-13

Project number: 1000 **Report number:** 135467 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-18258
Date\Time Sampled			N/A
Dibromomethane	S	---	<0.010
Dichloromethane	S	---	<0.050
Bromochloromethane	S	---	<0.050
Bromodichloromethane	S	---	<0.010
Dibromochloromethane	S	---	<0.002
1,2 Dibromoethane	S	---	<0.002
1,2-Dichloroethane	S	---	<0.010
Tetrachloroethene	S	---	<0.002
1,1,1-Trichloroethane	S	---	<0.005
1,1,2-Trichloroethane	S	---	<0.005
Hexachlorobutadiene	S	---	<0.002
1,1,1,2-Tetrachloroethane	S	---	<0.010
1,1,2,2-Tetrachloroethane	S	---	<0.010
2 Chlorotoluene	S	---	<0.002
4 Chlorotoluene	S	---	<0.002
1,1-Dichloroethene	S	---	<0.010
1,1-Dichloroethane	S	---	<0.010
cis-1,2-Dichloroethene	S	---	<0.010
trans-1,2-Dichloroethene	S	---	<0.010
1,2-Dichloropropane	S	---	<0.010
1,3-Dichloropropane	S	---	<0.010
2,2-Dichloropropane	S	---	<0.010
1,2,3 Trichloropropane	S	---	<0.010
1,1-Dichloropropene	S	---	<0.005
cis-1,3-Dichloropropene	S	---	<0.005
trans-1,3-Dichloropropene	S	---	<0.005



J. Ngobeza - Chemical Technical Signatory



E. Nkabinde - Chemical & Microbiological Technical Signatory

Start date of analysis: 2024/08/22 Date of Issue: 2024/09/13

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CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-03-18 **Date completed:** 2024-04-22

Project number: 1000 **Report number:** 130515 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-02024
Date\Time Sampled			N/A
pH - Value @ 25 ºC	A	WLAB065	8.0
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	20.2
Total Dissolved Solids @ 180°C	A	WLAB003	160
Suspended Solids at 105°C	A	WLAB004	6.7
Colour in PtCo Units	A	WLAB006	21
Turbidity in N.T.U	A	WLAB005	17
Total Alkalinity as $CaCO_3$	A	WLAB007	88
P-Alkalinity as $CaCO_3$	A	WLAB023	<5
Bicarbonate as HCO_3	A	WLAB023	107
Carbonate as CO_3	A	WLAB023	<5
Hydroxide as OH	A	WLAB023	<5
Total Hardness as $CaCO_3$	A	WLAB051	82
Calcium Hardness as $CaCO_3$	A	WLAB051	51
Magnesium Hardness as $CaCO_3$	A	WLAB051	31
Chloride as Cl	A	WLAB046	3
Chlorite as ClO	S	---	<0.0005
Sulphate as SO_4	A	WLAB046	9
Fluoride as F	A	WLAB014	<0.2
Nitrate as N	A	WLAB046	0.2
Nitrite as N	A	WLAB046	<0.05
Bromide as Br	S	---	<0.1
Bromate as BrO	S	---	<0.0002
Silica as SiO_2	N	WLAB046	13.3
Ortho Phosphate as P	A	WLAB046	0.3
Total Cyanide as CN	S	---	<0.07
Hydrogen Sulfide	S	---	<0.1
Total Organic Carbon as C	A	WLAB060	2.9

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

Start date of analysis: 2024/03/18 Date of Issue: 2024/04/22

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CERTIFICATE OF ANALYSES
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Date received: 2024-03-18 **Date completed:** 2024-04-22

Project number: 1000 **Report number:** 130515 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-02024
Date\Time Sampled			N/A
Dissolved Organic Carbon as C	A	WLAB060	2.7
Dibromooacetic Acid	S	---	<0.0002
Dibromoacetonitrile	S	---	<0.0002
Dichloroacetic Acid	S	---	<0.0002
Chloroacetic Acid	S	---	<0.0002
Dichloromethane	S	---	<0.0002
Bromochloroacetic Acid	S	---	<0.0002
Bromodichloroacetic Acid	S	---	<0.0002
Chlorodibromoacetic Acid	S	---	<0.0002
Monobromoacetic Acid	S	---	<0.00001
Tribromoacetic Acid	S	---	<0.0005
Chemical Oxygen Demand as O_2 (Total)	A	WLAB018	<10
Dissolved Oxygen as O_2	N	WLAB040	7.1
UV Absorbance at 254 nm	S	---	0.0741
UV Absorbance at 300 nm	S	---	0.0365
Chloroform as $CHCl_3$	S	---	<0.005
Bromoform as $CHBr_3$	S	---	<0.005
Dibromochloromethane as $CHBr_2Cl$	S	---	<0.002
Bromodichloromethane as $CHBrCl_2$	S	---	<0.010
Algae Identification	S	---	Aulacoseira granulata (362 cells/ml)
Algae Identification (continued)	S	---	Chlamydomonas sp (241 cells/ml)
Algae Identification (continued)	S	---	Cryptomonas major (121 cells/ml)
Algae Identification (continued)	S	---	Cryptomonas minor (241 cells/ml)
Algae Identification (continued)	S	---	Fragilaria sp (1931 cells/ml)
Algae Identification (continued)	S	---	Microcystis sp (2051 cells/ml)
Chlorophyll-a (µg/ℓ)	N	WLAB033	<1
Total Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	440
Faecal Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	1

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

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Date received: 2024-03-18 **Date completed:** 2024-04-22

Project number: 1000 **Report number:** 130515 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-02024
Date\Time Sampled			N/A
Heterotrophic Plate Count (cfu/1 mℓ)	A	WLAB021	1100
Cryptosporidium species / (10 ℓ)	S	---	0
Giardia species / (10 ℓ)	S	---	0
Free and Saline Ammonia as N	A	WLAB046	<0.1
Sodium as Na	A	WLAB015	7
Potassium as K	A	WLAB015	1.1
Calcium as Ca	A	WLAB015	20
Magnesium as Mg	A	WLAB015	8
Aluminium as Al	A	WLAB015	0.417
Aluminium as Al (Dissolved)	A	WLAB015	<0.100
Antimony as Sb	A	WLAB050	<0.001
Arsenic as As	A	WLAB050	<0.001
Barium as Ba	A	WLAB015	0.037
Total Chromium as Cr	A	WLAB015	<0.025
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	<0.010
Iron as Fe	A	WLAB015	0.233
Iron as Fe (Dissolved)	A	WLAB015	<0.025
Ferrous Iron as Fe2+ (Dissolved)	N	WLAB045	<0.025
Manganese as Mn	A	WLAB015	<0.025
Manganese as Mn (Dissolved)	A	WLAB015	<0.025
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Selenium as Se	A	WLAB050	<0.001
Strontium as Sr	N	WLAB015	0.094
Thallium as Tl	N	WLAB050	<0.001
Vanadium as V	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	<0.025



A. van de Wetering - Chemical Technical Signatory



M. Nkambule - Microbiological Technical Signatory

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Project number: 1000 **Report number:** 130515 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-02024
Date\Time Sampled			N/A
% Anion-Cation Balance	N	---	97.7
TPH GRO C6-C10 & BTEX	S	---	See Below
TPH C10-C40	S	---	<0.382
TPH C10-C28	S	---	<0.382
TPH C28-C40	S	---	<0.382
Volatile Organic Compounds (VOCs)	S	---	See Below

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

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Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

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Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

TPH GRO C6-C10 & BTEX

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-02024
Date\Time Sampled			N/A
MTBE	S	---	<0.005
Tame	S	---	<0.005
Benzene	S	---	<0.0004
Toluene	S	---	<0.001
Ethylbenzene	S	---	<0.0004
m+p-Xylene	S	---	<0.0008
o-Xylene	S	---	<0.0004
1,3,5-Trimethylbenzene	S	---	<0.0004
1,2,4-Trimethyl benzene	S	---	<0.0004
Naphthalene	S	---	<0.0004
GRO TPH (C6 – C10)	S	---	<0.010

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

Start date of analysis: 2024/03/18 Date of Issue: 2024/04/22

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Project number: 1000 **Report number:** 130515 **Order number:**

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VOC

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-02024
Date\Time Sampled			N/A
Benzene	S	---	<0.001
Toluene	S	---	<0.010
Ethylbenzene	S	---	<0.002
m+p Xylene	S	---	<0.004
o-Xylene	S	---	<0.002
1,3,5 Trimethyl benzene	S	---	<0.002
1,2,4 Trimethyl benzene	S	---	<0.002
n Propylbenzene	S	---	<0.002
Tertiary Butylbenzene	S	---	<0.002
Secondary Butylbenzene	S	---	<0.002
n Butylbenzene	S	---	<0.002
Isopropylbenzene	S	---	<0.002
Styrene	S	---	<0.005
4-Isopropyltoluene	S	---	<0.005
Bromobenzene	S	---	<0.002
Chlorobenzene	S	---	<0.002
1,2-Dichlorobenzene	S	---	<0.002
1,3 Dichlorobenzene	S	---	<0.002
1,4-Dichlorobenzene	S	---	<0.002
1,2,3 Trichlorobenzene	S	---	<0.002
1,2,4 Trichlorobenzene	S	---	<0.002
1,3,5-Trichlorobenzene	S	---	<0.002
Naphthalene	S	---	<0.002
Bromoform	S	---	<0.005
Chloroform	S	---	<0.005
Carbon Tetrachloride	S	---	<0.005
Trichloroethene	S	---	<0.005



A. van de Wetering - Chemical Technical Signatory



M. Nkambule - Microbiological Technical Signatory

Start date of analysis: 2024/03/18 Date of Issue: 2024/04/22

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Project number: 1000 **Report number:** 130515 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-02024
Date\Time Sampled			N/A
Dibromomethane	S	---	<0.010
Dichloromethane	S	---	<0.050
Bromochloromethane	S	---	<0.050
Bromodichloromethane	S	---	<0.010
Dibromochloromethane	S	---	<0.002
1,2 Dibromoethane	S	---	<0.002
1,2-Dichloroethane	S	---	<0.010
Tetrachloroethene	S	---	<0.002
1,1,1-Trichloroethane	S	---	<0.005
1,1,2-Trichloroethane	S	---	<0.005
Hexachlorobutadiene	S	---	<0.002
1,1,1,2-Tetrachloroethane	S	---	<0.010
1,1,2,2-Tetrachloroethane	S	---	<0.010
2 Chlorotoluene	S	---	<0.002
4 Chlorotoluene	S	---	<0.002
1,1-Dichloroethene	S	---	<0.010
1,1-Dichloroethane	S	---	<0.010
cis-1,2-Dichloroethene	S	---	<0.010
trans-1,2-Dichloroethene	S	---	<0.010
1,2-Dichloropropane	S	---	<0.010
1,3-Dichloropropane	S	---	<0.010
2,2-Dichloropropane	S	---	<0.010
1,2,3 Trichloropropane	S	---	<0.010
1,1-Dichloropropene	S	---	<0.005
cis-1,3-Dichloropropene	S	---	<0.005
trans-1,3-Dichloropropene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

Start date of analysis: 2024/03/18 Date of Issue: 2024/04/22

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Sampled by: Waterlab

WATERLAB (Pty) Ltd

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T0391

AMENDED CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-03-28 **Date completed:** 2024-05-13

Project number: 1000 **Report number:** 130851-A **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-03317
Date\Time Sampled			N/A
pH - Value @ 25 ºC	A	WLAB065	8.1
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	19.9
Total Dissolved Solids @ 180°C	A	WLAB003	92
Suspended Solids at 105°C	A	WLAB004	12.2
Colour in PtCo Units	A	WLAB006	14
Turbidity in N.T.U	A	WLAB005	18
Total Alkalinity as $CaCO_3$	A	WLAB007	88
P-Alkalinity as $CaCO_3$	A	WLAB023	<5
Bicarbonate as HCO_3	A	WLAB023	107
Carbonate as CO_3	A	WLAB023	<5
Hydroxide Alkalinity as $CaCO_3$	A	WLAB023	<5
Total Hardness as $CaCO_3$	A	WLAB051	80
Calcium Hardness as $CaCO_3$	A	WLAB051	48
Magnesium Hardness as $CaCO_3$	A	WLAB051	32
Chloride as Cl	A	WLAB046	4
Sulphate as SO_4	A	WLAB046	9
Fluoride as F	A	WLAB014	0.2
Nitrate as N	A	WLAB046	0.6
Nitrite as N	A	WLAB046	<0.05
Bromide as Br	S	---	<0.1
Silica as SiO_2	N	WLAB046	11.7
Ortho Phosphate as P	A	WLAB046	<0.1
Total Cyanide as CN	S	---	<0.07
Hydrogen Sulfide	S	---	<0.1
Total Organic Carbon as C	A	WLAB060	2.7
Dissolved Organic Carbon as C	A	WLAB060	2.7
Dibromooacetic Acid	S	---	<0.0002

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

This Certificate, **130851-A,** replaces the previous Certificate of Analysis **130851** Start date of analysis: 2024/04/02 Date of Issue: 2024/05/13

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Sampled by: Client

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Date received: 2024-03-28 **Date completed:** 2024-05-13

Project number: 1000 **Report number:** 130851-A **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-03317
Date\Time Sampled			N/A
Dibromoacetonitrile	S	---	<0.0002
Dichloroacetic Acid	S	---	<0.0002
Chloroacetic Acid	S	---	<0.0002
Dichloromethane	S	---	<0.0002
Bromochloroacetic Acid	S	---	<0.0002
Bromodichloroacetic Acid	S	---	<0.0002
Chlorodibromoacetic Acid	S	---	<0.0002
Monobromoacetic Acid	S	---	<0.00001
Tribromoacetic Acid	S	---	<0.0005
Chemical Oxygen Demand as O_2 (Total)	A	WLAB018	28
Dissolved Oxygen as O_2	N	WLAB040	9.2
UV Absorbance at 254 nm	S	---	0.0471
UV Absorbance at 300 nm	S	---	0.0348
Chloroform as $CHCl_3$	S	---	<0.005
Bromoform as $CHBr_3$	S	---	<0.005
Dibromochloromethane as $CHBr_2Cl$	S	---	<0.002
Bromodichloromethane as $CHBrCl_2$	S	---	<0.010
Chlorophyll-a (µg/ℓ)	N	WLAB033	<1
Total Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	160
Faecal Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	3
Heterotrophic Plate Count (cfu/1 mℓ)	A	WLAB021	290
Free and Saline Ammonia as N	A	WLAB046	<0.1
Sodium as Na	A	WLAB015	6
Potassium as K	A	WLAB015	1.4
Calcium as Ca	A	WLAB015	19
Magnesium as Mg	A	WLAB015	8
Aluminium as Al	A	WLAB015	0.234
Aluminium as Al (Dissolved)	A	WLAB015	0.101

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Date received: 2024-03-28 **Date completed:** 2024-05-13

Project number: 1000 **Report number:** 130851-A **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-03317
Date\Time Sampled			N/A
Antimony as Sb	A	WLAB050	<0.001
Arsenic as As	A	WLAB050	<0.001
Barium as Ba	A	WLAB015	0.039
Total Chromium as Cr	A	WLAB015	<0.025
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	0.019
Iron as Fe	A	WLAB015	0.170
Iron as Fe (Dissolved)	A	WLAB015	0.051
Ferrous Iron as Fe2+ (Dissolved)	N	WLAB045	<0.025
Manganese as Mn	A	WLAB015	<0.025
Manganese as Mn (Dissolved)	A	WLAB015	<0.025
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Selenium as Se	A	WLAB050	<0.001
Strontium as Sr	N	WLAB015	0.044
Thallium as Tl	N	WLAB050	<0.001
Vanadium as V	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	<0.025
% Anion-Cation Balance	N	---	94.6
TPH GRO C6-C10 & BTEX	S	---	See Below
TPH C10-C40	S	---	<0.382
TPH C10-C28	S	---	<0.382
TPH C28-C40	S	---	<0.382
Volatile Organic Compounds (VOCs)	S	---	See Below

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Date received: 2024-03-28 **Date completed:** 2024-05-13

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Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

TPH GRO C6-C10 & BTEX

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-03317
Date\Time Sampled			N/A
MTBE	S	---	<0.005
Tame	S	---	<0.005
Benzene	S	---	<0.0004
Toluene	S	---	<0.001
Ethylbenzene	S	---	<0.0004
m+p-Xylene	S	---	<0.0008
o-Xylene	S	---	<0.0004
1,3,5-Trimethylbenzene	S	---	<0.0004
1,2,4-Trimethyl benzene	S	---	<0.0004
Naphthalene	S	---	<0.0004
GRO TPH (C6 – C10)	S	---	<0.010

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Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

VOC

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-03317
Date\Time Sampled			N/A
Benzene	S	---	<0.001
Toluene	S	---	<0.010
Ethylbenzene	S	---	<0.002
m+p Xylene	S	---	<0.004
o-Xylene	S	---	<0.002
1,3,5 Trimethyl benzene	S	---	<0.002
1,2,4 Trimethyl benzene	S	---	<0.002
n Propylbenzene	S	---	<0.002
Tertiary Butylbenzene	S	---	<0.002
Secondary Butylbenzene	S	---	<0.002
n Butylbenzene	S	---	<0.002
Isopropylbenzene	S	---	<0.002
Styrene	S	---	<0.005
4-Isopropyltoluene	S	---	<0.005
Bromobenzene	S	---	<0.002
Chlorobenzene	S	---	<0.002
1,2-Dichlorobenzene	S	---	<0.002
1,3 Dichlorobenzene	S	---	<0.002
1,4-Dichlorobenzene	S	---	<0.002
1,2,3 Trichlorobenzene	S	---	<0.002
1,2,4 Trichlorobenzene	S	---	<0.002
1,3,5-Trichlorobenzene	S	---	<0.002
Naphthalene	S	---	<0.002
Bromoform	S	---	<0.005
Chloroform	S	---	<0.005
Carbon Tetrachloride	S	---	<0.005
Trichloroethene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-03317
Date\Time Sampled			N/A
Dibromomethane	S	---	<0.010
Dichloromethane	S	---	<0.050
Bromochloromethane	S	---	<0.050
Bromodichloromethane	S	---	<0.010
Dibromochloromethane	S	---	<0.002
1,2 Dibromoethane	S	---	<0.002
1,2-Dichloroethane	S	---	<0.010
Tetrachloroethene	S	---	<0.002
1,1,1-Trichloroethane	S	---	<0.005
1,1,2-Trichloroethane	S	---	<0.005
Hexachlorobutadiene	S	---	<0.002
1,1,1,2-Tetrachloroethane	S	---	<0.010
1,1,2,2-Tetrachloroethane	S	---	<0.010
2 Chlorotoluene	S	---	<0.002
4 Chlorotoluene	S	---	<0.002
1,1-Dichloroethene	S	---	<0.010
1,1-Dichloroethane	S	---	<0.010
cis-1,2-Dichloroethene	S	---	<0.010
trans-1,2-Dichloroethene	S	---	<0.010
1,2-Dichloropropane	S	---	<0.010
1,3-Dichloropropane	S	---	<0.010
2,2-Dichloropropane	S	---	<0.010
1,2,3 Trichloropropane	S	---	<0.010
1,1-Dichloropropene	S	---	<0.005
cis-1,3-Dichloropropene	S	---	<0.005
trans-1,3-Dichloropropene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-04-16 **Date completed:** 2024-05-13

Project number: 1000 **Report number:** 131419 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTP Raw
Sample Number			24-05307
Date\Time Sampled			N/A
pH - Value @ 25 ºC	A	WLAB065	8.2
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	19.8
Total Dissolved Solids @ 180°C	A	WLAB003	138
Suspended Solids at 105°C	A	WLAB004	11.3
Colour in PtCo Units	A	WLAB006	65
Turbidity in N.T.U	A	WLAB005	22
Total Alkalinity as $CaCO_3$	A	WLAB007	88
P-Alkalinity as $CaCO_3$	A	WLAB023	<5
Bicarbonate as HCO_3	A	WLAB023	107
Carbonate as CO_3	A	WLAB023	<5
Hydroxide as OH	A	WLAB023	<5
Total Hardness as $CaCO_3$	A	WLAB051	83
Calcium Hardness as $CaCO_3$	A	WLAB051	52
Magnesium Hardness as $CaCO_3$	A	WLAB051	32
Chloride as Cl	A	WLAB046	4
Chlorite as ClO	S	---	<0.0005
Sulphate as SO_4	A	WLAB046	13
Fluoride as F	A	WLAB014	<0.2
Nitrate as N	A	WLAB046	0.2
Nitrite as N	A	WLAB046	<0.05
Bromide as Br	S	---	0.1
Bromate as BrO	S	---	<0.0002
Silica as SiO_2	N	WLAB046	13.4
Ortho Phosphate as P	A	WLAB046	0.2
Total Cyanide as CN	S	---	<0.07
Hydrogen Sulfide	S	---	<0.1
Total Organic Carbon as C	A	WLAB060	2.9

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

Start date of analysis: 2024/04/18 Date of Issue: 2024/05/13

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CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-04-16 **Date completed:** 2024-05-13

Project number: 1000 **Report number:** 131419 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTP Raw
Sample Number			24-05307
Date\Time Sampled			N/A
Dissolved Organic Carbon as C	A	WLAB060	2.6
Dibromooacetic Acid	S	---	<0.0002
Dibromoacetonitrile	S	---	<0.0002
Dichloroacetic Acid	S	---	<0.0002
Chloroacetic Acid	S	---	<0.0002
Dichloromethane	S	---	<0.0002
Bromochloroacetic Acid	S	---	<0.0002
Bromodichloroacetic Acid	S	---	<0.0002
Chlorodibromoacetic Acid	S	---	<0.0002
Monobromoacetic Acid	S	---	<0.00001
Tribromoacetic Acid	S	---	<0.0005
Chemical Oxygen Demand as O_2 (Total)	A	WLAB018	16
Dissolved Oxygen as O_2	N	WLAB040	9.2
UV Absorbance at 254 nm	S	---	0.0646
UV Absorbance at 300 nm	S	---	0.0336
Chloroform as $CHCl_3$	S	---	<0.005
Bromoform as $CHBr_3$	S	---	<0.005
Dibromochloromethane as $CHBr_2Cl$	S	---	<0.002
Bromodichloromethane as $CHBrCl_2$	S	---	<0.010
Algae Identification	S	---	Aulacoseira granulata (121 cells/ml)
Algae Identification (continued)	S	---	Centric diatoms (40 cells/ml)
Algae Identification (continued)	S	---	Fragilaria sp (161 cells/ml)
Algae Identification (continued)	S	---	Microcystis sp (80 cells/ml)
Chlorophyll-a (µg/ℓ)	N	WLAB033	<1
Total Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	120
Faecal Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	2
Heterotrophic Plate Count (cfu/1 mℓ)	A	WLAB021	200
Cryptosporidium species / (10 ℓ)	S	---	0

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

Start date of analysis: 2024/04/18 Date of Issue: 2024/05/13

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Sampled by: Client

WATERLAB (Pty) Ltd

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T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-04-16 **Date completed:** 2024-05-13

Project number: 1000 **Report number:** 131419 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTP Raw
Sample Number			24-05307
Date\Time Sampled			N/A
Giardia species / (10 ℓ)	S	---	0
Free and Saline Ammonia as N	A	WLAB046	<0.1
Sodium as Na	A	WLAB015	6
Potassium as K	A	WLAB015	1.2
Calcium as Ca	A	WLAB015	21
Magnesium as Mg	A	WLAB015	8
Aluminium as Al	A	WLAB015	0.228
Aluminium as Al (Dissolved)	A	WLAB015	<0.100
Antimony as Sb	A	WLAB050	<0.001
Arsenic as As	A	WLAB050	<0.001
Barium as Ba	A	WLAB015	0.031
Total Chromium as Cr	A	WLAB015	<0.025
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	<0.010
Iron as Fe	A	WLAB015	0.236
Iron as Fe (Dissolved)	A	WLAB015	0.027
Ferrous Iron as Fe2+ (Dissolved)	N	WLAB045	<0.025
Manganese as Mn	A	WLAB015	<0.025
Manganese as Mn (Dissolved)	A	WLAB015	<0.025
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Selenium as Se	A	WLAB050	<0.001
Strontium as Sr	N	WLAB015	0.082
Thallium as Tl	N	WLAB050	<0.001
Vanadium as V	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	<0.025
% Anion-Cation Balance	N	---	95.8
TPH GRO C6-C10 & BTEX	S	---	See Below

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTP Raw
Sample Number			24-05307
Date\Time Sampled			N/A
TPH C10-C40	S	---	<0.382
TPH C10-C28	S	---	<0.382
TPH C28-C40	S	---	<0.382
Volatile Organic Compounds (VOCs)	S	---	See Below

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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TPH GRO C6-C10 & BTEX

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTP Raw
Sample Number			24-05307
Date\Time Sampled			N/A
MTBE	S	---	<0.005
Tame	S	---	<0.005
Benzene	S	---	<0.0004
Toluene	S	---	<0.001
Ethylbenzene	S	---	<0.0004
m+p-Xylene	S	---	<0.0008
o-Xylene	S	---	<0.0004
1,3,5-Trimethylbenzene	S	---	<0.0004
1,2,4-Trimethyl benzene	S	---	<0.0004
Naphthalene	S	---	<0.0004
GRO TPH (C6 – C10)	S	---	<0.010

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VOC

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTP Raw
Sample Number			24-05307
Date\Time Sampled			N/A
Benzene	S	---	<0.001
Toluene	S	---	<0.010
Ethylbenzene	S	---	<0.002
m+p Xylene	S	---	<0.004
o-Xylene	S	---	<0.002
1,3,5 Trimethyl benzene	S	---	<0.002
1,2,4 Trimethyl benzene	S	---	<0.002
n Propylbenzene	S	---	<0.002
Tertiary Butylbenzene	S	---	<0.002
Secondary Butylbenzene	S	---	<0.002
n Butylbenzene	S	---	<0.002
Isopropylbenzene	S	---	<0.002
Styrene	S	---	<0.005
4-Isopropyltoluene	S	---	<0.005
Bromobenzene	S	---	<0.002
Chlorobenzene	S	---	<0.002
1,2-Dichlorobenzene	S	---	<0.002
1,3 Dichlorobenzene	S	---	<0.002
1,4-Dichlorobenzene	S	---	<0.002
1,2,3 Trichlorobenzene	S	---	<0.002
1,2,4 Trichlorobenzene	S	---	<0.002
1,3,5-Trichlorobenzene	S	---	<0.002
Naphthalene	S	---	<0.002
Bromoform	S	---	<0.005
Chloroform	S	---	<0.005
Carbon Tetrachloride	S	---	<0.005
Trichloroethene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTP Raw
Sample Number			24-05307
Date\Time Sampled			N/A
Dibromomethane	S	---	<0.010
Dichloromethane	S	---	<0.050
Bromochloromethane	S	---	<0.050
Bromodichloromethane	S	---	<0.010
Dibromochloromethane	S	---	<0.002
1,2 Dibromoethane	S	---	<0.002
1,2-Dichloroethane	S	---	<0.010
Tetrachloroethene	S	---	<0.002
1,1,1-Trichloroethane	S	---	<0.005
1,1,2-Trichloroethane	S	---	<0.005
Hexachlorobutadiene	S	---	<0.002
1,1,1,2-Tetrachloroethane	S	---	<0.010
1,1,2,2-Tetrachloroethane	S	---	<0.010
2 Chlorotoluene	S	---	<0.002
4 Chlorotoluene	S	---	<0.002
1,1-Dichloroethene	S	---	<0.010
1,1-Dichloroethane	S	---	<0.010
cis-1,2-Dichloroethene	S	---	<0.010
trans-1,2-Dichloroethene	S	---	<0.010
1,2-Dichloropropane	S	---	<0.010
1,3-Dichloropropane	S	---	<0.010
2,2-Dichloropropane	S	---	<0.010
1,2,3 Trichloropropane	S	---	<0.010
1,1-Dichloropropene	S	---	<0.005
cis-1,3-Dichloropropene	S	---	<0.005
trans-1,3-Dichloropropene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-04-26 **Date completed:** 2024-06-03

Project number: 1000 **Report number:** 131735 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-06379
Date\Time Sampled			N/A
pH - Value @ 25 ºC	A	WLAB065	8.1
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	19.8
Total Dissolved Solids @ 180°C	A	WLAB003	142
Suspended Solids at 105°C	A	WLAB004	14.0
Colour in PtCo Units	A	WLAB006	68
Turbidity in N.T.U	A	WLAB005	26
Total Alkalinity as $CaCO_3$	A	WLAB007	92
P-Alkalinity as $CaCO_3$	A	WLAB023	<5
Bicarbonate as HCO_3	A	WLAB023	112
Carbonate as CO_3	A	WLAB023	<5
Hydroxide Alkalinity as $CaCO_3$	A	WLAB023	<5
Total Hardness as $CaCO_3$	A	WLAB051	83
Calcium Hardness as $CaCO_3$	A	WLAB051	50
Magnesium Hardness as $CaCO_3$	A	WLAB051	33
Chloride as Cl	A	WLAB046	4
Sulphate as SO_4	A	WLAB046	17
Fluoride as F	A	WLAB014	<0.2
Nitrate as N	A	WLAB046	<0.1
Nitrite as N	A	WLAB046	<0.05
Bromide as Br	S	---	<0.1
Silica as SiO_2	N	WLAB046	12.8
Ortho Phosphate as P	A	WLAB046	<0.1
Total Cyanide as CN	S	---	<0.07
Hydrogen Sulfide	S	---	<0.1
Total Organic Carbon as C	A	WLAB060	2.8
Dibromooacetic Acid	S	---	<0.0002
Dibromoacetonitrile	S	---	<0.0002

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

Start date of analysis: 2024/04/29 Date of Issue: 2024/07/29

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Project number: 1000 **Report number:** 131735 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-06379
Date\Time Sampled			N/A
Dichloroacetic Acid	S	---	<0.0002
Chloroacetic Acid	S	---	<0.0002
Dichloromethane	S	---	<0.0002
Bromochloroacetic Acid	S	---	<0.0002
Bromodichloroacetic Acid	S	---	<0.0002
Chlorodibromoacetic Acid	S	---	<0.0002
Dissolved Organic Carbon as C	A	WLAB060	2.8
Monobromoacetic Acid	S	---	<0.00001
Tribromoacetic Acid	S	---	<0.0005
Chemical Oxygen Demand as O_2 (Total)	A	WLAB018	<10
Dissolved Oxygen as O_2	N	WLAB040	9.0
UV Absorbance at 254 nm	S	---	0.0633
UV Absorbance at 300 nm	S	---	0.0401
Chloroform as $CHCl_3$	S	---	<0.005
Bromoform as $CHBr_3$	S	---	<0.005
Dibromochloromethane as $CHBr_2Cl$	S	---	<0.002
Bromodichloromethane as $CHBrCl_2$	S	---	<0.010
Chlorophyll-a (µg/ℓ)	N	WLAB033	5
Total Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	500
Faecal Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	2
Heterotrophic Plate Count (cfu/1 mℓ)	A	WLAB021	670
Free and Saline Ammonia as N	A	WLAB046	<0.1
Sodium as Na	A	WLAB015	8
Potassium as K	A	WLAB015	1.4
Calcium as Ca	A	WLAB015	20
Magnesium as Mg	A	WLAB015	8
Aluminium as Al	A	WLAB015	0.239
Aluminium as Al (Dissolved)	A	WLAB015	<0.100



A. van de Wetering - Chemical Technical Signatory



M. Nkambule - Microbiological Technical Signatory

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T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-04-26 **Date completed:** 2024-06-03

Project number: 1000 **Report number:** 131735 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-06379
Date\Time Sampled			N/A
Antimony as Sb	A	WLAB050	<0.001
Arsenic as As	A	WLAB050	0.001
Barium as Ba	A	WLAB015	0.042
Total Chromium as Cr	A	WLAB015	<0.025
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	<0.010
Iron as Fe	A	WLAB015	0.239
Iron as Fe (Dissolved)	A	WLAB015	0.051
Ferrous Iron as Fe2+ (Dissolved)	N	WLAB045	<0.025
Manganese as Mn	A	WLAB015	<0.025
Manganese as Mn (Dissolved)	A	WLAB015	<0.025
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Selenium as Se	A	WLAB050	<0.001
Strontium as Sr	N	WLAB015	0.072
Thallium as Tl	N	WLAB050	<0.001
Vanadium as V	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	<0.025
% Anion-Cation Balance	N	---	95.0
TPH GRO C6-C10 & BTEX	S	---	See Below
TPH C10-C40	S	---	<0.382
TPH C10-C28	S	---	<0.382
TPH C28-C40	S	---	<0.382
Volatile Organic Compounds (VOCs)	S	---	See Below



A. van de Wetering - Chemical Technical Signatory



M. Nkambule - Microbiological Technical Signatory

Start date of analysis: 2024/04/29 Date of Issue: 2024/07/29

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Sampled by: Client

WATERLAB (Pty) Ltd

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Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

TPH GRO C6-C10 & BTEX

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-06379
Date\Time Sampled			N/A
MTBE	S	---	<0.005
Tame	S	---	<0.005
Benzene	S	---	<0.0004
Toluene	S	---	<0.001
Ethylbenzene	S	---	<0.0004
m+p-Xylene	S	---	<0.0008
o-Xylene	S	---	<0.0004
1,3,5-Trimethylbenzene	S	---	<0.0004
1,2,4-Trimethyl benzene	S	---	<0.0004
Naphthalene	S	---	<0.0004
GRO TPH (C6 – C10)	S	---	<0.010

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

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VOC

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-06379
Date\Time Sampled			N/A
Benzene	S	---	<0.001
Toluene	S	---	<0.010
Ethylbenzene	S	---	<0.002
m+p Xylene	S	---	<0.004
o-Xylene	S	---	<0.002
1,3,5 Trimethyl benzene	S	---	<0.002
1,2,4 Trimethyl benzene	S	---	<0.002
n Propylbenzene	S	---	<0.002
Tertiary Butylbenzene	S	---	<0.002
Secondary Butylbenzene	S	---	<0.002
n Butylbenzene	S	---	<0.002
Isopropylbenzene	S	---	<0.002
Styrene	S	---	<0.005
4-Isopropyltoluene	S	---	<0.005
Bromobenzene	S	---	<0.002
Chlorobenzene	S	---	<0.002
1,2-Dichlorobenzene	S	---	<0.002
1,3 Dichlorobenzene	S	---	<0.002
1,4-Dichlorobenzene	S	---	<0.002
1,2,3 Trichlorobenzene	S	---	<0.002
1,2,4 Trichlorobenzene	S	---	<0.002
1,3,5-Trichlorobenzene	S	---	<0.002
Naphthalene	S	---	<0.002
Bromoform	S	---	<0.005
Chloroform	S	---	<0.005
Carbon Tetrachloride	S	---	<0.005
Trichloroethene	S	---	<0.005



A. van de Wetering - Chemical Technical Signatory



M. Nkambule - Microbiological Technical Signatory

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Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-06379
Date\Time Sampled			N/A
Dibromomethane	S	---	<0.010
Dichloromethane	S	---	<0.050
Bromochloromethane	S	---	<0.050
Bromodichloromethane	S	---	<0.010
Dibromochloromethane	S	---	<0.002
1,2 Dibromoethane	S	---	<0.002
1,2-Dichloroethane	S	---	<0.010
Tetrachloroethene	S	---	<0.002
1,1,1-Trichloroethane	S	---	<0.005
1,1,2-Trichloroethane	S	---	<0.005
Hexachlorobutadiene	S	---	<0.002
1,1,1,2-Tetrachloroethane	S	---	<0.010
1,1,2,2-Tetrachloroethane	S	---	<0.010
2 Chlorotoluene	S	---	<0.002
4 Chlorotoluene	S	---	<0.002
1,1-Dichloroethene	S	---	<0.010
1,1-Dichloroethane	S	---	<0.010
cis-1,2-Dichloroethene	S	---	<0.010
trans-1,2-Dichloroethene	S	---	<0.010
1,2-Dichloropropane	S	---	<0.010
1,3-Dichloropropane	S	---	<0.010
2,2-Dichloropropane	S	---	<0.010
1,2,3 Trichloropropane	S	---	<0.010
1,1-Dichloropropene	S	---	<0.005
cis-1,3-Dichloropropene	S	---	<0.005
trans-1,3-Dichloropropene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

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CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-05-08 **Date completed:** 2024-06-07

Project number: 1000 **Report number:** 132069 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-07337
Date\Time Sampled			N/A
pH - Value @ 25 ºC	A	WLAB065	8.1
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	20.5
Total Dissolved Solids @ 180°C	A	WLAB003	128
Suspended Solids at 105°C	A	WLAB004	42
Colour in PtCo Units	A	WLAB006	15
Turbidity in N.T.U	A	WLAB005	28
Total Alkalinity as $CaCO_3$	A	WLAB007	84
P-Alkalinity as $CaCO_3$	A	WLAB023	<5
Bicarbonate as HCO_3	A	WLAB023	102
Carbonate as CO_3	A	WLAB023	<5
Hydroxide Alkalinity as $CaCO_3$	A	WLAB023	<5
Total Hardness as $CaCO_3$	A	WLAB051	81
Calcium Hardness as $CaCO_3$	A	WLAB051	51
Magnesium Hardness as $CaCO_3$	A	WLAB051	31
Chloride as Cl	A	WLAB046	4
Chlorite as ClO	S	---	<0.0005
Sulphate as SO_4	A	WLAB046	10
Fluoride as F	A	WLAB014	0.2
Nitrate as N	A	WLAB046	<0.1
Nitrite as N	A	WLAB046	<0.05
Bromide as Br	S	---	0.3
Bromate as BrO	S	---	<0.0002
Silica as SiO_2	N	WLAB046	13.2
Ortho Phosphate as P	A	WLAB046	<0.1
Total Cyanide as CN	S	---	<0.07
Hydrogen Sulfide	S	---	<0.1
Total Organic Carbon as C	A	WLAB060	2.6



A. van de Wetering - Chemical Technical Signatory



M. Nkambule - Microbiological Technical Signatory

Start date of analysis: 2024/05/09 Date of Issue: 2024/07/17

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Sampled by: Waterlab

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Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-07337
Date\Time Sampled			N/A
Dissolved Organic Carbon as C	A	WLAB060	2.2
Dibromooacetic Acid	S	---	<0.0002
Dibromoacetonitrile	S	---	<0.0002
Dichloroacetic Acid	S	---	<0.0002
Chloroacetic Acid	S	---	<0.0002
Dichloromethane	S	---	<0.0002
Bromochloroacetic Acid	S	---	<0.0002
Bromodichloroacetic Acid	S	---	<0.0002
Chlorodibromoacetic Acid	S	---	<0.0002
Monobromoacetic Acid	S	---	<0.00001
Tribromoacetic Acid	S	---	<0.0005
Chemical Oxygen Demand as O_2 (Total)	A	WLAB018	20
Dissolved Oxygen as O_2	N	WLAB040	8.9
UV Absorbance at 254 nm	S	---	0.0657
UV Absorbance at 300 nm	S	---	0.0299
Chloroform as $CHCl_3$	S	---	<0.005
Bromoform as $CHBr_3$	S	---	<0.005
Dibromochloromethane as $CHBr_2Cl$	S	---	<0.002
Bromodichloromethane as $CHBrCl_2$	S	---	<0.010
Algae Identification	S	---	Aulacoseira granulata (121 cells/ml)
Algae Identification (continued)	S	---	Centric diatoms (40 cells/ml)
Algae Identification (continued)	S	---	Fragilaria sp (1247 cells/ml|)
Algae Identification (continued)	S	---	Microcystis sp (80 cells/ml)
Chlorophyll-a (µg/ℓ)	N	WLAB033	3
Total Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	2000
Faecal Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	1
Heterotrophic Plate Count (cfu/1 mℓ)	A	WLAB021	560
Cryptosporidium species / (10 ℓ)	S	---	0

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M. Nkambule - Microbiological Technical Signatory

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Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-07337
Date\Time Sampled			N/A
Giardia species / (10 ℓ)	S	---	0
Free and Saline Ammonia as N	A	WLAB046	<0.1
Sodium as Na	A	WLAB015	7
Potassium as K	A	WLAB015	1.3
Calcium as Ca	A	WLAB015	20
Magnesium as Mg	A	WLAB015	7
Aluminium as Al	A	WLAB015	0.229
Aluminium as Al (Dissolved)	A	WLAB015	<0.100
Antimony as Sb	A	WLAB050	<0.001
Arsenic as As	A	WLAB050	<0.001
Barium as Ba	A	WLAB015	0.039
Total Chromium as Cr	A	WLAB015	<0.025
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	<0.010
Iron as Fe	A	WLAB015	0.192
Iron as Fe (Dissolved)	A	WLAB015	0.038
Manganese as Mn	A	WLAB015	<0.025
Manganese as Mn (Dissolved)	A	WLAB015	<0.025
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Selenium as Se	A	WLAB050	<0.001
Strontium as Sr	N	WLAB015	0.075
Thallium as Tl	N	WLAB050	<0.001
Vanadium as V	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	<0.025
% Anion-Cation Balance	N	---	97.5
TPH GRO C6-C10 & BTEX	S	---	See Below
TPH C10-C40	S	---	<0.382

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

Start date of analysis: 2024/05/09 Date of Issue: 2024/07/17

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Sampled by: Waterlab

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Project number: 1000 **Report number:** 132069 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

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Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-07337
Date\Time Sampled			N/A
TPH C10-C28	S	---	<0.382
TPH C28-C40	S	---	<0.382
Volatile Organic Compounds (VOCs)	S	---	See Below

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M. Nkambule - Microbiological Technical Signatory

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T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-05-08 **Date completed:** 2024-06-07

Project number: 1000 **Report number:** 132069 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

TPH GRO C6-C10 & BTEX

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-07337
Date\Time Sampled			N/A
MTBE	S	---	<0.005
Tame	S	---	<0.005
Benzene	S	---	<0.0004
Toluene	S	---	<0.001
Ethylbenzene	S	---	<0.0004
m+p-Xylene	S	---	<0.0008
o-Xylene	S	---	<0.0004
1,3,5-Trimethylbenzene	S	---	<0.0004
1,2,4-Trimethyl benzene	S	---	<0.0004
Naphthalene	S	---	<0.0004
GRO TPH (C6 – C10)	S	---	<0.010



A. van de Wetering - Chemical Technical Signatory



M. Nkambule - Microbiological Technical Signatory

Start date of analysis: 2024/05/09 Date of Issue: 2024/07/17

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Sampled by: Waterlab

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

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VOC

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-07337
Date\Time Sampled			N/A
Benzene	S	---	<0.001
Toluene	S	---	<0.010
Ethylbenzene	S	---	<0.002
m+p Xylene	S	---	<0.004
o-Xylene	S	---	<0.002
1,3,5 Trimethyl benzene	S	---	<0.002
1,2,4 Trimethyl benzene	S	---	<0.002
n Propylbenzene	S	---	<0.002
Tertiary Butylbenzene	S	---	<0.002
Secondary Butylbenzene	S	---	<0.002
n Butylbenzene	S	---	<0.002
Isopropylbenzene	S	---	<0.002
Styrene	S	---	<0.005
4-Isopropyltoluene	S	---	<0.005
Bromobenzene	S	---	<0.002
Chlorobenzene	S	---	<0.002
1,2-Dichlorobenzene	S	---	<0.002
1,3 Dichlorobenzene	S	---	<0.002
1,4-Dichlorobenzene	S	---	<0.002
1,2,3 Trichlorobenzene	S	---	<0.002
1,2,4 Trichlorobenzene	S	---	<0.002
1,3,5-Trichlorobenzene	S	---	<0.002
Naphthalene	S	---	<0.002
Bromoform	S	---	<0.005
Chloroform	S	---	<0.005
Carbon Tetrachloride	S	---	<0.005
Trichloroethene	S	---	<0.005



A. van de Wetering - Chemical Technical Signatory



M. Nkambule - Microbiological Technical Signatory

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Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-07337
Date\Time Sampled			N/A
Dibromomethane	S	---	<0.010
Dichloromethane	S	---	<0.050
Bromochloromethane	S	---	<0.050
Bromodichloromethane	S	---	<0.010
Dibromochloromethane	S	---	<0.002
1,2 Dibromoethane	S	---	<0.002
1,2-Dichloroethane	S	---	<0.010
Tetrachloroethene	S	---	<0.002
1,1,1-Trichloroethane	S	---	<0.005
1,1,2-Trichloroethane	S	---	<0.005
Hexachlorobutadiene	S	---	<0.002
1,1,1,2-Tetrachloroethane	S	---	<0.010
1,1,2,2-Tetrachloroethane	S	---	<0.010
2 Chlorotoluene	S	---	<0.002
4 Chlorotoluene	S	---	<0.002
1,1-Dichloroethene	S	---	<0.010
1,1-Dichloroethane	S	---	<0.010
cis-1,2-Dichloroethene	S	---	<0.010
trans-1,2-Dichloroethene	S	---	<0.010
1,2-Dichloropropane	S	---	<0.010
1,3-Dichloropropane	S	---	<0.010
2,2-Dichloropropane	S	---	<0.010
1,2,3 Trichloropropane	S	---	<0.010
1,1-Dichloropropene	S	---	<0.005
cis-1,3-Dichloropropene	S	---	<0.005
trans-1,3-Dichloropropene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

Start date of analysis: 2024/05/09 Date of Issue: 2024/07/17

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CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-05-20 **Date completed:** 2024-07-09

Project number: 1000 **Report number:** 132517 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-08731
Date\Time Sampled			N/A
pH - Value @ 25 °C	A	WLAB065	8.1
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	19.7
Total Dissolved Solids @ 180°C	A	WLAB003	142
Suspended Solids at 105°C	A	WLAB004	<1.0
Colour in PtCo Units	A	WLAB006	29
Turbidity in N.T.U	A	WLAB005	28
Total Alkalinity as $CaCO_3$	A	WLAB007	84
P-Alkalinity as $CaCO_3$	A	WLAB023	<5
Bicarbonate as HCO_3	A	WLAB023	102
Carbonate as CO_3	A	WLAB023	<5
Hydroxide Alkalinity as $CaCO_3$	A	WLAB023	<5
Total Hardness as $CaCO_3$	A	WLAB051	93
Calcium Hardness as $CaCO_3$	A	WLAB051	59
Magnesium Hardness as $CaCO_3$	A	WLAB051	34
Chloride as Cl	A	WLAB046	3
Sulphate as SO_4	A	WLAB046	21
Fluoride as F	A	WLAB014	0.3
Nitrate as N	A	WLAB046	3.2
Nitrite as N	A	WLAB046	<0.05
Bromide as Br	S	---	0.2
Silica as SiO_2	N	WLAB046	12.7
Ortho Phosphate as P	A	WLAB046	0.1
Total Cyanide as CN	S	---	<0.07
Hydrogen Sulfide	S	---	<0.1
Total Organic Carbon as C	A	WLAB060	2.4
Dissolved Organic Carbon as C	A	WLAB060	2.3
Dibromooacetic Acid	S	---	<0.0002

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

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Sampled by: Waterlab

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Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-08731
Date\Time Sampled			N/A
Dibromoacetonitrile	S	---	<0.0002
Dichloroacetic Acid	S	---	<0.0002
Chloroacetic Acid	S	---	<0.0002
Dichloromethane	S	---	<0.0002
Bromochloroacetic Acid	S	---	<0.0002
Bromodichloroacetic Acid	S	---	<0.0002
Chlorodibromoacetic Acid	S	---	<0.0002
Monobromoacetic Acid	S	---	<0.00001
Tribromoacetic Acid	S	---	<0.0005
Chemical Oxygen Demand as O_2 (Total)	A	WLAB018	<10
Dissolved Oxygen as O_2	N	WLAB040	9.1
UV Absorbance at 254 nm	S	---	0.0688
UV Absorbance at 300 nm	S	---	0.0362
Chloroform as $CHCl_3$	S	---	<0.005
Bromoform as $CHBr_3$	S	---	<0.005
Dibromochloromethane as $CHBr_2Cl$	S	---	<0.002
Bromodichloromethane as $CHBrCl_2$	S	---	<0.010
Chlorophyll-a (µg/ℓ)	N	WLAB033	2
Total Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	1100
Faecal Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	1
Heterotrophic Plate Count (cfu/1 mℓ)	A	WLAB021	65
Free and Saline Ammonia as N	A	WLAB046	<0.1
Sodium as Na	A	WLAB015	8
Potassium as K	A	WLAB015	1.8
Calcium as Ca	A	WLAB015	24
Magnesium as Mg	A	WLAB015	8
Aluminium as Al	A	WLAB015	0.327
Aluminium as Al (Dissolved)	A	WLAB015	0.108

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

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Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-08731
Date\Time Sampled			N/A
Antimony as Sb	A	WLAB050	<0.001
Arsenic as As	A	WLAB050	<0.001
Barium as Ba	A	WLAB015	0.034
Total Chromium as Cr	A	WLAB015	<0.025
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	0.019
Iron as Fe	A	WLAB015	0.200
Iron as Fe (Dissolved)	A	WLAB015	0.066
Manganese as Mn	A	WLAB015	<0.025
Manganese as Mn (Dissolved)	A	WLAB015	<0.025
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Selenium as Se	A	WLAB050	<0.001
Strontium as Sr	N	WLAB015	0.090
Thallium as Tl	N	WLAB050	<0.001
Vanadium as V	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	<0.025
% Anion-Cation Balance	N	---	95.5
TPH GRO C6-C10 & BTEX	S	---	See Below
TPH C10-C40	S	---	<0.382
TPH C10-C28	S	---	<0.382
TPH C28-C40	S	---	<0.382
Volatile Organic Compounds (VOCs)	S	---	See Below

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

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TPH GRO C6-C10 & BTEX

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-08731
Date\Time Sampled			N/A
MTBE	S	---	<0.005
Tame	S	---	<0.005
Benzene	S	---	<0.0004
Toluene	S	---	<0.001
Ethylbenzene	S	---	<0.0004
m+p-Xylene	S	---	<0.0008
o-Xylene	S	---	<0.0004
1,3,5-Trimethylbenzene	S	---	<0.0004
1,2,4-Trimethyl benzene	S	---	<0.0004
Naphthalene	S	---	<0.0004
GRO TPH (C6 – C10)	S	---	<0.010

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VOC

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-08731
Date\Time Sampled			N/A
Benzene	S	---	<0.001
Toluene	S	---	<0.010
Ethylbenzene	S	---	<0.002
m+p Xylene	S	---	<0.004
o-Xylene	S	---	<0.002
1,3,5 Trimethyl benzene	S	---	<0.002
1,2,4 Trimethyl benzene	S	---	<0.002
n Propylbenzene	S	---	<0.002
Tertiary Butylbenzene	S	---	<0.002
Secondary Butylbenzene	S	---	<0.002
n Butylbenzene	S	---	<0.002
Isopropylbenzene	S	---	<0.002
Styrene	S	---	<0.005
4-Isopropyltoluene	S	---	<0.005
Bromobenzene	S	---	<0.002
Chlorobenzene	S	---	<0.002
1,2-Dichlorobenzene	S	---	<0.002
1,3 Dichlorobenzene	S	---	<0.002
1,4-Dichlorobenzene	S	---	<0.002
1,2,3 Trichlorobenzene	S	---	<0.002
1,2,4 Trichlorobenzene	S	---	<0.002
1,3,5-Trichlorobenzene	S	---	<0.002
Naphthalene	S	---	<0.002
Bromoform	S	---	<0.005
Chloroform	S	---	<0.005
Carbon Tetrachloride	S	---	<0.005
Trichloroethene	S	---	<0.005



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M. Nkambule - Microbiological Technical Signatory

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Sampled by: Waterlab

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

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T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-05-20 **Date completed:** 2024-07-09

Project number: 1000 **Report number:** 132517 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-08731
Date\Time Sampled			N/A
Dibromomethane	S	---	<0.010
Dichloromethane	S	---	<0.050
Bromochloromethane	S	---	<0.050
Bromodichloromethane	S	---	<0.010
Dibromochloromethane	S	---	<0.002
1,2 Dibromoethane	S	---	<0.002
1,2-Dichloroethane	S	---	<0.010
Tetrachloroethene	S	---	<0.002
1,1,1-Trichloroethane	S	---	<0.005
1,1,2-Trichloroethane	S	---	<0.005
Hexachlorobutadiene	S	---	<0.002
1,1,1,2-Tetrachloroethane	S	---	<0.010
1,1,2,2-Tetrachloroethane	S	---	<0.010
2 Chlorotoluene	S	---	<0.002
4 Chlorotoluene	S	---	<0.002
1,1-Dichloroethene	S	---	<0.010
1,1-Dichloroethane	S	---	<0.010
cis-1,2-Dichloroethene	S	---	<0.010
trans-1,2-Dichloroethene	S	---	<0.010
1,2-Dichloropropane	S	---	<0.010
1,3-Dichloropropane	S	---	<0.010
2,2-Dichloropropane	S	---	<0.010
1,2,3 Trichloropropane	S	---	<0.010
1,1-Dichloropropene	S	---	<0.005
cis-1,3-Dichloropropene	S	---	<0.005
trans-1,3-Dichloropropene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

Start date of analysis: 2024/05/20 Date of Issue: 2024/07/09

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CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-06-04 **Date completed:** 2024-07-09

Project number: 1000 **Report number:** 132950 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-10223
Date\Time Sampled			N/A
pH - Value @ 25 °C	A	WLAB065	8.1
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	19.0
Total Dissolved Solids @ 180°C	A	WLAB003	118
Suspended Solids at 105°C	A	WLAB004	6.7
Colour in PtCo Units	A	WLAB006	17
Turbidity in N.T.U	A	WLAB005	29
Total Alkalinity as $CaCO_3$	A	WLAB007	80
P-Alkalinity as $CaCO_3$	A	WLAB023	<5
Bicarbonate as HCO_3	A	WLAB023	98
Carbonate as CO_3	A	WLAB023	<5
Hydroxide Alkalinity as $CaCO_3$	A	WLAB023	<5
Total Hardness as $CaCO_3$	A	WLAB051	84
Calcium Hardness as $CaCO_3$	A	WLAB051	51
Magnesium Hardness as $CaCO_3$	A	WLAB051	34
Chloride as Cl	A	WLAB046	4
Chlorite as ClO	S	---	<0.0005
Sulphate as SO_4	A	WLAB046	14
Fluoride as F	A	WLAB014	<0.2
Nitrate as N	A	WLAB046	2.0
Nitrite as N	A	WLAB046	<0.05
Bromide as Br	S	---	0.2
Bromate as BrO	S	---	<0.0002
Silica as SiO_2	N	WLAB046	13.7
Ortho Phosphate as P	A	WLAB046	0.2
Total Cyanide as CN	S	---	<0.07
Hydrogen Sulfide	S	---	<0.1
Total Organic Carbon as C	A	WLAB060	2.5



A. van de Wetering - Chemical Technical Signatory



M. Nkambule - Microbiological Technical Signatory

Start date of analysis: 2024/06/05 Date of Issue: 2024/07/09

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Date received: 2024-06-04 **Date completed:** 2024-07-09

Project number: 1000 **Report number:** 132950 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-10223
Date\Time Sampled			N/A
Dissolved Organic Carbon as C	A	WLAB060	2.3
Dibromooacetic Acid	S	---	<0.0002
Dibromoacetonitrile	S	---	<0.0002
Dichloroacetic Acid	S	---	<0.0002
Chloroacetic Acid	S	---	<0.0002
Dichloromethane	S	---	<0.0002
Bromochloroacetic Acid	S	---	<0.0002
Bromodichloroacetic Acid	S	---	<0.0002
Chlorodibromoacetic Acid	S	---	<0.0002
Monobromoacetic Acid	S	---	<0.00001
Tribromoacetic Acid	S	---	<0.0005
Chemical Oxygen Demand as O_2 (Total)	A	WLAB018	12
Dissolved Oxygen as O_2	N	WLAB040	7.9
UV Absorbance at 254 nm	S	---	0.0079
UV Absorbance at 300 nm	S	---	0.0234
Chloroform as $CHCl_3$	S	---	<0.005
Bromoform as $CHBr_3$	S	---	<0.005
Dibromochloromethane as $CHBr_2Cl$	S	---	<0.002
Bromodichloromethane as $CHBrCl_2$	S	---	<0.010
Algae Identification	S	---	Aulacoseira granulata (40 cells/ml)
Algae Identification (continued)	S	---	Centric diatoms (121 cells/ml)
Algae Identification (continued)	S	---	Fragilaria sp (161 cells/ml)
Algae Identification (continued)	S	---	Microcystis sp (161 cells/ml)
Chlorophyll-a (µg/ℓ)	N	WLAB033	<1
Total Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	1300
Faecal Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	19
Heterotrophic Plate Count (cfu/1 mℓ)	A	WLAB021	130
Cryptosporidium species / (10 ℓ)	S	---	0

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M. Nkambule - Microbiological Technical Signatory

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Date received: 2024-06-04 **Date completed:** 2024-07-09

Project number: 1000 **Report number:** 132950 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-10223
Date\Time Sampled			N/A
Giardia species / (10 ℓ)	S	---	0
Free and Saline Ammonia as N	A	WLAB046	<0.1
Sodium as Na	A	WLAB015	8
Potassium as K	A	WLAB015	1.6
Calcium as Ca	A	WLAB015	20
Magnesium as Mg	A	WLAB015	8
Aluminium as Al	A	WLAB015	0.224
Aluminium as Al (Dissolved)	A	WLAB015	0.106
Antimony as Sb	A	WLAB050	<0.001
Arsenic as As	A	WLAB050	<0.001
Barium as Ba	A	WLAB015	0.033
Total Chromium as Cr	A	WLAB015	<0.025
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	0.026
Iron as Fe	A	WLAB015	0.157
Iron as Fe (Dissolved)	A	WLAB015	0.042
Manganese as Mn	A	WLAB015	<0.025
Manganese as Mn (Dissolved)	A	WLAB015	<0.025
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Selenium as Se	A	WLAB050	<0.001
Strontium as Sr	N	WLAB015	0.080
Thallium as Tl	N	WLAB050	<0.001
Vanadium as V	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	0.040
% Anion-Cation Balance	N	---	97.2
TPH GRO C6-C10 & BTEX	S	---	See Below
TPH C10-C40	S	---	<0.382

A. van de Wetering - Chemical Technical Signatory

M. Nkambule - Microbiological Technical Signatory

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Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-10223
Date\Time Sampled			N/A
TPH C10-C28	S	---	<0.382
TPH C28-C40	S	---	<0.382
Volatile Organic Compounds (VOCs)	S	---	See Below

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M. Nkambule - Microbiological Technical Signatory

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Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

TPH GRO C6-C10 & BTEX

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-10223
Date\Time Sampled			N/A
MTBE	S	---	<0.005
Tame	S	---	<0.005
Benzene	S	---	<0.0004
Toluene	S	---	<0.001
Ethylbenzene	S	---	<0.0004
m+p-Xylene	S	---	<0.0008
o-Xylene	S	---	<0.0004
1,3,5-Trimethylbenzene	S	---	<0.0004
1,2,4-Trimethyl benzene	S	---	<0.0004
Naphthalene	S	---	<0.0004
GRO TPH (C6 – C10)	S	---	<0.010

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VOC

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-10223
Date\Time Sampled			N/A
Benzene	S	---	<0.001
Toluene	S	---	<0.010
Ethylbenzene	S	---	<0.002
m+p Xylene	S	---	<0.004
o-Xylene	S	---	<0.002
1,3,5 Trimethyl benzene	S	---	<0.002
1,2,4 Trimethyl benzene	S	---	<0.002
n Propylbenzene	S	---	<0.002
Tertiary Butylbenzene	S	---	<0.002
Secondary Butylbenzene	S	---	<0.002
n Butylbenzene	S	---	<0.002
Isopropylbenzene	S	---	<0.002
Styrene	S	---	<0.005
4-Isopropyltoluene	S	---	<0.005
Bromobenzene	S	---	<0.002
Chlorobenzene	S	---	<0.002
1,2-Dichlorobenzene	S	---	<0.002
1,3 Dichlorobenzene	S	---	<0.002
1,4-Dichlorobenzene	S	---	<0.002
1,2,3 Trichlorobenzene	S	---	<0.002
1,2,4 Trichlorobenzene	S	---	<0.002
1,3,5-Trichlorobenzene	S	---	<0.002
Naphthalene	S	---	<0.002
Bromoform	S	---	<0.005
Chloroform	S	---	<0.005
Carbon Tetrachloride	S	---	<0.005
Trichloroethene	S	---	<0.005

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M. Nkambule - Microbiological Technical Signatory

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Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-10223
Date\Time Sampled			N/A
Dibromomethane	S	---	<0.010
Dichloromethane	S	---	<0.050
Bromochloromethane	S	---	<0.050
Bromodichloromethane	S	---	<0.010
Dibromochloromethane	S	---	<0.002
1,2 Dibromoethane	S	---	<0.002
1,2-Dichloroethane	S	---	<0.010
Tetrachloroethene	S	---	<0.002
1,1,1-Trichloroethane	S	---	<0.005
1,1,2-Trichloroethane	S	---	<0.005
Hexachlorobutadiene	S	---	<0.002
1,1,1,2-Tetrachloroethane	S	---	<0.010
1,1,2,2-Tetrachloroethane	S	---	<0.010
2 Chlorotoluene	S	---	<0.002
4 Chlorotoluene	S	---	<0.002
1,1-Dichloroethene	S	---	<0.010
1,1-Dichloroethane	S	---	<0.010
cis-1,2-Dichloroethene	S	---	<0.010
trans-1,2-Dichloroethene	S	---	<0.010
1,2-Dichloropropane	S	---	<0.010
1,3-Dichloropropane	S	---	<0.010
2,2-Dichloropropane	S	---	<0.010
1,2,3 Trichloropropane	S	---	<0.010
1,1-Dichloropropene	S	---	<0.005
cis-1,3-Dichloropropene	S	---	<0.005
trans-1,3-Dichloropropene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

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Sampled by: Waterlab

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

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T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-06-19 **Date completed:** 2024-07-23

Project number: 1000 **Report number:** 133443 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-11854
Date\Time Sampled			N/A
pH - Value @ 25 ºC	A	WLAB065	8.1
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	20.4
Total Dissolved Solids @ 180°C	A	WLAB003	142
Suspended Solids at 105°C	A	WLAB004	4.7
Colour in PtCo Units	A	WLAB006	23
Turbidity in N.T.U	A	WLAB005	26
Total Alkalinity as $CaCO_3$	A	WLAB007	84
P-Alkalinity as $CaCO_3$	A	WLAB023	<5
Bicarbonate as HCO_3	A	WLAB023	102
Carbonate as CO_3	A	WLAB023	<5
Hydroxide Alkalinity as $CaCO_3$	A	WLAB023	<5
Total Hardness as $CaCO_3$	A	WLAB051	82
Calcium Hardness as $CaCO_3$	A	WLAB051	52
Magnesium Hardness as $CaCO_3$	A	WLAB051	31
Chloride as Cl	A	WLAB046	4
Sulphate as SO_4	A	WLAB046	10
Fluoride as F	A	WLAB014	<0.2
Nitrate as N	A	WLAB046	1.5
Nitrite as N	A	WLAB046	<0.05
Bromide as Br	S	---	0.2
Silica as SiO_2	N	WLAB046	15.5
Ortho Phosphate as P	A	WLAB046	<0.1
Total Cyanide as CN	S	---	<0.07
Hydrogen Sulfide	S	---	<0.1
Total Organic Carbon as C	A	WLAB060	2.6
Dissolved Organic Carbon as C	A	WLAB060	2.2
Dibromooacetic Acid	S	---	<0.0002

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

Start date of analysis: 2024/06/20 Date of Issue: 2024/07/23

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Sampled by: Waterlab

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Project number: 1000 **Report number:** 133443 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-11854
Date\Time Sampled			N/A
Dibromoacetonitrile	S	---	<0.0002
Dichloroacetic Acid	S	---	<0.0002
Chloroacetic Acid	S	---	<0.0002
Dichloromethane	S	---	<0.0002
Bromochloroacetic Acid	S	---	<0.0002
Bromodichloroacetic Acid	S	---	<0.0002
Chlorodibromoacetic Acid	S	---	<0.0002
Monobromoacetic Acid	S	---	<0.00001
Tribromoacetic Acid	S	---	<0.0005
Chemical Oxygen Demand as O_2 (Total)	A	WLAB018	<10
Dissolved Oxygen as O_2	N	WLAB040	8.2
UV Absorbance at 254 nm	S	---	0.0624
UV Absorbance at 300 nm	S	---	0.0345
Chloroform as $CHCl_3$	S	---	<0.005
Bromoform as $CHBr_3$	S	---	<0.005
Dibromochloromethane as $CHBr_2Cl$	S	---	<0.002
Bromodichloromethane as $CHBrCl_2$	S	---	<0.010
Chlorophyll-a (µg/ℓ)	N	WLAB033	2
Total Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	580
Faecal Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	2
Heterotrophic Plate Count (cfu/1 mℓ)	A	WLAB021	72
Free and Saline Ammonia as N	A	WLAB046	<0.1
Sodium as Na	A	WLAB015	6
Potassium as K	A	WLAB015	1.3
Calcium as Ca	A	WLAB015	21
Magnesium as Mg	A	WLAB015	7
Aluminium as Al	A	WLAB015	0.489
Aluminium as Al (Dissolved)	A	WLAB015	<0.100

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

Start date of analysis: 2024/06/20 Date of Issue: 2024/07/23

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Project number: 1000 **Report number:** 133443 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-11854
Date\Time Sampled			N/A
Antimony as Sb	A	WLAB050	<0.001
Arsenic as As	A	WLAB050	<0.001
Barium as Ba	A	WLAB015	0.031
Total Chromium as Cr	A	WLAB015	<0.025
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	<0.010
Iron as Fe	A	WLAB015	0.318
Iron as Fe (Dissolved)	A	WLAB015	0.060
Manganese as Mn	A	WLAB015	<0.025
Manganese as Mn (Dissolved)	A	WLAB015	<0.025
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Selenium as Se	A	WLAB050	<0.001
Strontium as Sr	N	WLAB015	0.084
Thallium as Tl	N	WLAB050	<0.001
Vanadium as V	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	<0.025
% Anion-Cation Balance	N	---	97.2
TPH GRO C6-C10 & BTEX	S	---	See Below
TPH C10-C40	S	---	<0.382
TPH C10-C28	S	---	<0.382
TPH C28-C40	S	---	<0.382
Volatile Organic Compounds (VOCs)	S	---	See Below

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Date received: 2024-06-19 **Date completed:** 2024-07-23

Project number: 1000 **Report number:** 133443 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

TPH GRO C6-C10 & BTEX

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-11854
Date\Time Sampled			N/A
MTBE	S	---	<0.005
Tame	S	---	<0.005
Benzene	S	---	<0.0004
Toluene	S	---	<0.001
Ethylbenzene	S	---	<0.0004
m+p-Xylene	S	---	<0.0008
o-Xylene	S	---	<0.0004
1,3,5-Trimethylbenzene	S	---	<0.0004
1,2,4-Trimethyl benzene	S	---	<0.0004
Naphthalene	S	---	<0.0004
GRO TPH (C6 – C10)	S	---	<0.010

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D.O. Mohlaloga - Microbiological Technical Signatory

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Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

VOC

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-11854
Date\Time Sampled			N/A
Benzene	S	---	<0.001
Toluene	S	---	<0.010
Ethylbenzene	S	---	<0.002
m+p Xylene	S	---	<0.004
o-Xylene	S	---	<0.002
1,3,5 Trimethyl benzene	S	---	<0.002
1,2,4 Trimethyl benzene	S	---	<0.002
n Propylbenzene	S	---	<0.002
Tertiary Butylbenzene	S	---	<0.002
Secondary Butylbenzene	S	---	<0.002
n Butylbenzene	S	---	<0.002
Isopropylbenzene	S	---	<0.002
Styrene	S	---	<0.005
4-Isopropyltoluene	S	---	<0.005
Bromobenzene	S	---	<0.002
Chlorobenzene	S	---	<0.002
1,2-Dichlorobenzene	S	---	<0.002
1,3 Dichlorobenzene	S	---	<0.002
1,4-Dichlorobenzene	S	---	<0.002
1,2,3 Trichlorobenzene	S	---	<0.002
1,2,4 Trichlorobenzene	S	---	<0.002
1,3,5-Trichlorobenzene	S	---	<0.002
Naphthalene	S	---	<0.002
Bromoform	S	---	<0.005
Chloroform	S	---	<0.005
Carbon Tetrachloride	S	---	<0.005
Trichloroethene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Project number: 1000 **Report number:** 133443 **Order number:**

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Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-11854
Date\Time Sampled			N/A
Dibromomethane	S	---	<0.010
Dichloromethane	S	---	<0.050
Bromochloromethane	S	---	<0.050
Bromodichloromethane	S	---	<0.010
Dibromochloromethane	S	---	<0.002
1,2 Dibromoethane	S	---	<0.002
1,2-Dichloroethane	S	---	<0.010
Tetrachloroethene	S	---	<0.002
1,1,1-Trichloroethane	S	---	<0.005
1,1,2-Trichloroethane	S	---	<0.005
Hexachlorobutadiene	S	---	<0.002
1,1,1,2-Tetrachloroethane	S	---	<0.010
1,1,2,2-Tetrachloroethane	S	---	<0.010
2 Chlorotoluene	S	---	<0.002
4 Chlorotoluene	S	---	<0.002
1,1-Dichloroethene	S	---	<0.010
1,1-Dichloroethane	S	---	<0.010
cis-1,2-Dichloroethene	S	---	<0.010
trans-1,2-Dichloroethene	S	---	<0.010
1,2-Dichloropropane	S	---	<0.010
1,3-Dichloropropane	S	---	<0.010
2,2-Dichloropropane	S	---	<0.010
1,2,3 Trichloropropane	S	---	<0.010
1,1-Dichloropropene	S	---	<0.005
cis-1,3-Dichloropropene	S	---	<0.005
trans-1,3-Dichloropropene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

Start date of analysis: 2024/06/20 Date of Issue: 2024/07/23

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CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-07-03 **Date completed:** 2024-08-06

Project number: 1000 **Report number:** 133809 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-13168
Date\Time Sampled			N/A
pH - Value @ 25 ºC	A	WLAB065	7.9
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	19.4
Total Dissolved Solids @ 180°C	A	WLAB003	122
Suspended Solids at 105°C	A	WLAB004	8.7
Colour in PtCo Units	A	WLAB006	14
Turbidity in N.T.U	A	WLAB005	27
Total Alkalinity as $CaCO_3$	A	WLAB007	88
P-Alkalinity as $CaCO_3$	A	WLAB023	<5
Bicarbonate as HCO_3	A	WLAB023	107
Carbonate as CO_3	A	WLAB023	<5
Hydroxide Alkalinity as $CaCO_3$	A	WLAB023	<5
Total Hardness as $CaCO_3$	A	WLAB051	81
Calcium Hardness as $CaCO_3$	A	WLAB051	50
Magnesium Hardness as $CaCO_3$	A	WLAB051	30
Chloride as Cl	A	WLAB046	3
Chlorite as ClO	S	---	<0.0005
Sulphate as SO_4	A	WLAB046	9
Fluoride as F	A	WLAB014	<0.2
Nitrate as N	A	WLAB046	1.0
Nitrite as N	A	WLAB046	<0.05
Bromide as Br	S	---	<0.1
Bromate as BrO	S	---	<0.0002
Silica as SiO_2	N	WLAB046	13.6
Ortho Phosphate as P	A	WLAB046	<0.1
Total Cyanide as CN	S	---	<0.07
Hydrogen Sulfide	S	---	<0.1
Total Organic Carbon as C	A	WLAB060	2.7

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

Start date of analysis: 2024/07/03 Date of Issue: 2024/08/06

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Date received: 2024-07-03 **Date completed:** 2024-08-06

Project number: 1000 **Report number:** 133809 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-13168
Date\Time Sampled			N/A
Dibromooacetic Acid	S	---	<0.0002
Dibromoacetonitrile	S	---	<0.0002
Dichloroacetic Acid	S	---	<0.0002
Chloroacetic Acid	S	---	<0.0002
Dichloromethane	S	---	<0.0002
Bromochloroacetic Acid	S	---	<0.0002
Bromodichloroacetic Acid	S	---	<0.0002
Chlorodibromoacetic Acid	S	---	<0.0002
Dissolved Organic Carbon as C	A	WLAB060	2.4
Monobromoacetic Acid	S	---	<0.00001
Tribromoacetic Acid	S	---	<0.0005
Chemical Oxygen Demand as O_2 (Total)	A	WLAB018	16
Dissolved Oxygen as O_2	N	WLAB040	7.9
UV Absorbance at 254 nm	S	---	0.0066
UV Absorbance at 300 nm	S	---	0.0219
Chloroform as $CHCl_3$	S	---	<0.005
Bromoform as $CHBr_3$	S	---	<0.005
Dibromochloromethane as $CHBr_2Cl$	S	---	<0.002
Bromodichloromethane as $CHBrCl_2$	S	---	<0.010
Algae Identification	S	---	Aulacoseira granulata (121 cells/ml)
Algae Identification (continued)	S	---	Centric diatoms (161 cells/ml)
Algae Identification (continued)	S	---	Chlorella sp (40 cells/ml)
Algae Identification (continued)	S	---	Cyclotella sp (121 cells/ml)
Algae Identification (continued)	S	---	Fragilaria sp (322 cells/ml)
Algae Identification (continued)	S	---	Microcystis sp (40 cells/ml)
Chlorophyll-a (µg/ℓ)	N	WLAB033	<1
Total Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	650
Faecal Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	<1

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

Start date of analysis: 2024/07/03 Date of Issue: 2024/08/06

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Sampled by: Waterlab

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

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T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-07-03 **Date completed:** 2024-08-06

Project number: 1000 **Report number:** 133809 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-13168
Date\Time Sampled			N/A
Heterotrophic Plate Count (cfu/1 mℓ)	A	WLAB021	7600
Cryptosporidium species / (10 ℓ)	S	---	0
Giardia species / (10 ℓ)	S	---	0
Free and Saline Ammonia as N	A	WLAB046	<0.1
Sodium as Na	A	WLAB015	7
Potassium as K	A	WLAB015	1.5
Calcium as Ca	A	WLAB015	20
Magnesium as Mg	A	WLAB015	7
Aluminium as Al	A	WLAB015	0.224
Aluminium as Al (Dissolved)	A	WLAB015	<0.100
Antimony as Sb	A	WLAB050	<0.001
Arsenic as As	A	WLAB050	<0.001
Barium as Ba	A	WLAB015	0.033
Total Chromium as Cr	A	WLAB015	<0.025
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	<0.010
Iron as Fe	A	WLAB015	0.184
Iron as Fe (Dissolved)	A	WLAB015	0.030
Manganese as Mn	A	WLAB015	<0.025
Manganese as Mn (Dissolved)	A	WLAB015	<0.025
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Selenium as Se	A	WLAB050	<0.001
Strontium as Sr	N	WLAB015	0.082
Thallium as Tl	N	WLAB050	<0.001
Vanadium as V	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	<0.025
% Anion-Cation Balance	N	---	95.4

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-13168
Date\Time Sampled			N/A
TPH GRO C6-C10 & BTEX	S	---	See Below
TPH C10-C40	S	---	<0.382
TPH C10-C28	S	---	<0.382
TPH C28-C40	S	---	<0.382
Volatile Organic Compounds (VOCs)	S	---	See Below

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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TPH GRO C6-C10 & BTEX

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-13168
Date\Time Sampled			N/A
MTBE	S	---	<0.005
Tame	S	---	<0.005
Benzene	S	---	<0.0004
Toluene	S	---	<0.001
Ethylbenzene	S	---	<0.0004
m+p-Xylene	S	---	<0.0008
o-Xylene	S	---	<0.0004
1,3,5-Trimethylbenzene	S	---	<0.0004
1,2,4-Trimethyl benzene	S	---	<0.0004
Naphthalene	S	---	<0.0004
GRO TPH (C6 – C10)	S	---	<0.010

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Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

VOC

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-13168
Date\Time Sampled			N/A
Benzene	S	---	<0.001
Toluene	S	---	<0.010
Ethylbenzene	S	---	<0.002
m+p Xylene	S	---	<0.004
o-Xylene	S	---	<0.002
1,3,5 Trimethyl benzene	S	---	<0.002
1,2,4 Trimethyl benzene	S	---	<0.002
n Propylbenzene	S	---	<0.002
Tertiary Butylbenzene	S	---	<0.002
Secondary Butylbenzene	S	---	<0.002
n Butylbenzene	S	---	<0.002
Isopropylbenzene	S	---	<0.002
Styrene	S	---	<0.005
4-Isopropyltoluene	S	---	<0.005
Bromobenzene	S	---	<0.002
Chlorobenzene	S	---	<0.002
1,2-Dichlorobenzene	S	---	<0.002
1,3 Dichlorobenzene	S	---	<0.002
1,4-Dichlorobenzene	S	---	<0.002
1,2,3 Trichlorobenzene	S	---	<0.002
1,2,4 Trichlorobenzene	S	---	<0.002
1,3,5-Trichlorobenzene	S	---	<0.002
Naphthalene	S	---	<0.002
Bromoform	S	---	<0.005
Chloroform	S	---	<0.005
Carbon Tetrachloride	S	---	<0.005
Trichloroethene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep Dam WTW Raw
Sample Number			24-13168
Date\Time Sampled			N/A
Dibromomethane	S	---	<0.010
Dichloromethane	S	---	<0.050
Bromochloromethane	S	---	<0.050
Bromodichloromethane	S	---	<0.010
Dibromochloromethane	S	---	<0.002
1,2 Dibromoethane	S	---	<0.002
1,2-Dichloroethane	S	---	<0.010
Tetrachloroethene	S	---	<0.002
1,1,1-Trichloroethane	S	---	<0.005
1,1,2-Trichloroethane	S	---	<0.005
Hexachlorobutadiene	S	---	<0.002
1,1,1,2-Tetrachloroethane	S	---	<0.010
1,1,2,2-Tetrachloroethane	S	---	<0.010
2 Chlorotoluene	S	---	<0.002
4 Chlorotoluene	S	---	<0.002
1,1-Dichloroethene	S	---	<0.010
1,1-Dichloroethane	S	---	<0.010
cis-1,2-Dichloroethene	S	---	<0.010
trans-1,2-Dichloroethene	S	---	<0.010
1,2-Dichloropropane	S	---	<0.010
1,3-Dichloropropane	S	---	<0.010
2,2-Dichloropropane	S	---	<0.010
1,2,3 Trichloropropane	S	---	<0.010
1,1-Dichloropropene	S	---	<0.005
cis-1,3-Dichloropropene	S	---	<0.005
trans-1,3-Dichloropropene	S	---	<0.005

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Date received: 2024-07-16 **Date completed:** 2024-08-16

Project number: 1000 **Report number:** 134328 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-14757
Date\Time Sampled			N/A
pH - Value @ 25 ºC	A	WLAB065	8.1
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	19.5
Total Dissolved Solids @ 180°C	A	WLAB003	138
Suspended Solids at 105°C	A	WLAB004	1.1
Colour in PtCo Units	A	WLAB006	122
Turbidity in N.T.U	A	WLAB005	23
Total Alkalinity as $CaCO_3$	A	WLAB007	88
P-Alkalinity as $CaCO_3$	A	WLAB023	<5
Bicarbonate as HCO_3	A	WLAB023	107
Carbonate as CO_3	A	WLAB023	<5
Hydroxide Alkalinity as $CaCO_3$	A	WLAB023	<5
Total Hardness as $CaCO_3$	A	WLAB051	86
Calcium Hardness as $CaCO_3$	A	WLAB051	53
Magnesium Hardness as $CaCO_3$	A	WLAB051	33
Chloride as Cl	A	WLAB046	3
Sulphate as SO_4	A	WLAB046	14
Fluoride as F	A	WLAB014	<0.2
Nitrate as N	A	WLAB046	1.8
Nitrite as N	A	WLAB046	<0.05
Bromide as Br	S	---	0.1
Silica as SiO_2	N	WLAB046	27
Ortho Phosphate as P	A	WLAB046	<0.1
Total Cyanide as CN	S	---	<0.07
Hydrogen Sulfide	S	---	<0.1
Total Organic Carbon as C	A	WLAB060	2.5
Dibromooacetic Acid	S	---	<0.0002
Dibromoacetonitrile	S	---	<0.0002

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

Start date of analysis: 2024/07/17 Date of Issue: 2024/08/16

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Project number: 1000 **Report number:** 134328 **Order number:**

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Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-14757
Date\Time Sampled			N/A
Dichloroacetic Acid	S	---	<0.0002
Chloroacetic Acid	S	---	<0.0002
Dichloromethane	S	---	<0.0002
Bromochloroacetic Acid	S	---	<0.0002
Bromodichloroacetic Acid	S	---	<0.0002
Chlorodibromoacetic Acid	S	---	<0.0002
Dissolved Organic Carbon as C	A	WLAB060	2.3
Monobromoacetic Acid	S	---	<0.00001
Tribromoacetic Acid	S	---	<0.0005
Chemical Oxygen Demand as O_2 (Total)	A	WLAB018	16
Dissolved Oxygen as O_2	N	WLAB040	8.3
UV Absorbance at 254 nm	S	---	0.0242
UV Absorbance at 300 nm	S	---	0.0250
Chloroform as $CHCl_3$	S	---	<0.005
Bromoform as $CHBr_3$	S	---	<0.005
Dibromochloromethane as $CHBr_2Cl$	S	---	<0.002
Bromodichloromethane as $CHBrCl_2$	S	---	<0.010
Chlorophyll-a (µg/ℓ)	N	WLAB033	2
Total Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	390
Faecal Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	<1
Heterotrophic Plate Count (cfu/1 mℓ)	A	WLAB021	22
Free and Saline Ammonia as N	A	WLAB046	0.1
Sodium as Na	A	WLAB015	8
Potassium as K	A	WLAB015	1.6
Calcium as Ca	A	WLAB015	21
Magnesium as Mg	A	WLAB015	8
Aluminium as Al	A	WLAB015	0.290
Aluminium as Al (Dissolved)	A	WLAB015	0.126

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-14757
Date\Time Sampled			N/A
Antimony as Sb	A	WLAB050	<0.001
Arsenic as As	A	WLAB050	<0.001
Barium as Ba	A	WLAB015	0.041
Total Chromium as Cr	A	WLAB015	<0.025
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	<0.010
Iron as Fe	A	WLAB015	0.226
Iron as Fe (Dissolved)	A	WLAB015	0.078
Manganese as Mn	A	WLAB015	<0.025
Manganese as Mn (Dissolved)	A	WLAB015	<0.025
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Selenium as Se	A	WLAB050	<0.001
Strontium as Sr	N	WLAB015	0.083
Thallium as Tl	N	WLAB050	<0.001
Vanadium as V	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	<0.025
% Anion-Cation Balance	N	---	96.4
TPH GRO C6-C10 & BTEX	S	---	See Below
TPH C10-C40	S	---	<0.382
TPH C10-C28	S	---	<0.382
TPH C28-C40	S	---	<0.382
Volatile Organic Compounds (VOCs)	S	---	See Below

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

Start date of analysis: 2024/07/17 Date of Issue: 2024/08/16

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Sampled by: Waterlab

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

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T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-07-16 **Date completed:** 2024-08-16

Project number: 1000 **Report number:** 134328 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

TPH GRO C6-C10 & BTEX

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-14757
Date\Time Sampled			N/A
MTBE	S	---	<0.005
Tame	S	---	<0.005
Benzene	S	---	<0.0004
Toluene	S	---	<0.001
Ethylbenzene	S	---	<0.0004
m+p-Xylene	S	---	<0.0008
o-Xylene	S	---	<0.0004
1,3,5-Trimethylbenzene	S	---	<0.0004
1,2,4-Trimethyl benzene	S	---	<0.0004
Naphthalene	S	---	<0.0004
GRO TPH (C6 – C10)	S	---	<0.010

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

VOC

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-14757
Date\Time Sampled			N/A
Benzene	S	---	<0.001
Toluene	S	---	<0.010
Ethylbenzene	S	---	<0.002
m+p Xylene	S	---	<0.004
o-Xylene	S	---	<0.002
1,3,5 Trimethyl benzene	S	---	<0.002
1,2,4 Trimethyl benzene	S	---	<0.002
n Propylbenzene	S	---	<0.002
Tertiary Butylbenzene	S	---	<0.002
Secondary Butylbenzene	S	---	<0.002
n Butylbenzene	S	---	<0.002
Isopropylbenzene	S	---	<0.002
Styrene	S	---	<0.005
4-Isopropyltoluene	S	---	<0.005
Bromobenzene	S	---	<0.002
Chlorobenzene	S	---	<0.002
1,2-Dichlorobenzene	S	---	<0.002
1,3 Dichlorobenzene	S	---	<0.002
1,4-Dichlorobenzene	S	---	<0.002
1,2,3 Trichlorobenzene	S	---	<0.002
1,2,4 Trichlorobenzene	S	---	<0.002
1,3,5-Trichlorobenzene	S	---	<0.002
Naphthalene	S	---	<0.002
Bromoform	S	---	<0.005
Chloroform	S	---	<0.005
Carbon Tetrachloride	S	---	<0.005
Trichloroethene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Date received: 2024-07-16 **Date completed:** 2024-08-16

Project number: 1000 **Report number:** 134328 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-14757
Date\Time Sampled			N/A
Dibromomethane	S	---	<0.010
Dichloromethane	S	---	<0.050
Bromochloromethane	S	---	<0.050
Bromodichloromethane	S	---	<0.010
Dibromochloromethane	S	---	<0.002
1,2 Dibromoethane	S	---	<0.002
1,2-Dichloroethane	S	---	<0.010
Tetrachloroethene	S	---	<0.002
1,1,1-Trichloroethane	S	---	<0.005
1,1,2-Trichloroethane	S	---	<0.005
Hexachlorobutadiene	S	---	<0.002
1,1,1,2-Tetrachloroethane	S	---	<0.010
1,1,2,2-Tetrachloroethane	S	---	<0.010
2 Chlorotoluene	S	---	<0.002
4 Chlorotoluene	S	---	<0.002
1,1-Dichloroethene	S	---	<0.010
1,1-Dichloroethane	S	---	<0.010
cis-1,2-Dichloroethene	S	---	<0.010
trans-1,2-Dichloroethene	S	---	<0.010
1,2-Dichloropropane	S	---	<0.010
1,3-Dichloropropane	S	---	<0.010
2,2-Dichloropropane	S	---	<0.010
1,2,3 Trichloropropane	S	---	<0.010
1,1-Dichloropropene	S	---	<0.005
cis-1,3-Dichloropropene	S	---	<0.005
trans-1,3-Dichloropropene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-08-07 **Date completed:** 2024-09-11

Project number: 1000 **Report number:** 134933 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-16528
Date\Time Sampled			N/A
pH - Value @ 25 ºC	A	WLAB065	8.1
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	19.2
Total Dissolved Solids @ 180°C	A	WLAB003	130
Suspended Solids at 105°C	A	WLAB004	8.7
Colour in PtCo Units	A	WLAB006	9
Turbidity in N.T.U	A	WLAB005	22
Total Alkalinity as $CaCO_3$	A	WLAB007	88
P-Alkalinity as $CaCO_3$	A	WLAB023	<5
Bicarbonate as HCO_3	A	WLAB023	107
Carbonate as CO_3	A	WLAB023	<5
Hydroxide Alkalinity as $CaCO_3$	A	WLAB023	<5
Total Hardness as $CaCO_3$	A	WLAB051	84
Calcium Hardness as $CaCO_3$	A	WLAB051	54
Magnesium Hardness as $CaCO_3$	A	WLAB051	30
Chloride as Cl	A	WLAB046	2
Chlorite as ClO	S	---	<0.0005
Sulphate as SO_4	A	WLAB046	7
Fluoride as F	A	WLAB014	0.2
Nitrate as N	A	WLAB046	0.4
Nitrite as N	A	WLAB046	<0.05
Bromide as Br	S	---	0.4
Bromate as BrO	S	---	<0.0002
Silica as SiO_2	N	WLAB046	16.3
Ortho Phosphate as P	A	WLAB046	<0.1
Total Cyanide as CN	S	---	<0.07
Hydrogen Sulfide	S	---	<0.1
Total Organic Carbon as C	A	WLAB060	2.8

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D.O. Mohlaloga - Microbiological Technical Signatory

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Project number: 1000 **Report number:** 134933 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-16528
Date\Time Sampled			N/A
Dibromooacetic Acid	S	---	<0.0002
Dibromoacetonitrile	S	---	<0.0002
Dichloroacetic Acid	S	---	<0.0002
Chloroacetic Acid	S	---	<0.0002
Dichloromethane	S	---	<0.0002
Bromochloroacetic Acid	S	---	<0.0002
Bromodichloroacetic Acid	S	---	<0.0002
Chlorodibromoacetic Acid	S	---	<0.0002
Dissolved Organic Carbon as C	A	WLAB060	2.6
Monobromoacetic Acid	S	---	<0.00001
Tribromoacetic Acid	S	---	<0.0005
Chemical Oxygen Demand as O_2 (Total)	A	WLAB018	<10
Dissolved Oxygen as O_2	N	WLAB040	9.0
UV Absorbance at 254 nm	S	---	0.0523
UV Absorbance at 300 nm	S	---	0.0384
Chloroform as $CHCl_3$	S	---	<0.005
Bromoform as $CHBr_3$	S	---	<0.005
Dibromochloromethane as $CHBr_2Cl$	S	---	<0.002
Bromodichloromethane as $CHBrCl_2$	S	---	<0.010
Algae Identification	S	---	Aulacoseira granulata (626 cells/ml)
Algae Identification	S	---	Centric diatoms (536 cells/ml)
Algae Identification	S	---	Chlorella sp (89 cells/ml)
Algae Identification	S	---	Cryptomonas minor (89 cells/ml)
Algae Identification	S	---	Microcystis sp (179 cells/ml)
Chlorophyll-a (µg/ℓ)	N	WLAB033	2
Total Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	520
Faecal Coliform Bacteria (MPN/100 mℓ)	A	WLAB021	<1
Heterotrophic Plate Count (cfu/1 mℓ)	A	WLAB021	690

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D.O. Mohlaloga - Microbiological Technical Signatory

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Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-16528
Date\Time Sampled			N/A
Cryptosporidium species / (10 ℓ)	S	---	0
Giardia species / (10 ℓ)	S	---	0
Free and Saline Ammonia as N	A	WLAB046	<0.1
Sodium as Na	A	WLAB015	7
Potassium as K	A	WLAB015	1.2
Calcium as Ca	A	WLAB015	22
Magnesium as Mg	A	WLAB015	7
Aluminium as Al	A	WLAB015	0.214
Aluminium as Al (Dissolved)	A	WLAB015	<0.100
Antimony as Sb	A	WLAB050	<0.001
Arsenic as As	A	WLAB050	0.001
Barium as Ba	A	WLAB015	0.057
Total Chromium as Cr	A	WLAB015	<0.025
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	<0.010
Iron as Fe	A	WLAB015	0.200
Iron as Fe (Dissolved)	A	WLAB015	<0.025
Manganese as Mn	A	WLAB015	<0.025
Manganese as Mn (Dissolved)	A	WLAB015	<0.025
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Selenium as Se	A	WLAB050	<0.001
Strontium as Sr	N	WLAB015	0.099
Thallium as Tl	N	WLAB050	<0.001
Vanadium as V	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	<0.025
% Anion-Cation Balance	N	---	99.7
TPH GRO C6-C10 & BTEX	S	---	See Below

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D.O. Mohlaloga - Microbiological Technical Signatory

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Project number: 1000 **Report number:** 134933 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-16528
Date\Time Sampled			N/A
TPH C10-C40	S	---	<0.382
TPH C10-C28	S	---	<0.382
TPH C28-C40	S	---	<0.382
Volatile Organic Compounds (VOCs)	S	---	See Below

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

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Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

TPH GRO C6-C10 & BTEX

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-16528
Date\Time Sampled			N/A
MTBE	S	---	<0.005
Tame	S	---	<0.005
Benzene	S	---	<0.0004
Toluene	S	---	<0.001
Ethylbenzene	S	---	<0.0004
m+p-Xylene	S	---	<0.0008
o-Xylene	S	---	<0.0004
1,3,5-Trimethylbenzene	S	---	<0.0004
1,2,4-Trimethyl benzene	S	---	<0.0004
Naphthalene	S	---	<0.0004
GRO TPH (C6 – C10)	S	---	<0.010

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

Start date of analysis: 2024/08/07 Date of Issue: 2024/09/11

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Sampled by: Waterlab

WATERLAB (Pty) Ltd

Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891

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T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-08-07 **Date completed:** 2024-09-11

Project number: 1000 **Report number:** 134933 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

VOC

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-16528
Date\Time Sampled			N/A
Benzene	S	---	<0.001
Toluene	S	---	<0.010
Ethylbenzene	S	---	<0.002
m+p Xylene	S	---	<0.004
o-Xylene	S	---	<0.002
1,3,5 Trimethyl benzene	S	---	<0.002
1,2,4 Trimethyl benzene	S	---	<0.002
n Propylbenzene	S	---	<0.002
Tertiary Butylbenzene	S	---	<0.002
Secondary Butylbenzene	S	---	<0.002
n Butylbenzene	S	---	<0.002
Isopropylbenzene	S	---	<0.002
Styrene	S	---	<0.005
4-Isopropyltoluene	S	---	<0.005
Bromobenzene	S	---	<0.002
Chlorobenzene	S	---	<0.002
1,2-Dichlorobenzene	S	---	<0.002
1,3 Dichlorobenzene	S	---	<0.002
1,4-Dichlorobenzene	S	---	<0.002
1,2,3 Trichlorobenzene	S	---	<0.002
1,2,4 Trichlorobenzene	S	---	<0.002
1,3,5-Trichlorobenzene	S	---	<0.002
Naphthalene	S	---	<0.002
Bromoform	S	---	<0.005
Chloroform	S	---	<0.005
Carbon Tetrachloride	S	---	<0.005
Trichloroethene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

Start date of analysis: 2024/08/07 Date of Issue: 2024/09/11

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Sampled by: Waterlab

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T0391

CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2024-08-07 **Date completed:** 2024-09-11

Project number: 1000 **Report number:** 134933 **Order number:**

Client name: Zutari Pty Ltd **Contact person:** Mr. L. Krouwkamp

Address: **e-mail:** louis.krouwkamp@zutari.com; Tony.Cero

Telephone: 021 526 5742 **Facsimile:** **Mobile:** 083 406 0789

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification
			Gariep WTW Raw
Sample Number			24-16528
Date\Time Sampled			N/A
Dibromomethane	S	---	<0.010
Dichloromethane	S	---	<0.050
Bromochloromethane	S	---	<0.050
Bromodichloromethane	S	---	<0.010
Dibromochloromethane	S	---	<0.002
1,2 Dibromoethane	S	---	<0.002
1,2-Dichloroethane	S	---	<0.010
Tetrachloroethene	S	---	<0.002
1,1,1-Trichloroethane	S	---	<0.005
1,1,2-Trichloroethane	S	---	<0.005
Hexachlorobutadiene	S	---	<0.002
1,1,1,2-Tetrachloroethane	S	---	<0.010
1,1,2,2-Tetrachloroethane	S	---	<0.010
2 Chlorotoluene	S	---	<0.002
4 Chlorotoluene	S	---	<0.002
1,1-Dichloroethene	S	---	<0.010
1,1-Dichloroethane	S	---	<0.010
cis-1,2-Dichloroethene	S	---	<0.010
trans-1,2-Dichloroethene	S	---	<0.010
1,2-Dichloropropane	S	---	<0.010
1,3-Dichloropropane	S	---	<0.010
2,2-Dichloropropane	S	---	<0.010
1,2,3 Trichloropropane	S	---	<0.010
1,1-Dichloropropene	S	---	<0.005
cis-1,3-Dichloropropene	S	---	<0.005
trans-1,3-Dichloropropene	S	---	<0.005

A. van de Wetering - Chemical Technical Signatory

D.O. Mohlaloga - Microbiological Technical Signatory

Start date of analysis: 2024/08/07 Date of Issue: 2024/09/11

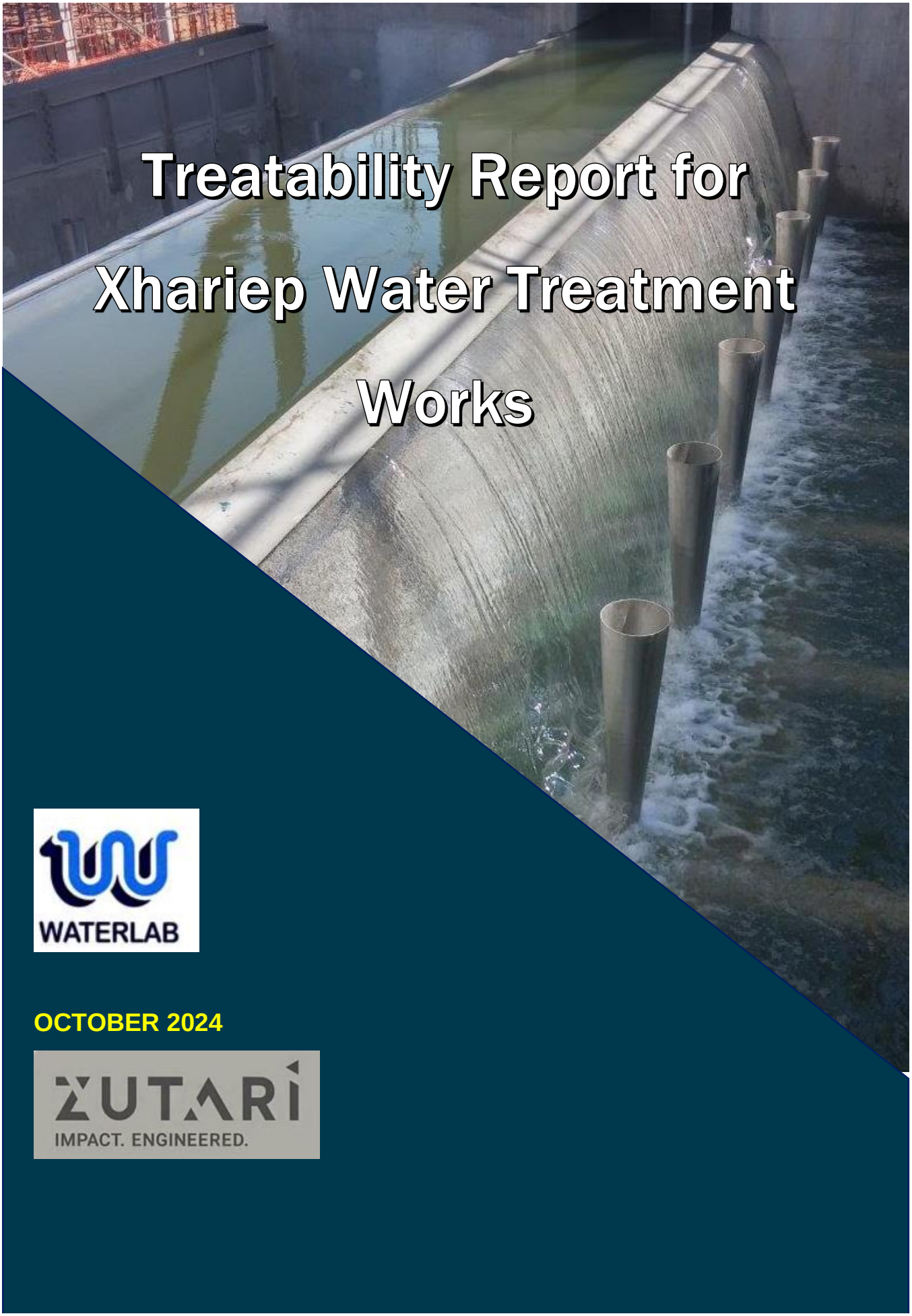
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Sampled by: Waterlab

Appendix B: Treatability Test Report



Treatability Report for Xhariep Water Treatment Works

WATERLAB

OCTOBER 2024

ZUTARI
IMPACT. ENGINEERED.

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1. Introduction

Waterlab was appointed by Zutari to collect samples from the Xhariep Water Treatment Works for a period of five weeks every week. Samples were collected at different locations during each visit including: -

- 5 samples of the raw water
- 4 samples of water discharged from elevated tanks *
- 5 samples of water within the distribution system *

Along with a full chemical and microbiological analysis the following analysis were requested.

- Jar tests to determine optimum dosage.
- Chlorine demand tests on the raw water
- Chlorine decay tests on the raw water
- Determine Total Trihalomethane Formation Potential

This report focuses on these aspects of the scope of work provided.

*Only the raw water samples have been considered in this report.

2. Raw Water Quality

Samples have been drawn from the Xhariep Dam over a period of 6 months from March to August 2024 and a full set of analysis have been performed on each of these samples. The water is characterized by a low to medium turbidity, low incidence of algae in the samples (winter season) and low nutrients. Samples were collected and analysed as per the table below.

Table 1: Sample collection and report dates for Xhariep Raw Water

No	Date of collection	Report Number
1	2024/03/18	130515
2	2024/04/02	130851-A
3	2024/04/18	131419
4	2024/04/29	131735
5	2024/05/09	132069
6	2024/05/20	132517
7	2024/06/05	132950
8	2024/06/20	133443
9	2024/07/03	133809
10	2024/07/17	134328
11	2024/08/07	134933
12	2024/08/22	135467

The water quality of Xhariep dam is provided in table 2. Parameters which are required for testing and risk assessment as part of Water Safety Planning were analysed and the SANS 241 drinking water standard was used to determine the potential risks within the raw water. Results which are non-compliant with SANS 241 are highlighted in red as identified risks within the raw water while compliant

results are highlighted in green. This classification allows us to determine which parameters are potential risks within this system.

The table shows that the water quality is generally good and has a stable pH of approximately 8.1 with turbidity fluctuation of between 17 and 28 NTU for the samples analysed. Turbidity and colour measured indicates that the raw water has some suspended and organic material present, however Total Organic Carbon levels were low at a maximum of 2.8mg/L. Chlorophyll levels were low during the assessment period ranging between 0.9 and 5 µg/L while nutrient levels including orthophosphate ammonia and nitrate were also found to be low. Algal species included *Aulacoseira granulata, Cryptomonas, Fragilaria, Centric Diatoms* and some *Microcystis* species albeit at low levels.

The microbiological quality of the raw water is good although not suitable for drinking without treatment (disinfection). Some high coliform counts and heterotrophic counts are evident. No protozoan parasites were found to be present in any of the samples tested.

Table 2: Summary of Raw Water Quality at Xhariep

Date	Units	SANS 241 Limits	Minimum	50th percentile	95th percentile	Maximum
pH - Value @ 25 ºC	pH units	5.0-9.7	7,9	8,1	8,1	8,1
Electrical Conductivity @ 25°C	mS/m	≤ 170	19,2	19,8	100	100
Total Dissolved Solids @ 180°C	mg/L	≤ 1200	122	142	722	722
Suspended Solids at 105°C	mg/L	-	1,1	10,45	32,1	42
Colour	Pt/Co units	≤ 15	9	15	68	122
Turbidity	NTU	≤ 1 ≤ 5	17	23	28	28
Total Alkalinity as $CaCO_3$	mg/L	-	84	88	88	92
P-Alkalinity as $CaCO_3$	mg/L	-	<5	<5	<5	<5
Bicarbonate as HCO_3	mg/L	-	102	107	107	112
Carbonate as CO_3	mg/L	-	<5	<5	<5	<5
Hydroxide as OH	mg/L	-	<5	<5	<5	<5
Total Hardness as $CaCO_3$	mg/L	-	79	82	86	93
Calcium Hardness as $CaCO_3$	mg/L	-	48	51	54	59
Magnesium Hardness as $CaCO_3$	mg/L	-	30	31	33	34
Chloride as Cl	mg/L	≤ 300	2	4	4	5
Chlorite as ClO	mg/L	-	<0,0005	<0,0005	<0,0005	<0,0005
Sulphate as SO_4	mg/L	≤ 500 ≤ 250	7	10	17	21
Fluoride as F	mg/L	≤ 1.5	0,2	0,2	0,25	0,3
Nitrate as N	mg/L	≤ 11.0	0,2	0,8	2,22	3,2
Nitrite as N	mg/L	≤ 0.9	<0,05	<0,05	<0,05	<0,05
Bromide as Br	mg/L	-	0,1	0,25	0,35	0,4

Date	Units	SANS 241 Limits	Minimum	50th percentile	95th percentile	Maximum
Bromate as BrO	mg/L	-	<0,0002	<0,0002	<0,0002	<0,0002
Silica as SiO_2	mg/L	-	11,7	13,3	17	27
Ortho Phosphate as P	mg/L	-	0,1	0,1	0,26	0,3
Total Cyanide as CN	mg/L	-	<0,07	<0,07	<0,07	<0,07
Hydrogen Sulfide	mg/L	-	<0,1	<0,1	<0,1	<0,1
Total Organic Carbon as C	mg/L	≤10.00	2,4	2,7	2,8	2,9
Dissolved Organic Carbon C	mg/L	-	2,2	2,7	2,74	2,8
Chemical Oxygen Demand	mg/L	-	16	24	33,5	39
Dissolved Oxygen as O_2	mg/L	-	7,1	9	9,2	9,3
UV Absorbance at 254 nm	mg/L	-	0,0066	0,0624	0,0688	0,0741
UV Absorbance at 300 nm	mg/L	-	0,0219	0,0348	0,0384	0,0401
Chlorophyll-a	mg/L	-	0,99	2	4	5
Total Coliform Bacteria	cfu/100mL	≤ 10.0	160	520	1100	2000
Faecal Coliform Bacteria	cfu/100mL	ND	0,9	1	3	3
Heterotrophic Plate Count	cfu/1mL	≤1000	22	290	1100	7600
Cryptosporidium species	cysts/10L	ND	0	0	0	0
Giardia species	cysts/10L	ND	0	0	0	0
Free and Saline Ammonia N	mg/L	≤ 1.5	0,1	0,1	0,1	0,1
Sodium as Na	mg/L	≤ 200	6	7	8	8
Potassium as K	mg/L	-	1,1	1,4	1,6	1,8
Calcium as Ca	mg/L	-	19	20	22	24
Magnesium as Mg	mg/L	-	7	8	8	8
Aluminium as Al (Total)	µg/L	-	0,214	0,239	0,417	0,489
Aluminium as Al (Dissolved)	µg/L	≤ 300	0,101	0,1045	0,1206	0,126
Antimony as Sb	µg/L	≤ 20	0,003	0,003	0,003	0,003
Arsenic as As	µg/L	≤ 10	<0,001	<0,001	<0,001	<0,001
Barium as Ba	µg/L	≤ 700	0,03	0,039	0,042	0,057
Total Chromium as Cr	µg/L	≤ 50	<0,025	<0,025	<0,025	<0,025
Cobalt as Co	µg/L	-	<0,025	<0,025	<0,025	<0,025
Copper as Cu	µg/L	≤ 2000	0,018	0,019	0,019	0,019
Iron as Fe (Total)	µg/L	-	0,17	0,2	0,256	0,318
Iron as Fe (Dissolved)	µg/L	≤ 300	0,03	0,051	0,069	0,078
Ferrous Iron as Fe2+ (Dissolved)	µg/L	-	<0,025	<0,025	<0,025	<0,025
Manganese as Mn (Total)	µg/L	-	<0,025	<0,025	<0,025	<0,025
Manganese as Mn (Dissolved)	µg/L	≤ 400 ≤ 100	<0,025	<0,025	<0,025	<0,025
Mercury as Hg	µg/L	≤ 6	<0,001	<0,001	<0,001	<0,001
Nickel as Ni	µg/L	≤ 70	<0,025	<0,025	<0,025	<0,025
Selenium as Se	µg/L	≤ 40	<0,001	<0,001	<0,001	<0,001
Strontium as Sr	µg/L	-	0,044	0,083	0,094	0,099
Thallium as Tl	µg/L	-	<0,001	<0,001	<0,001	<0,001
Vanadium as V	µg/L	-	<0,025	<0,025	<0,025	<0,025

Date	Units	SANS 241 Limits	Minimum	50th percentile	95th percentile	Maximum
Zinc as Zn	µg/L	≤ 5000	<0,025	<0,025	<0,025	<0,025
% Anion-Cation Balance			95	96,4	97,7	99,7
TPH C10-C40	µg/L	-	<0,382	<0,382	<0,382	<0,382
TPH C10-C28	µg/L	-	<0,382	<0,382	<0,382	<0,382
TPH C28-C40	µg/L	-	<0,382	<0,382	<0,382	<0,382

3. Treatability study

a) Jar tests

Jar tests are used to predict clarification at water works. There are four main factors that can influence performance, namely the raw water quality, mixing conditions, flocculant chemistry and the dosage rate. Jar tests are used to determine the best coagulant chemical to be used for the new Xhariep WTP. For each coagulant, a set of jar tests was performed to determine the best dosage based on the settled turbidity, filtered turbidity, stability, residual as well as the removal of organic carbon. The jar test methodology was provided by Zutari.

Raw water characteristics are provided in table 2 above. Flocculation test work was performed using three chemicals namely:

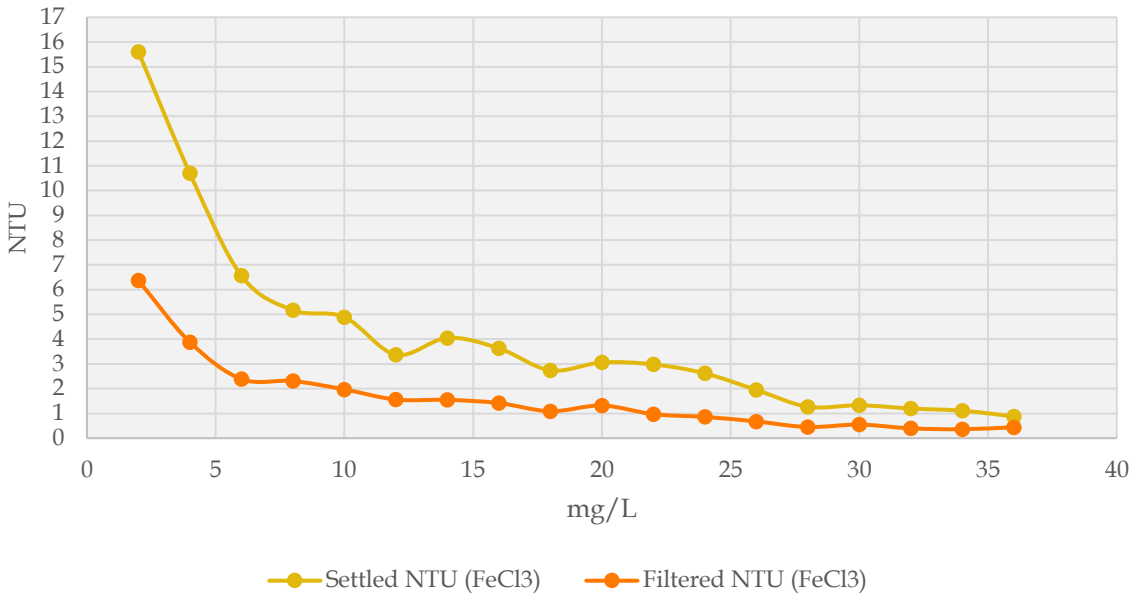
- Iron salt ($FeCl_3$) – Ferric chloride 42-44% metal salt.
- Polyaluminium chloride (PAC) – Sudfloc 3850 – Aluminium Chlorohydrate 24-28%
- Ultrafloc U3500 – 57% Aluminium Chlorohydrate (ACH),27% Polyamine (U5100) and blue dye (Blue Colour 2021)

Several jar tests were performed with the three different chemicals as per the Zutari method provided. Several sets of jar tests were performed until the optimal range of chemical dosages for each chemical was determined.

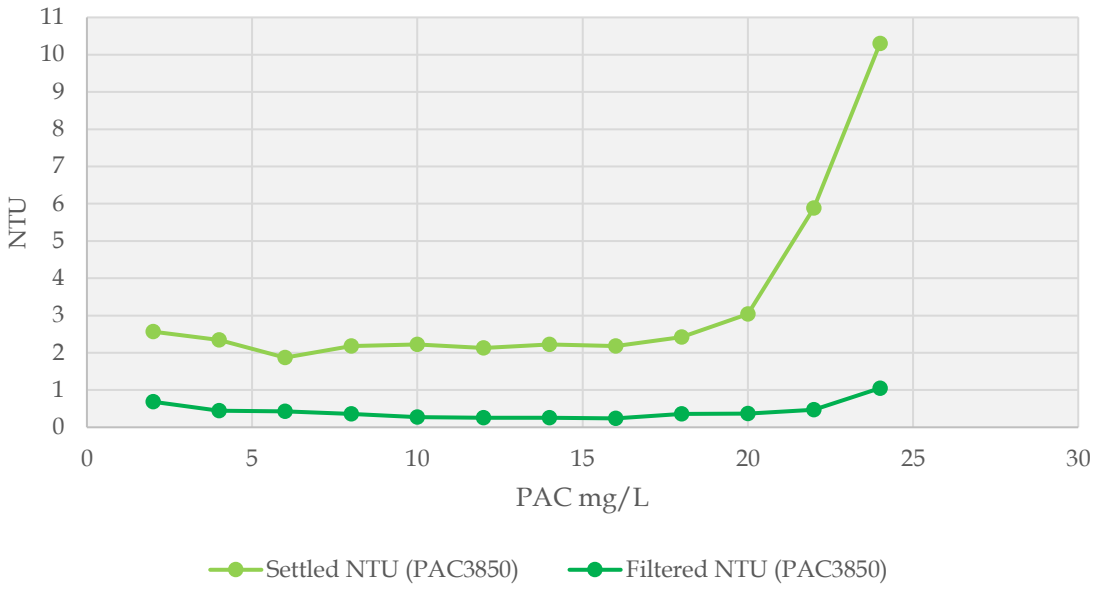
Table 3: Chemical dosages for Jar Test Set 1

Chemical	Jar Test Set 1
Ferric Chloride	2-36 mg/L
U3500	2-24 mg/L
PAC 3850	2-24 mg/L

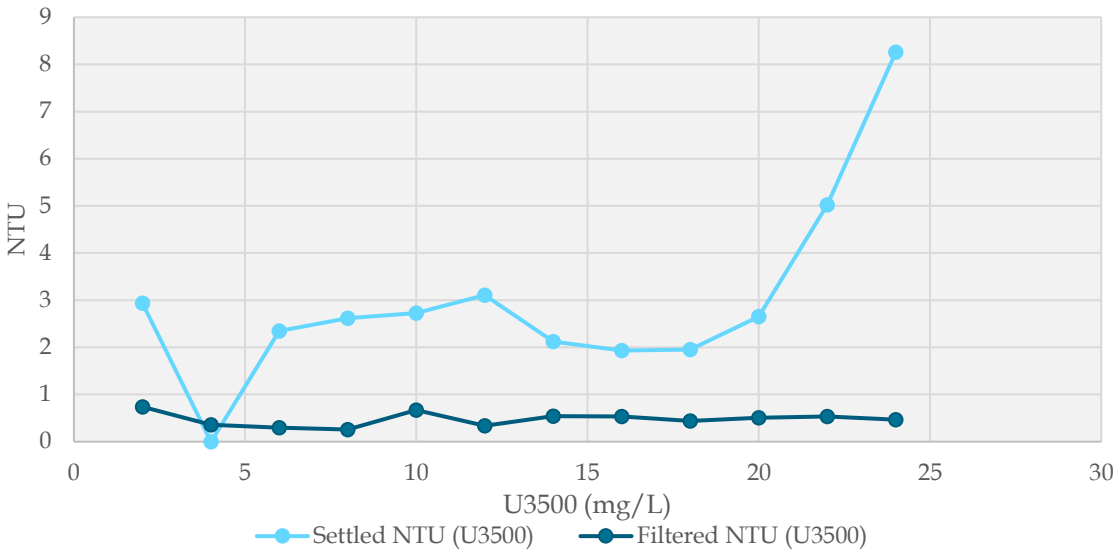
The results of the flocculation tests are presented in the figure below.



Ferric chloride jar tests were performed without lime with a dosage of 2 – 36 mg/L in increments of 2mg/L. The lowest optimal filtered turbidity measured was 0.363 NTU at 34 mg/L. Initial jar tests dosed up to 24 mg/L whereafter additional tests were performed to 36 mg/L.



PAC 3850 jar tests were performed without lime at dosages of 2-24mg/L in increments of 2 mg/L. The lowest optimal turbidity measured (filtered) was at a PAC3850 dosage of 16 mg/L



U3500 jar tests were performed without lime for at dosages of 2-24 mg/L in increments of 2 mg/L. The lowest optimal filtered turbidity was found to be 0.258 NTU at a dosage of 8.0 mg/L

Figure 1:Jar Test 1 (without lime)

From this data, it is evident that PAC 3850 and U3500 provide better results at a lower dosage than the Ferric Chloride, as the lowest turbidity measured for the Ferric Chloride jar tests was 0.363 NTU (filtered) at a dosage of 34 mg/L For the filtered samples, a dosage of 8 mg/L for U3500 provided the lowest measured turbidity of 0.258 NTU and PAC provided a reading of 0.239 NTU at a dosage of 16 mg/L.

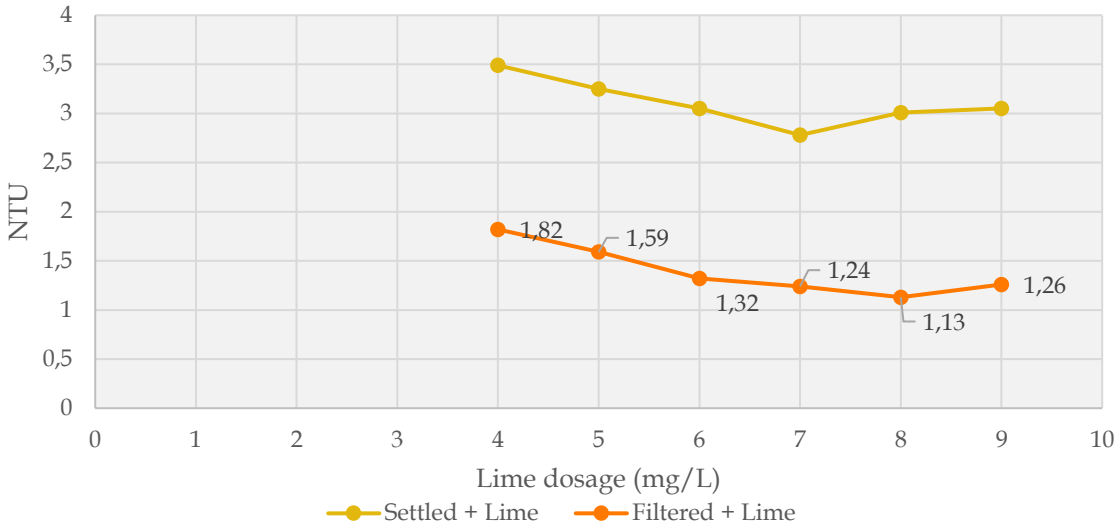
Table 4: Lowest turbidity measurements prior to lime addition (Jar Test Set 1)

Chemical	Settled	Filtered
Ferric Chloride	0.443 NTU (36 mg/L)	0.363 NTU (34 mg/L)
PAC 3850	1.87 NTU (6 mg/L)	0.239 NTU (16 mg/L)
U3500	1.93 NTU (16 mg/L)	0.258 NTU (8mg/L)

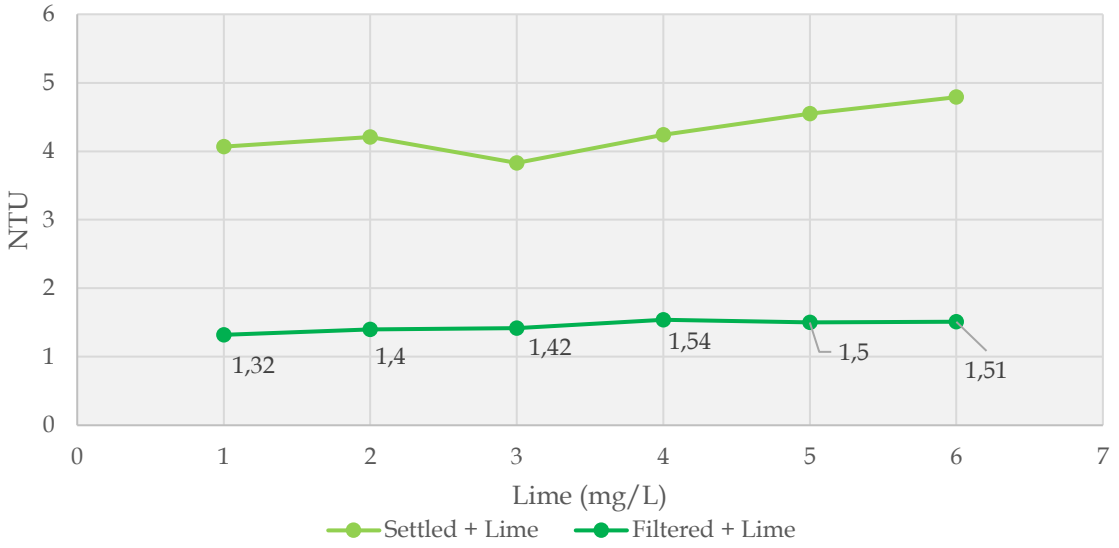
Once the optimum range was found for each of the chemicals, a second set of jar tests were performed with the addition of various lime dosage. The second round of tests included lime dosages based on a positive CCPP (+2 and higher) requirement for the selected flocculant dosages. The results are provided in the figure below.

Table 5: Chemical dosages for Jar Test Set 2

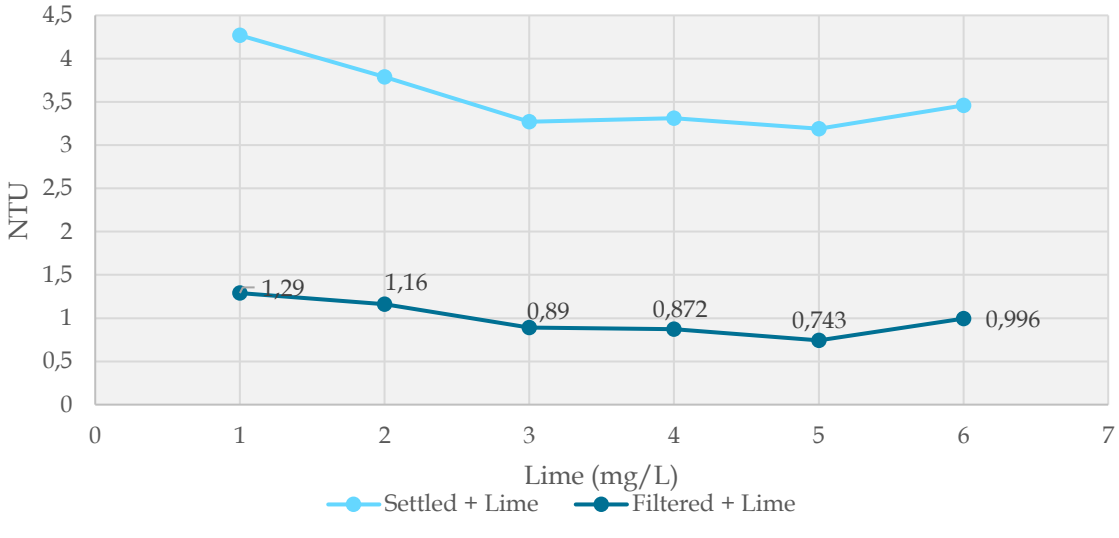
Chemical	Chemical Dosage	Lime Dosage
Ferric Chloride	22mg/L	4/5/6/7/8/9 mg/L lime
U3500	2 mg/L	1/2/3/4/5/6 mg/L Lime
PAC 3850	2 mg/ L	1/2/3/4/5/6 mg/L Lime



A Ferric chloride dosage of 22mg/L was maintained throughout while the lime dosage was varied (4-9mg/L). Turbidity values measured were all above 1.0 NTU.



PAC 3850 (2 mg/L) and various lime dosages (1-6 mg/L). The lowest turbidity measured at this dosage PAC 3850 (2mg/L) and lime (1-6 mg/L) provides a turbidity reading of 1.32 NTU (1mg/L Lime).



U3500 (2mg/L) and various lime dosages of 1-6 mg/L. The 2 mg/L dosage of U3500 provides a good, filtered turbidity (below 1 NTU) with the lowest reading at 0.743 NTU 2mg/L U3500 and 5 mg/L lime).

Figure 2: Jar Test 2 with various lime dosages.

In order to optimize the dosage of flocculant, another set of jar tests was performed using the lowest filtered turbidity measured as a guide to optimize the flocculation process. The results of this test are provided in the figure below. Note that a log scale has been used on the y-axis to allow for visualisation of the data.

Table 6: Chemical dosages for Jar Test Set 3

Chemical	Chemical Dosage	Lime Dosage
Ferric Chloride	28/30/32/34/36/38 mg/L	10 mg/L Lime
U3500	4/6/8/10/12/14 mg/L	3.5 mg/L Lime
PAC 3850	4/6/8/10/12/14 mg/ L	3.5 mg/L Lime

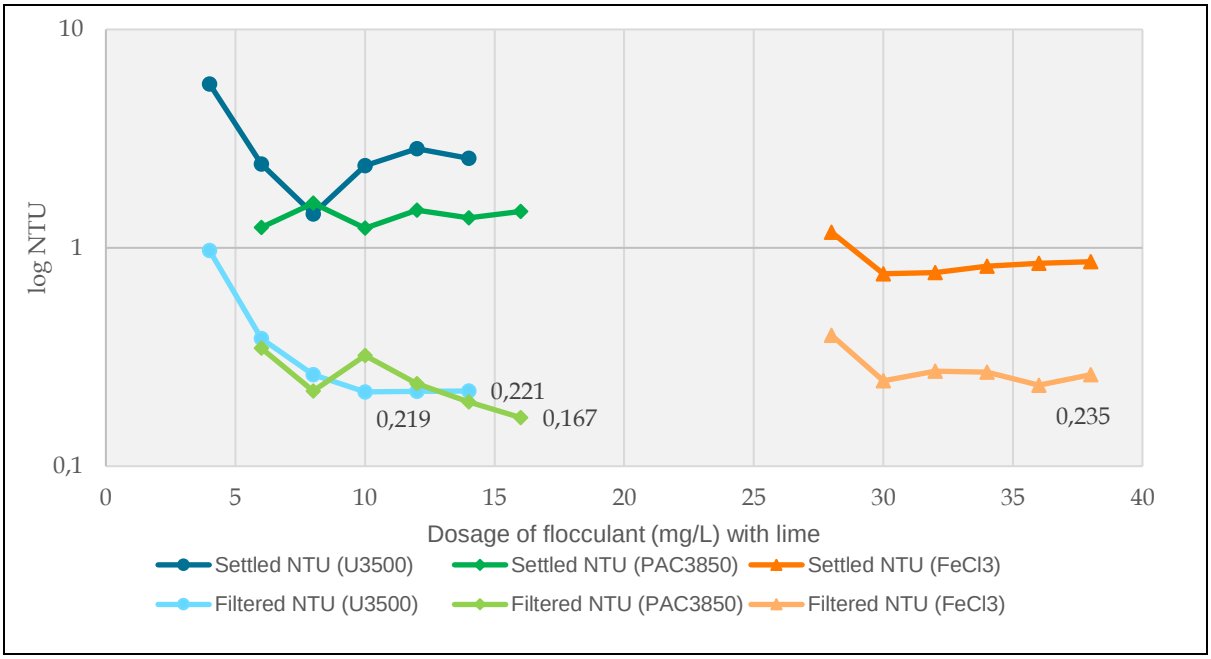


Figure 3: Optimised flocculation jar test 3.

The data indicates that the U3500 is suitable for use with this raw water and provides the lowest filtered turbidity, of 0.219 NTU, at a dosage of 10 mg/L. The PAC 3850 provides similar results with the lowest turbidity reading obtained at 0.167 NTU at a higher dosage of 16 mg/L. Both of these flocculants can be used; however, PAC 3850 will be required at a higher dosage than the U3500 with similar water quality.

Ferric chloride jar tests show that this chemical can be used but at much higher dosages than U3500 and PAC 3850 which will result in additional lime required as well as additional sludge residue production.

Both PAC3850 and U3500 are suitable for use. Since U3500 is already in use on the plant, a dosage of approximately 10mg/L should be sufficient to obtain a turbidity in the filtered water of 0.219 NTU.

During plant operation, it may be possible to reduce the dosage even further if carefully monitored by the process controllers.

Table 6: Best turbidity results from Jar Test Set 3

Chemical	Lime	Settled NTU	Filtered NTU
Ferric Chloride	10 mg/L	0.761 NTU (30 mg/L)	0.235 NTU (36mg/L)
PAC 3850	3.5 mg/L	1.43 NTU (8 mg/L)	0.167 NTU (16 mg/L)
U3500	3.5 mg/L	1.23 NTU (10 mg/L)	0.219 NTU (10 mg/L)

i. Sludge Production

In order to determine the residue contained in the flocculated water an estimate of the residue was performed by determination of the solids in the flocculated water, using the optimised dosage from the table above (10mg/L U3500 with 3.5 mg/L lime), a solids retention of 24mg/L was obtained.
Total Residue for flocculated water (March 2024) = 24g/m^3. This test was repeated with a sample from August 2024 with the same result of 24g/m^3.

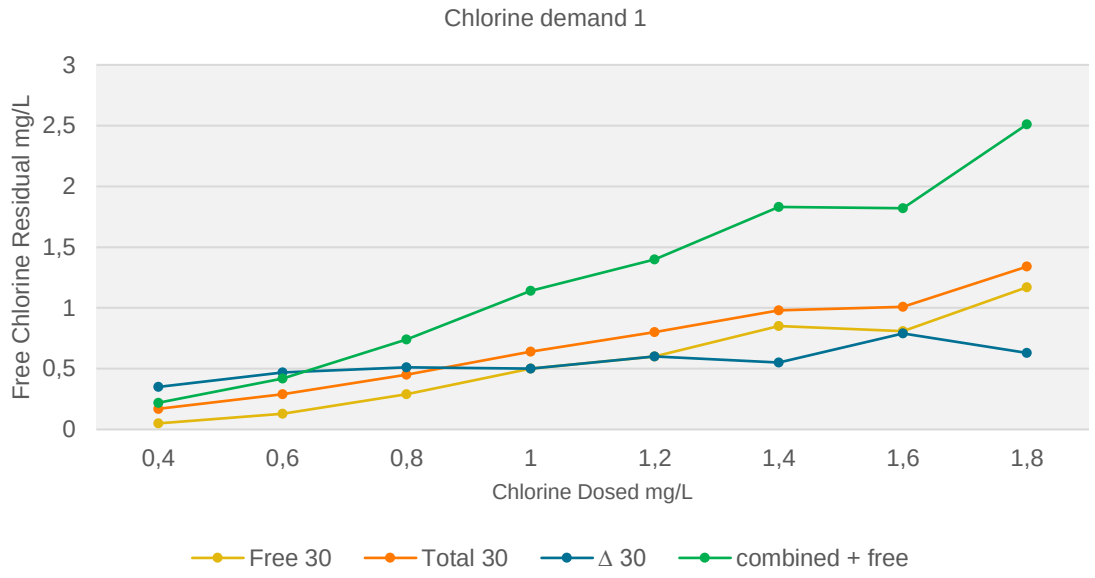
The suspended solids of the raw water for the data provided rises to 32.1 mg/L (95th percentile) with a maximum of 42 mg/L in May 2024. This should be considered during the design process.

b) Chlorine Demand

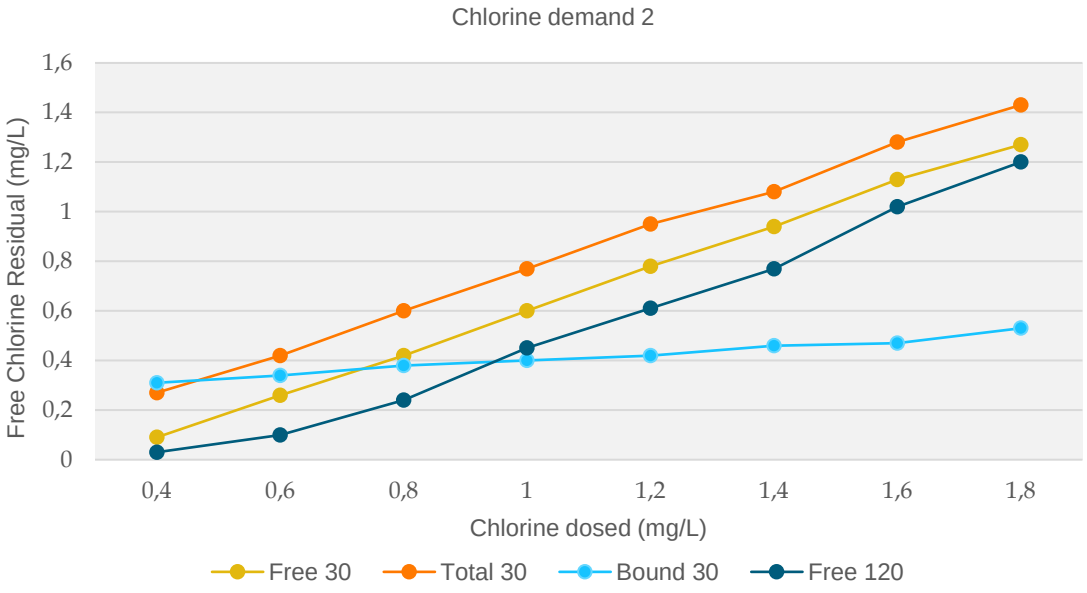
Chlorine demand is defined as the remaining chlorine concentration after the chlorine demand is met. Chlorine and its compounds are consumed by a variety of organic and inorganic materials present in water due to its oxidizing power before disinfection is achieved. Chlorination can be impacted by several compounds including Ammonia, BOD, Hardness Iron Nitrate and Nitrite, Total Suspended Solids and pH (Darby et al 1995).

A commercial bleach solution was used as a stock solution and the actual concentration of the chlorine in this solution was determined by titration with sodium thiosulphate. The solution was then dosed into the raw water or filtered flocculated water from Xhariep and chlorine measurements were performed at regular intervals.

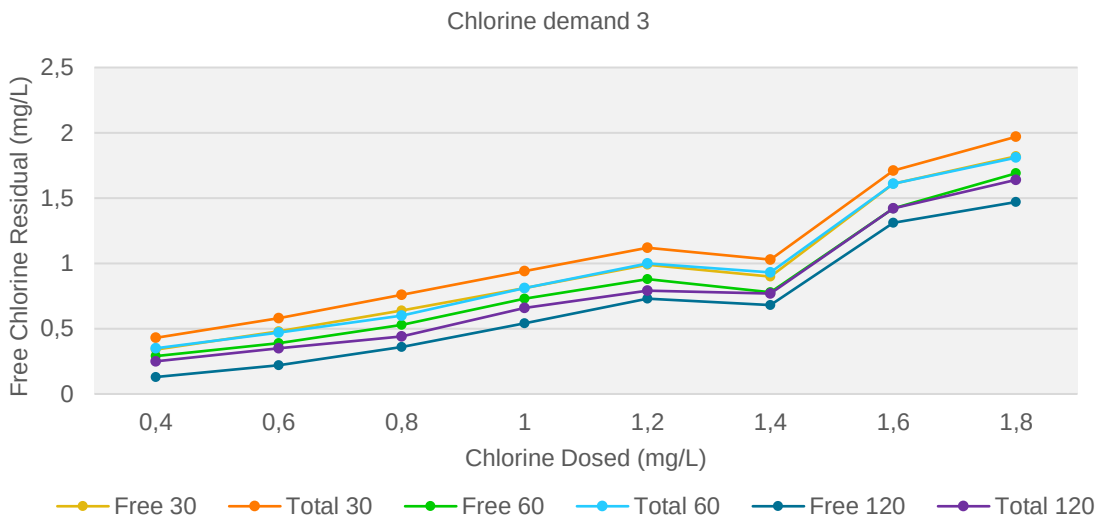
From some discussions with scientific staff at Umgeni Water, chlorine demand readings have been found to be the most consistent after an incubation period of 120 mins (2 hours). The results for chlorine demand on filtered flocculated water at Umgeni have been found to be inconsistent. In our test work on filtered flocculated water, this was also found to be the case, probably due to the interaction between contaminants in the water and the flocculant chemical. Therefore, during the test work performed, the chlorine demand was determined at 30 mins as well as at 60 and 120 mins.



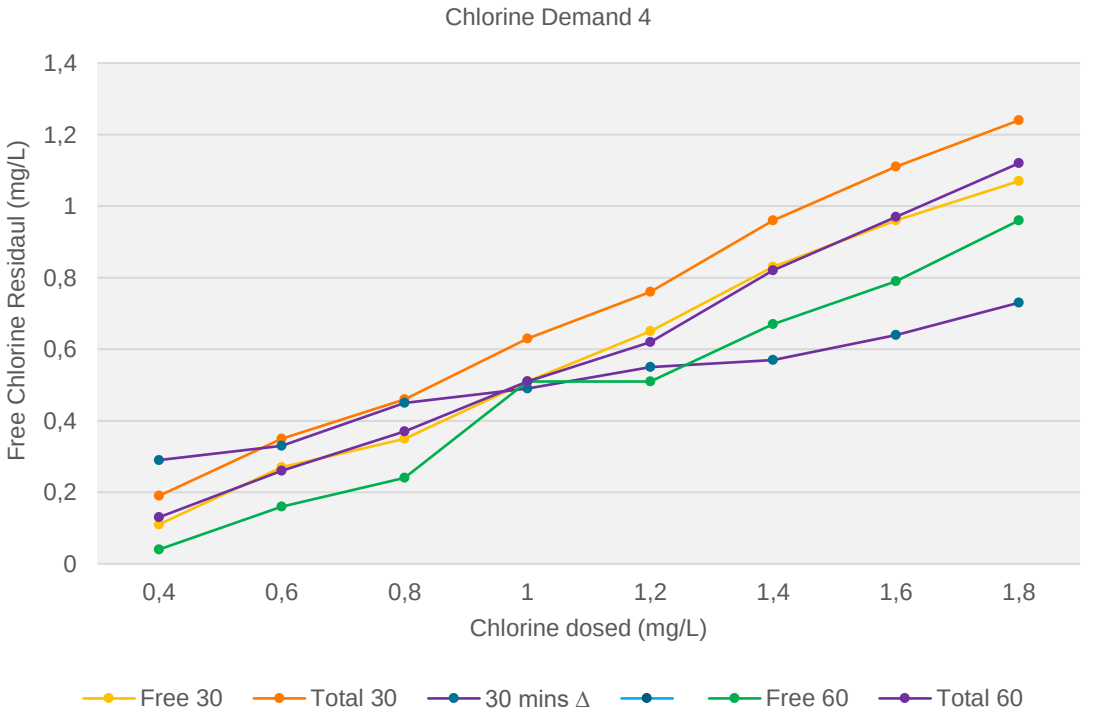
2027/07/03 Chlorine demand tests performed at 30 and 60 mins shows a chlorine demand of 1.6mg/L (prior to discussion with Umgeni Water staff



2027/07/17 Chlorine demand is measured at 1.6 to 1.8 mg/L. Demand is not as clear as other samples tested



2024/08/07 Chlorine demand is measured at 1.4 mg/L



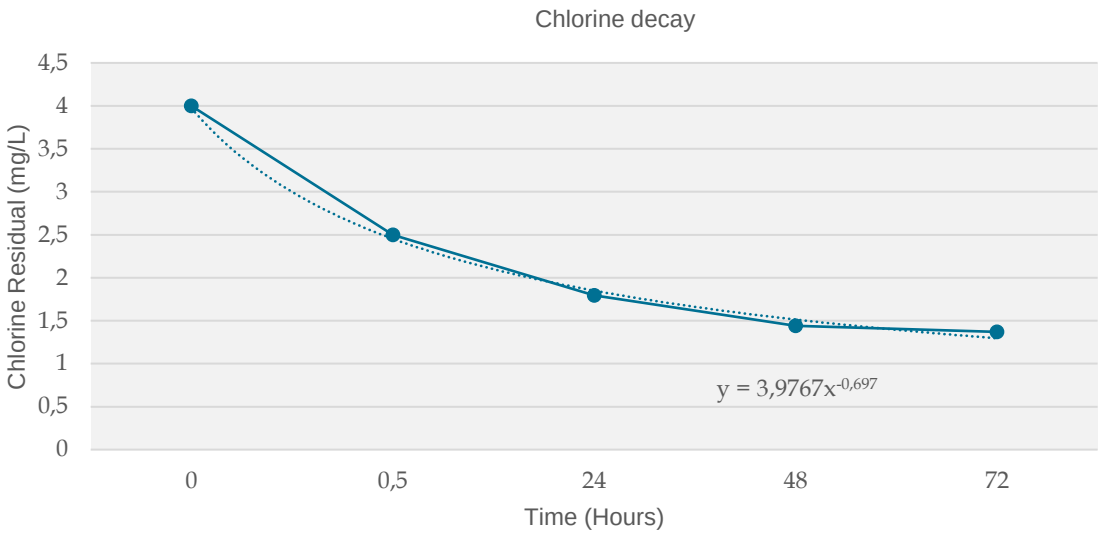
2024/08/22 The chlorine demand of the last sample is ± 1.6 mg/L

Figure 4: Chlorine Demand studies

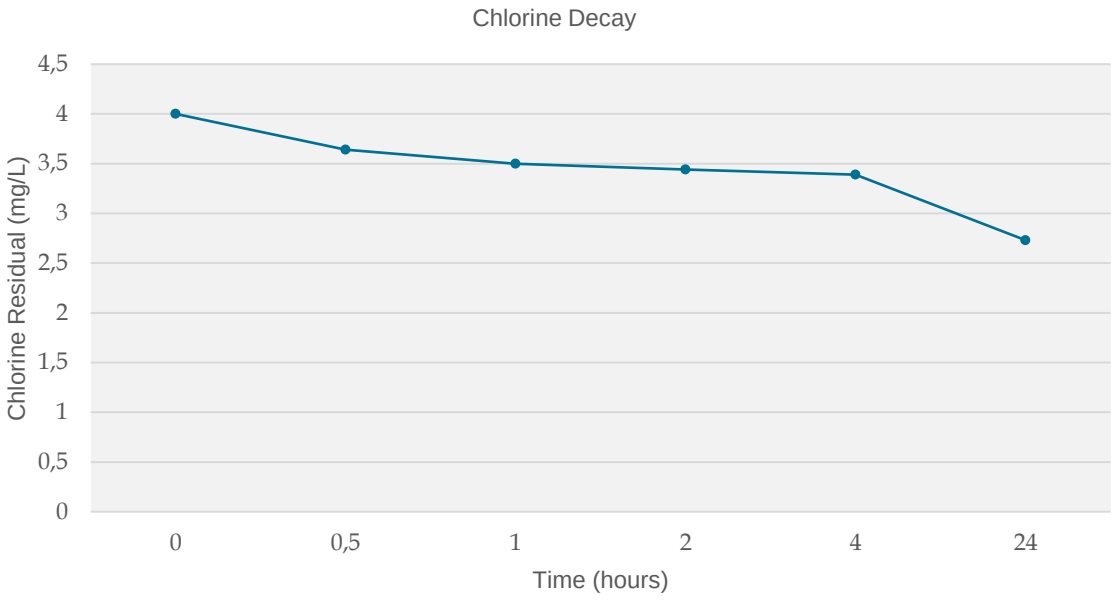
c) Chlorine Decay

It is important to maintain a chlorine residual concentration in treated drinking water up to the point of consumption, as this protects against the deterioration of water quality due to storage in reservoirs or from microbiological contamination. When free chlorine is added to water, it reacts rapidly (fast reaction) with contaminants including ammonia. The remaining chlorine reacts more slowly (slow reaction) with organic compounds or contaminants within the distribution system or is broken down by photolysis. This process can continue for days within the distribution system and is influenced by various parameters including temperature, organics, pipe integrity and pipe composition.

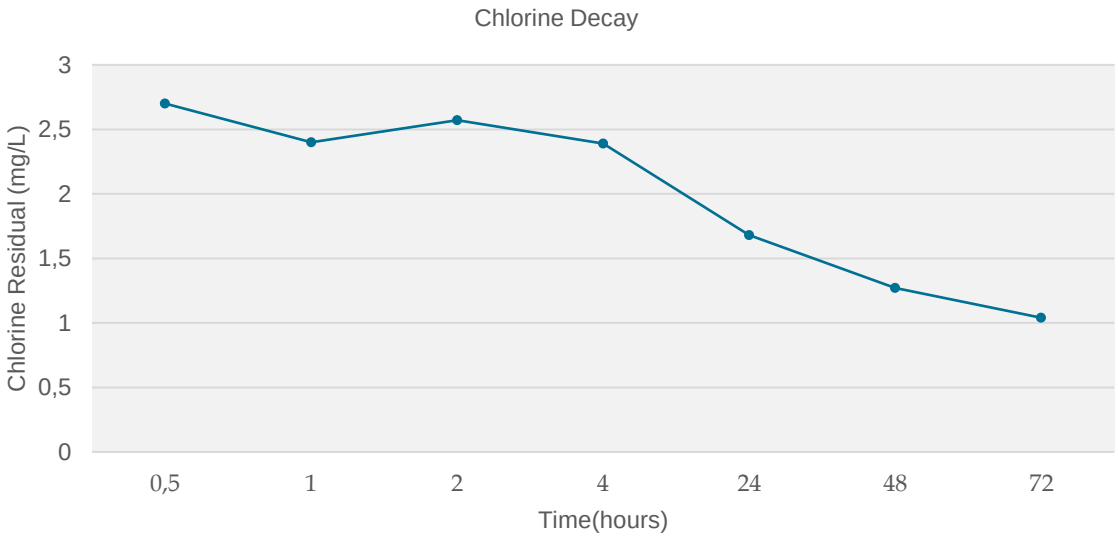
For the chlorine decay study, a dosage of 4 mg/L was used as the chlorine demand was found to be 1.4-1.8 mg/L in the chlorine demand study. The bulk decay constant is measured by dosing a water sample with chlorine and measuring the free chlorine residual at 30 mins (fast reaction) and then at 24 hours in the dark (slow reaction). In addition, the third test was extended to 72 hours.



2024/07/17 After 72 hours the data shows that there is still 1.37 mg/L of free chlorine remaining



2024/08/07 At 30 minutes the chlorine residual remaining was 3.64 mg/L and at 24 hours was measured at 2.73mg/L.



2024/08/22 An extended time period of 72 hours was used for chlorine decay test 4. A free chlorine residual of 1.04 mg/L was still measured 72 hours after dosage.

Figure 5: Chlorine decay.

Bulk decay coefficients were calculated with the following formula: -

$C = C_0 * e^{(-kt)}$

Table 7: Chlorine Decay and Bulk decay coefficients

	Hours	Free Chlorine	k (1/h)
	0	4	-
Chlorine decay 2024/07/17	0,5	2,5	0,94001
	24	1,795	0,03339
	48	1,44	0,02128
	72	1,37	0,01488
	Hours	**Free Chlorine (mg/L)**	**k (1/h)**
	0	4	-
Chlorine decay 2024/08/07	0,5	3,64	0,18862
	1	3,5	0,13353
	2	3,44	0,07541
	4	3,39	0,04137
	24	2,73	0,01592
	Hours	**Free Chlorine (mg/L)**	**k (1/h)**
	0	4	-
	0,5	2,7	0,78609
	1	2,4	0,51083
Chlorine decay 2024/08/24	2	2,57	0,22119
	4	2,39	0,12875
	24	1,68	0,03615
	48	1,27	0,0239
	72	1,04	0,01871

Assuming that the required chlorine dose at the end of the pipeline is 0.8mg/L and the distribution network and storage capacity (230kms of pipeline and 2 x 80ML reservoirs) provides a retention time of approximately 60 hours (2.5 days). From the last test performed, a free chlorine residual of 1.04 mg/L was evident after 72 hours. The in-field result will be impacted by pipeline composition and biofilm formation.

4. THM Formation Potential

Tri-halomethanes (THM's) are formed during the chlorination process. The four most commonly occurring THM's are:

- Chloroform ($CHCl_3$)
- Bromodichloromethane ($CHBrCl_2$)
- Dibromochloromethane ($CHBr_2Cl$)
- Bromoform ($CHBr_3$)

These are not the only chlorination byproducts that can be formed. Other chlorination byproducts such as haloacetic acids and halonitriles can be formed during a slow organic reaction of chlorine and naturally occurring precursors such as humic and fulvic acids.

a) Total Trihalomethane Formation Potential prior to chlorination ($TTHMFP_0$)

The ten raw water samples were analyzed for Total Trihalomethane Formation Potential (TTHMFP) prior to the dosage of chlorine. These samples are presumed to not contain any free chlorine and therefore should have a very low (close to zero) concentration of THMs (if any).

Raw water samples were tested for THMs and therefore no free chlorine residual is expected. Only one sample, 03317, displayed any THM formation potential at 0 mins (prior to chlorine dosage). Chloroform was found in this sample at a concentration of 44µg/L. No THMs were detected in any of the other samples tested. The results for the $TTHM_0$ are provided in the figure below.

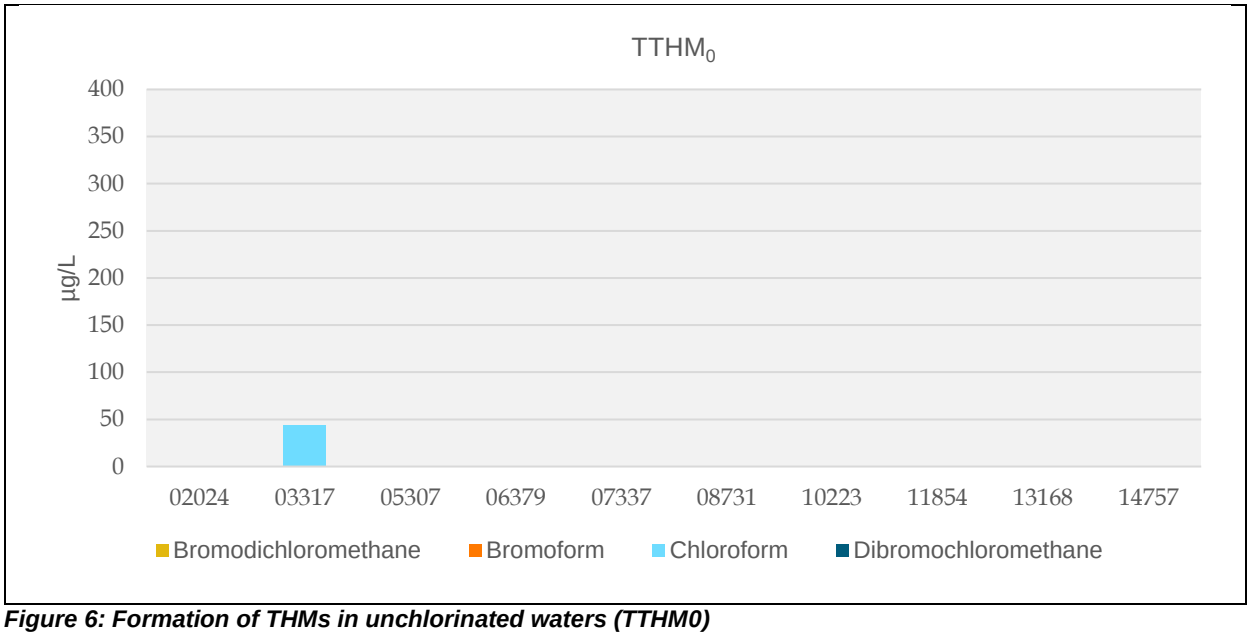


Figure 6: Formation of THMs in unchlorinated waters (TTHM0)

The raw water samples were dosed with a concentration of 10 mg/L free chlorine to ensure that sufficient chlorine was available to form THMs. Sample 03317, 10223 and 11854 were all found to have a combined THM concentrations of above 300 µg/L (See figure below).

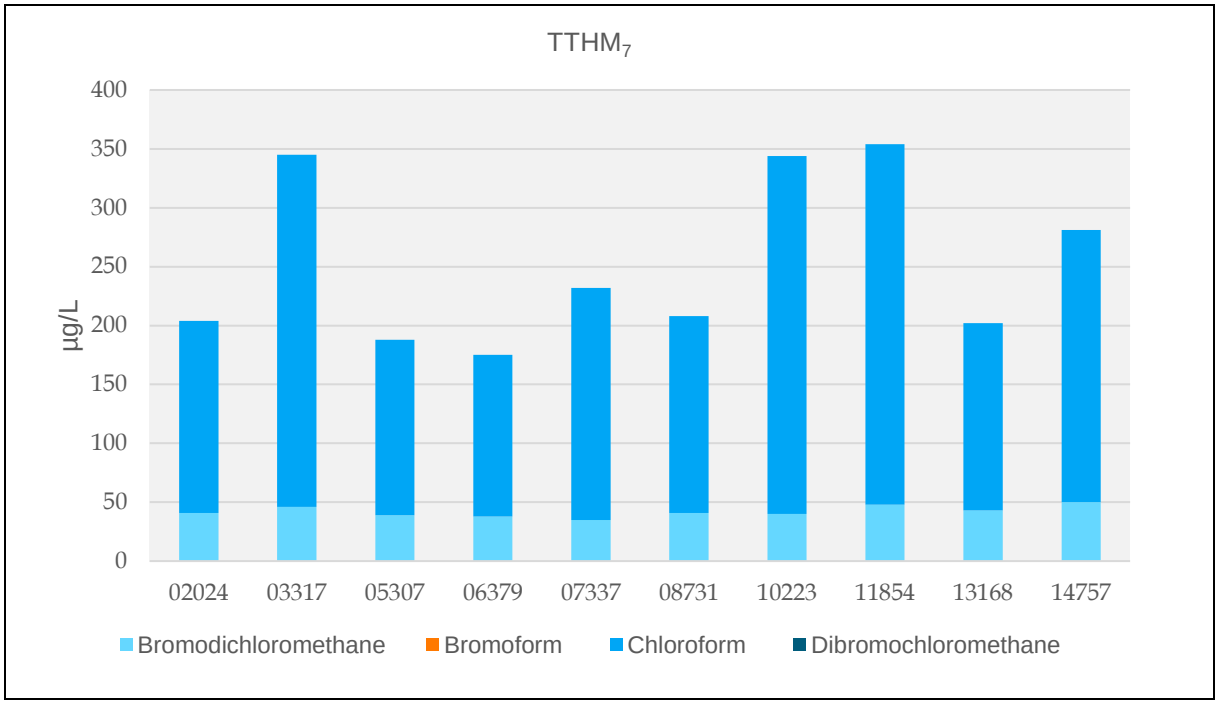


Figure 7: Total Trihalomethane Formation Potential at 7 days ($TTHM_7$)

Since the $TTHM_7$ is very close to or equal to zero for most samples (apart from 03317) THMFP is equal to $TTHM_7$. For sample no 03317, ΔTHMFP is 301 µg/L where the detection limit is 20µg/L per parameter.

Chloroform is generally the most prevalent THM, and the results indicate that the samples 03317, 10223 and 11854 all breached the 300µg/L limit for drinking water during the TTHM7 test.

The second most prevalent THM is bromodichloromethane, however none of these samples breached the limit of 60µg/L.

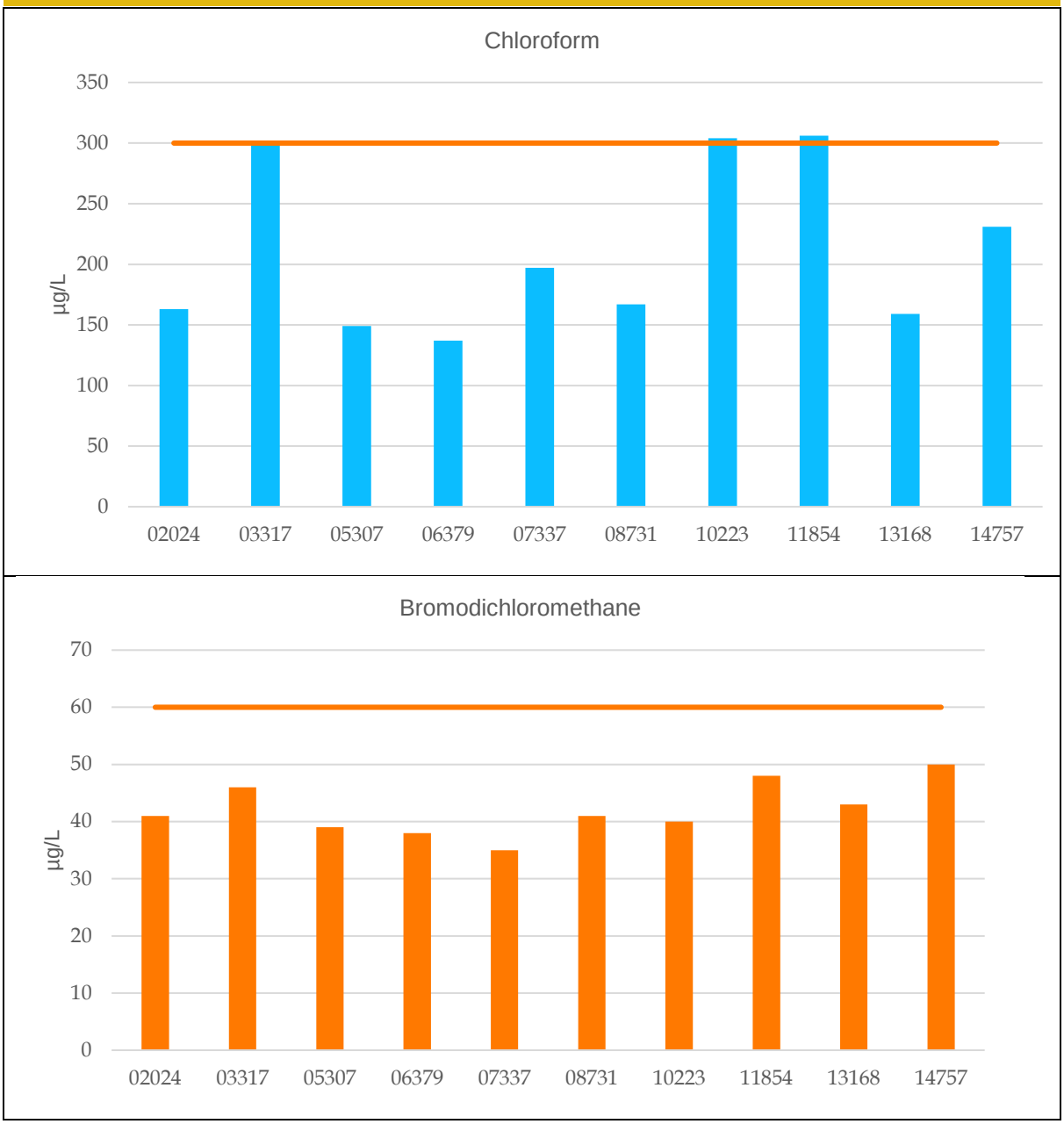


Figure 8: THMs formed during the TTHM$_7$ test.

In addition, the THM Ratio was exceeded for all samples during the TTHM$_7$ test. This is to be expected as this is raw untreated water and therefore any organic matter in the water will react with the chorine available to form THMs.

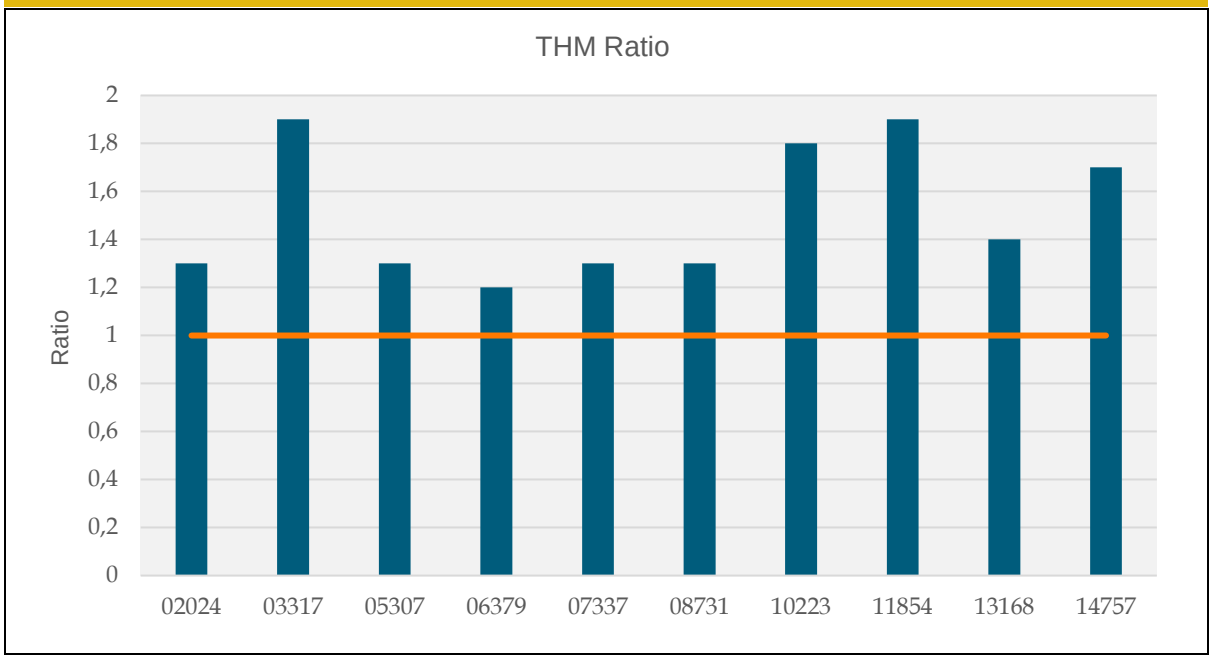
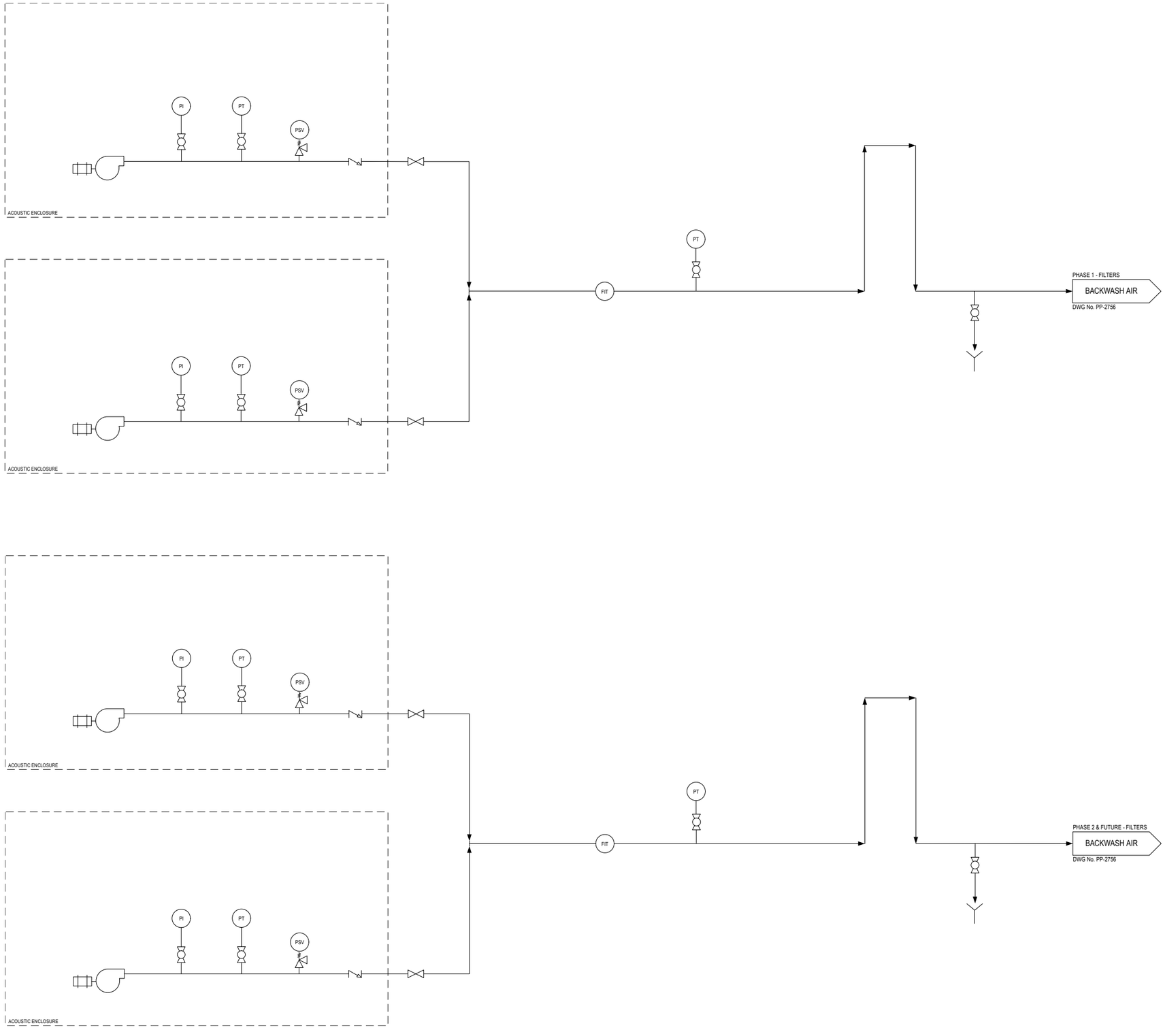


Figure 9: Total THM Ratio for $_{TTHM7}$ test.

Appendix C: Process Flow Diagrams

Drawing number	Title
1002533-2500-BFD-PP-2750	Block Flow Diagram
1002533-2500-PFD-PP-2751	Mechanical Flow Diagram - Over-all Process Flow Diagram (1 of 2)
1002533-2500-PFD-PP-2752	Mechanical Flow Diagram - Over-all Process Flow Diagram (2 of 2)
1002533-2500-PID-PP-2753	Mechanical Flow Diagram - Inlet Works
1002533-2500-PID-PP-2754	Mechanical Flow Diagram - Phase 1 Pulsator Clarifiers
1002533-2500-PID-PP-2755	Mechanical Flow Diagram - Phase 2 & Future Pulsator Clarifiers
1002533-2500-PID-PP-2756	Mechanical Flow Diagram - Phase 1, Phase 2, & Future Rapid Gravity Sand Filters
1002533-2500-PID-PP-2757	Mechanical Flow Diagram - Phase 1 ro 3 Reservoirs
1002533-2500-PID-PP-2758	Mechanical Flow Diagram - High Lift and Service Water Pump Stations
1002533-2500-PID-PP-2759	Mechanical Flow Diagram - Chlorine Storage and Dosage
1002533-2500-PID-PP-2760	Mechanical Flow Diagram - Coagulant Storage and Dosage
1002533-2500-PID-PP-2761	Mechanical Flow Diagram - Lime Storage and Dosing
1002533-2500-PID-PP-2762	Mechanical Flow Diagram - Filters (Air Scour Blowers)
1002533-2500-PID-PP-2763	Mechanical Flow Diagram - Sludge Lagoons and Supernatant Recycle System



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NOTES:

KEY:

- MAIN PROCESS LINE
- WASTE LINE
- SECONDARY PROCESS LINE
- OVERFLOW

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REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
1	04/12/24	ISSUED FOR INFORMATION	

SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
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DRAWN: D. GOHO
DESIGNED: T. CERONIO
REVIEWED: L. KROUWKAMP
APPROVED
DATE
PR TECH ENG

PROJECT

XHARIEP PIPELINE

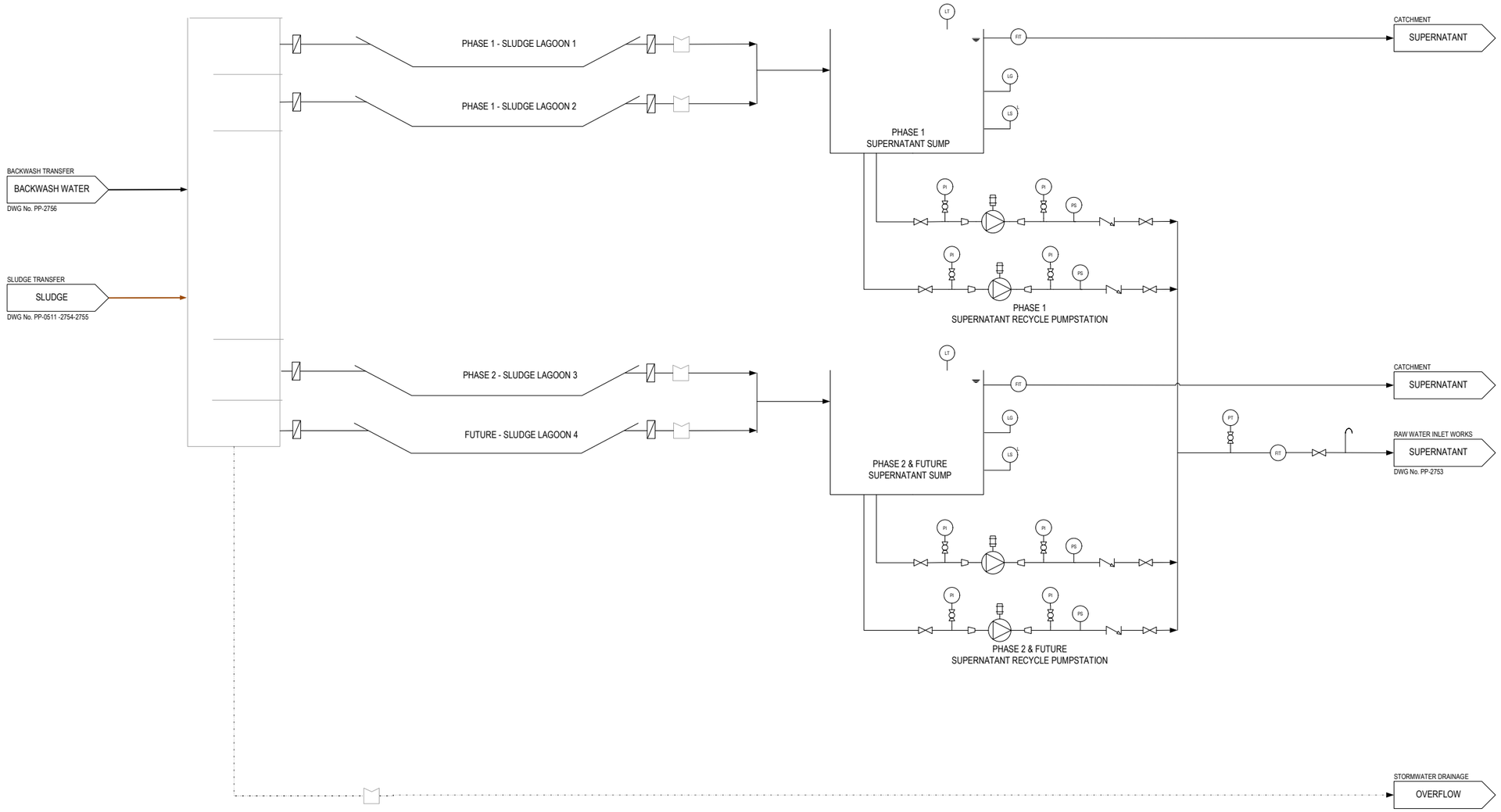
TITLE

WATER TREATMENT WORKS
MECHANICAL FLOW DIAGRAM :
FILTERS (AIR SCOUR BLOWERS)

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
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SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
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DRAWN	APPROVED
D. GOHO	DATE
DESIGNED	
T. CERONIO	
REVIEWED	PR TECH ENG
L. KROUWKAMP	

PROJECT

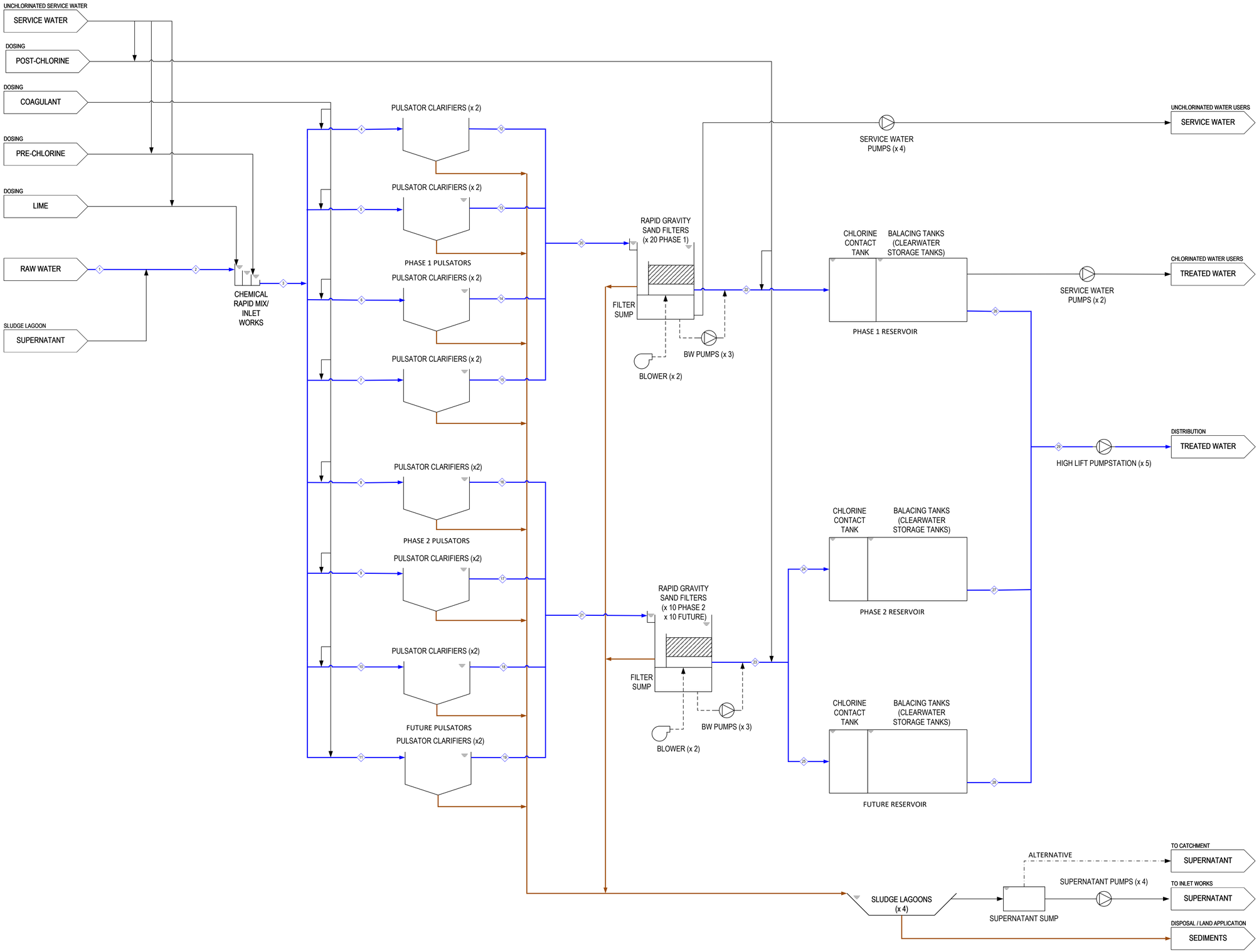
XHARIEP PIPELINE

TITLE

WATER TREATMENT WORKS
MECHANICAL FLOW DIAGRAM :
SLUDGE LAGOONS AND
SUPERNATANT RECYCLE SYSTEM

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
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NOTES:

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KEY:

- MAIN PROCESS FLOW
- SLUDGE AND WASHWATER
- CONTINOUS FLOW
- OVERFLOW
- INTERMITTENT FLOW
- ALTERNATIVE FLOW

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REV	DATE	REVISION DETAILS	APPROVED
A	25/11/24	ISSUED FOR INFORMATION	

SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
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DRAWN: L. PEYRON
DESIGNED: T. CERONIO
REVIEWED: L. KROUWKAMP
APPROVED
DATE
PR TECH ENG

PROJECT

XHARIEP WTW

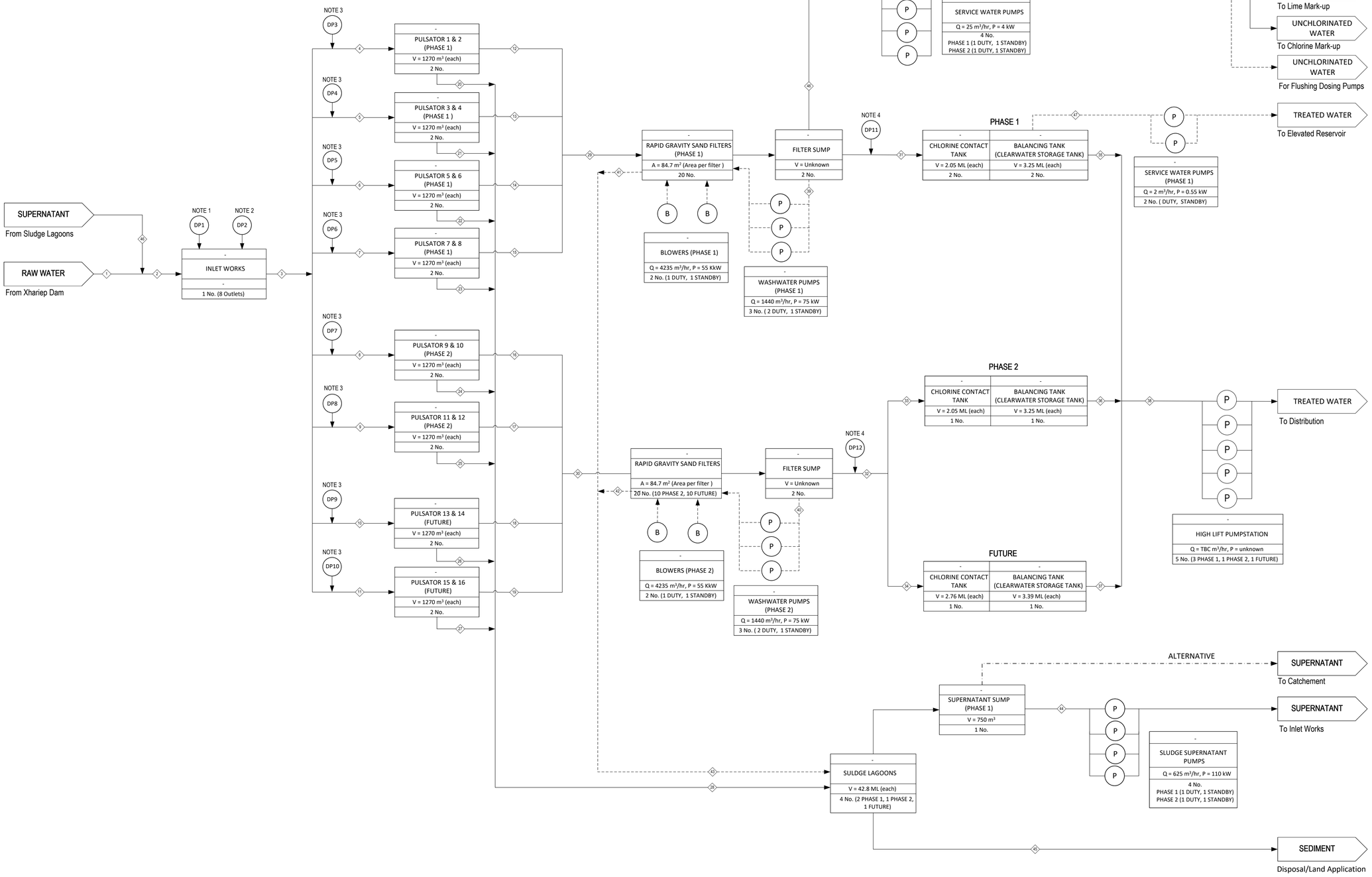
TITLE

WATER TREATMENT WORKS
PROCESS FLOW DIAGRAM :
OVERALL BLOCK FLOW DIAGRAM

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
1002533	-	2500	-	BFD	-	PP	-	2750	-	A

https://zutarilive.sharepoint.com/sites/1002533/Shared Documents/05 Deliver/502 Drawings/3. CAD/1. Feasibility Design Drawings/2. Process Drawings (do not use)/1002533-2500-BFD-PP-2750 (BFD).vsdx



STREAM No.	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
DESCRIPTION		RAW WATER	INLET WORKS FEED	COMBINED FEED TO PULSATORS	PULSATOR 1 & 2 FEED	PULSATOR 3 & 4 FEED	PULSATOR 5 & 6 FEED	PULSATOR 7 & 8 FEED	PULSATOR 9 & 10 FEED	PULSATOR 11 & 12 FEED	PULSATOR 13 & 14 FEED	PULSATOR 15 & 16 FEED	PULSATOR 1 & 2 CLARIFIED WATER	PULSATOR 3 & 4 CLARIFIED WATER	PULSATOR 5 & 6 CLARIFIED WATER	PULSATOR 7 & 8 CLARIFIED WATER	PULSATOR 9 & 10 CLARIFIED WATER	PULSATOR 11 & 12 CLARIFIED WATER	PULSATOR 13 & 14 CLARIFIED WATER	PULSATOR 15 & 16 CLARIFIED WATER	PULSATOR 1 & 2 UNDERFLOW	PULSATOR 3 & 4 UNDERFLOW	PULSATOR 5 & 6 UNDERFLOW	PULSATOR 7 & 8 UNDERFLOW	PULSATOR 9 & 10 UNDERFLOW	PULSATOR 11 & 12 UNDERFLOW	PULSATOR 13 & 14 UNDERFLOW	PULSATOR 15 & 16 UNDERFLOW
AVERAGE FLOWRATE	Ml/d	462	489	489	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	58.4	58.4	58.4	58.4	58.4	58.4	58.4	58.4	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75
AVERAGE FLOWRATE	m³/h	19244	20377	20377	2547	2547	2547	2547	2547	2547	2547	2547	2433	2433	2433	2433	2433	2433	2433	2433	-	-	-	-	-	-	-	-

STREAM No.	Unit	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
DESCRIPTION		COMBINED SLUDGE	FEED TO RGSF (PHASE 1)	FEED TO RGSF (PHASE 2 & FUTURE)	FILTERED WATER (PHASE 1)	FILTERED WATER (PHASE 2 & FUTURE)	PHASE 2 RESERVOIR FEED	FUTURE RESERVOIR FEED	TREATED WATER (PHASE 1)	TREATED WATER (PHASE 2)	TREATED WATER (FUTURE)	TOTAL TREATED WATER	BACKWASH WATER (PHASE 1)	BACKWASH WATER (PHASE 2 & FUTURE)	SPENT BACKWASH (PHASE 1)	SPENT BACKWASH (PHASE 2 & FUTURE)	COMBINED SPENT BACKWASH	SUPERNATANT	SEDIMENT	UN-CHLORINATED SERVICE WATER	CHLORINATED SERVICE WATER
AVERAGE FLOWRATE	Ml/d	22.0	234	234	226	228	114	114	226	114	114	454	6.00	6.00	6.00	6.00	12.0	27.2	6.80	1.19	0.0402
AVERAGE FLOWRATE	m³/h	-	9730	9730	9431	9480	4740	4740	9429	4740	4740	18909	250	250	250	250	500	1134	-	49.7	1.67

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NOTES:

1. LIME
2. PRE-CHLORINATION CHLORINE
3. COAGULANT ULTRAFLOC 3500
4. POST-CHLORINATION CHLORINE

KEY:

- MAIN PROCESS FLOW
- CONTINOUS FLOW
- CHEMICAL DOSING
- INTERMITTENT FLOW

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SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
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DRAWN: L. PEYRON
DESIGNED: T. CERONIO
REVIEWED: L. KROUWKAMP
APPROVED
DATE
PR TECH ENG

PROJECT

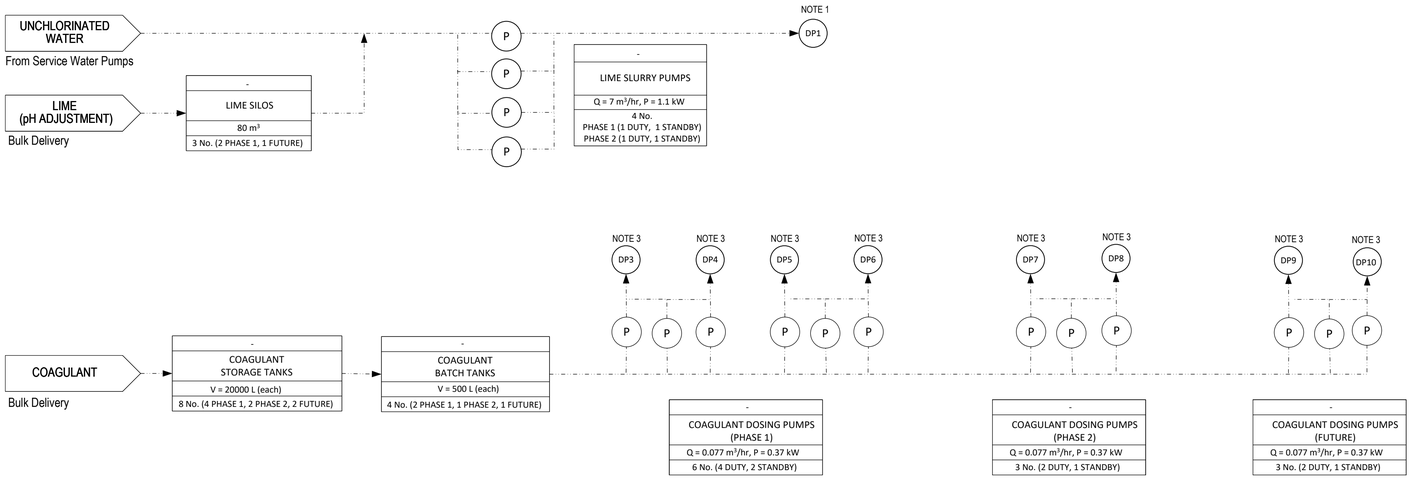
XHARIEP WTW

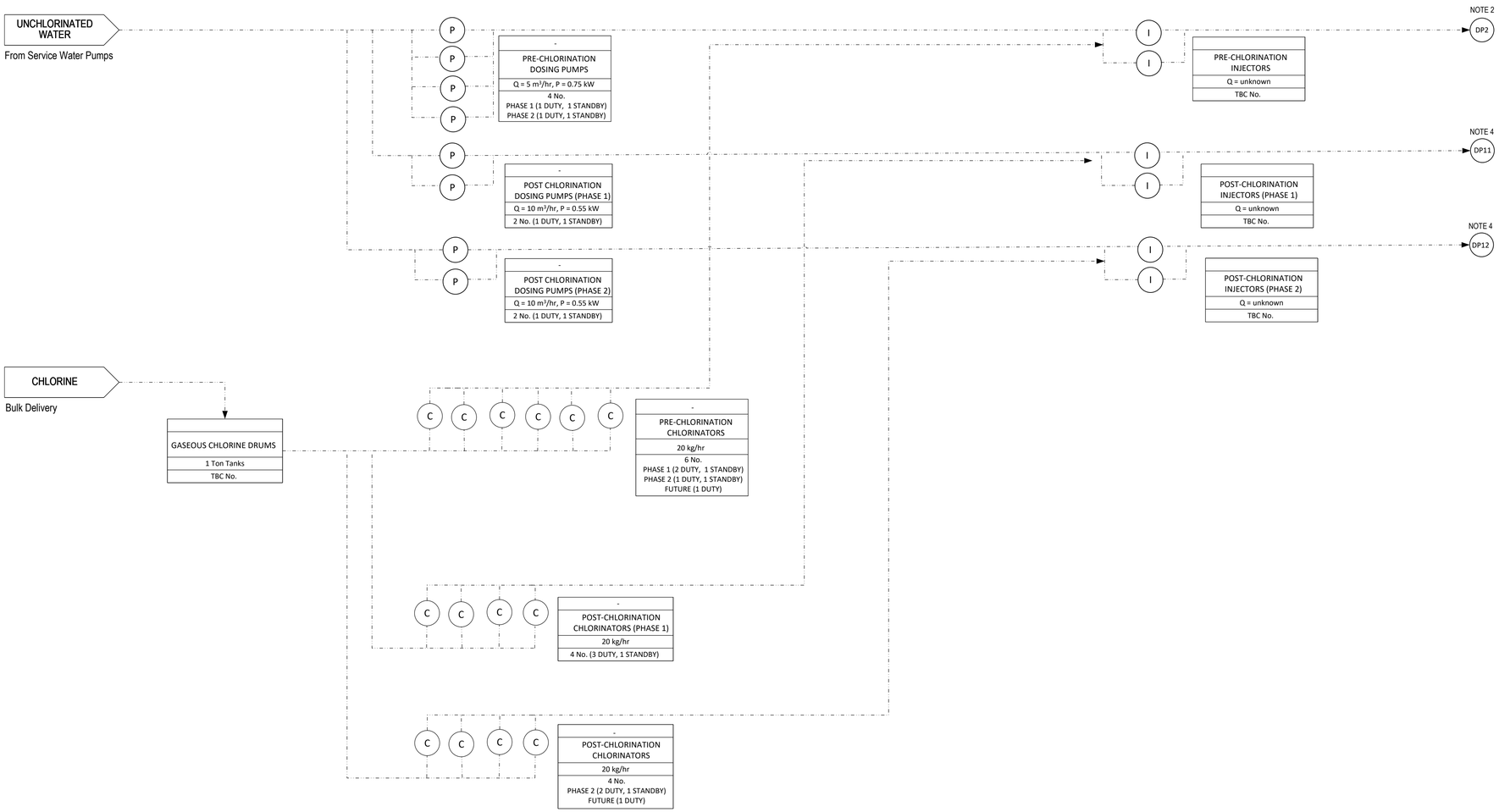
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WATER TREATMENT WORKS
PROCESS FLOW DIAGRAM :
OVERALL PROCESS FLOW DIAGRAM (½)

DRAWING NUMBER

PROJECT No.		WBS		TYPE	DISC		NUMBER		REV
1002533	-	2500	-	PFD	PP	-	2751	-	A





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1. LIME
2. PRE-CHLORINATION CHLORINE
3. COAGULANT ULTRAFLOC 3500
4. POST-CHLORINATION CHLORINE

KEY:

- MAIN PROCESS FLOW
- CONTINOUS FLOW
- CHEMICAL DOSING
- INTERMITTENT FLOW

ZUTARI
IMPACT. ENGINEERED.

CLIENT

REV	DATE	REVISION DETAILS	APPROVED
A	25/11/24	ISSUED FOR INFORMATION	

SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

DRAWN	DESIGNED	REVIEWED
L. PEYRON	T. CERONIO	L. KROUWKAMP

APPROVED

DATE

-

PR TECH ENG

PROJECT

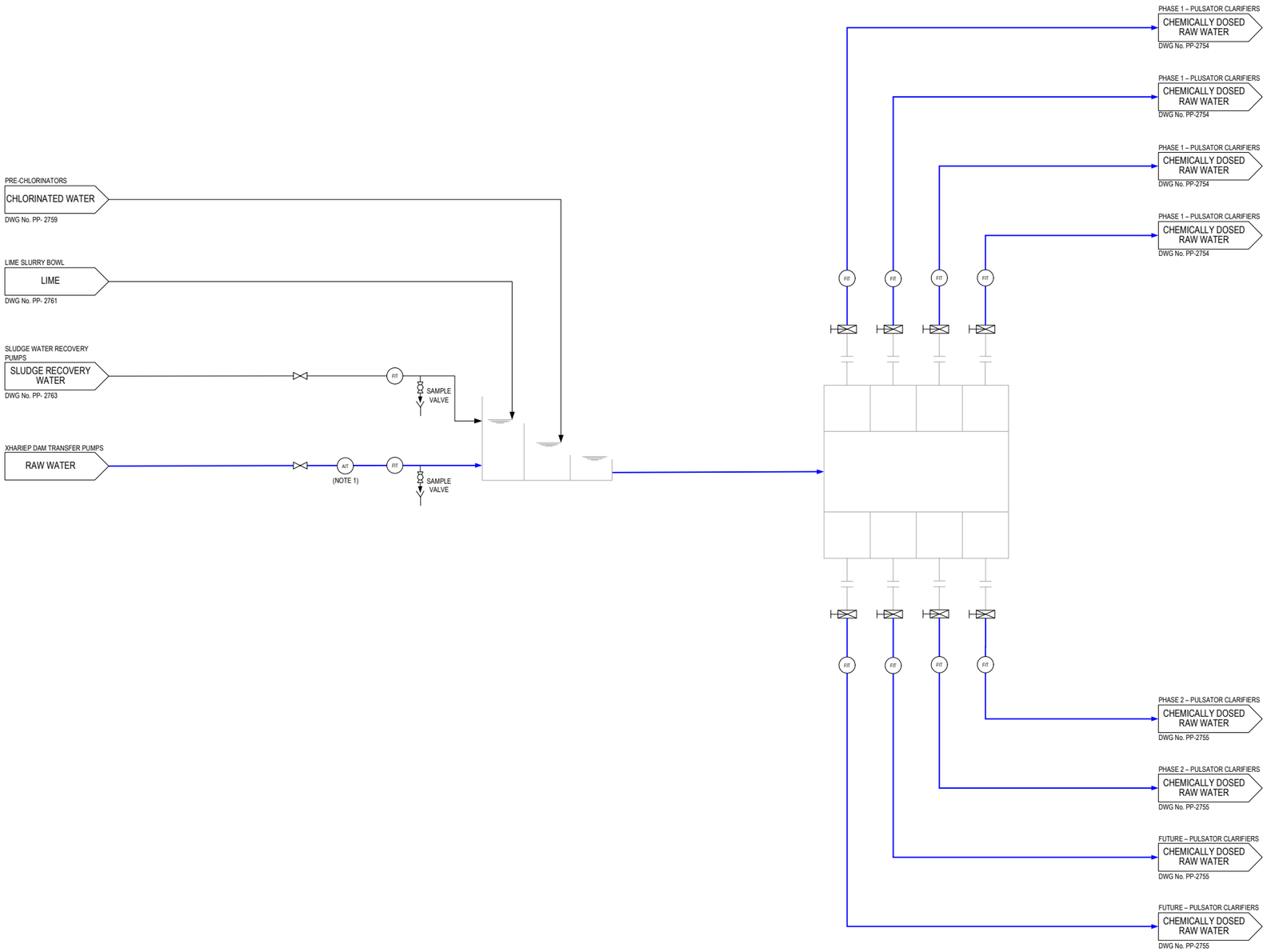
XHARIEP WTW

TITLE

WATER TREATMENT WORKS
PROCESS FLOW DIAGRAM :
OVERALL PROCESS FLOW DIAGRAM (2/2)

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
1002533	-	2500	-	PFD	-	PP	-	2752	-	A



DISCLAIMER

IF CONSTRUCTION DRAWINGS ARE ISSUED UNSIGNED, THE MASTER WITH THE ORIGINAL SIGNATURE OF APPROVAL WILL BE HELD AT THE ZUTARI OFFICE OF THE APPROVER

NOTES:

1. RAW WATER ANALYZING STATION MONITORING:
   - TURBIDITY (NTU)
   - pH
   - ELECTRICAL CONDUCTIVITY (COND)

KEY:

- MAIN PROCESS LINE
- WASTE LINE
- SECONDARY PROCESS LINE
- OVERFLOW

ZUTARI
IMPACT. ENGINEERED.

CLIENT

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
1	04/12/24	ISSUED FOR INFORMATION	

SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

DRAWN: D. GOHO
DESIGNED: T. CERONIO
REVIEWED: L. KROUWKAMP
APPROVED
DATE
PR TECH ENG

PROJECT

XHARIEP PIPELINE

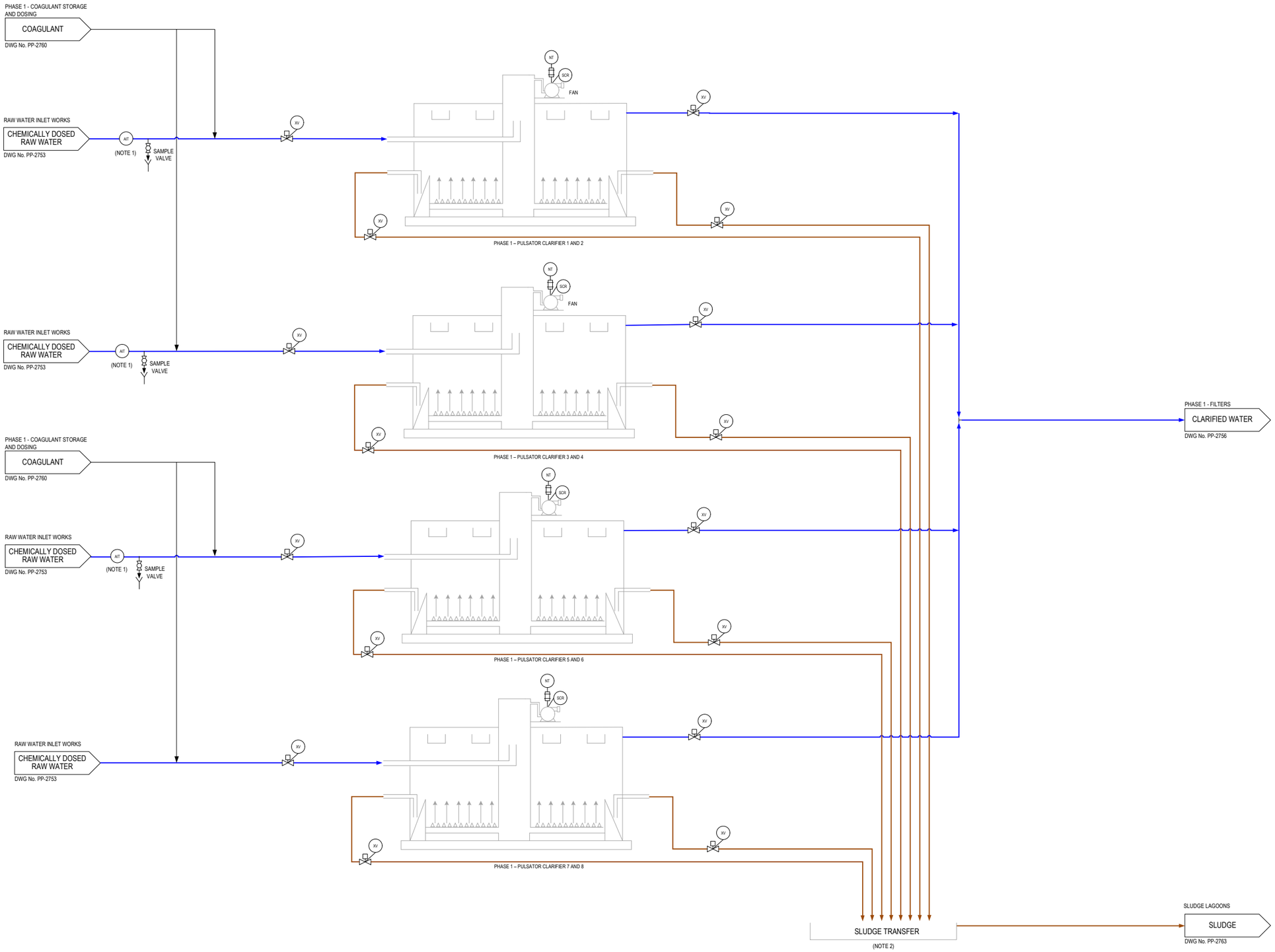
TITLE

WATER TREATMENT WORKS
MECHANICAL FLOW DIAGRAM :
INLET WORKS

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
1002533	-	2500	-	MFD	-	PP	-	2753	-	1

https://zutarilive.sharepoint.com/sites/1002533/Shared Documents/05 Deliver/502 Drawings/2. CAD/1. Feasibility Design Drawings/2. Process Drawings (do not use)/1002533-2500-PDP-PP-2753 (MFD).vsdx



DISCLAIMER

IF CONSTRUCTION DRAWINGS ARE ISSUED UNSIGNED, THE MASTER WITH THE ORIGINAL SIGNATURE OF APPROVAL WILL BE HELD AT THE ZUTARI OFFICE OF THE APPROVER

NOTES:

1. ANALYSING STATION MONITORING:
- pH
- TURBIDITY (NTU)

KEY:

- MAIN PROCESS LINE
- WASTE LINE
- SECONDARY PROCESS LINE
- OVERFLOW

ZUTARI
IMPACT. ENGINEERED.

CLIENT

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
1	04/12/24	ISSUED FOR INFORMATION	

SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

DRAWN: D. GOHO
DESIGNED: T. CERONIO
REVIEWED: L. KROUWKAMP
APPROVED
DATE
PR TECH ENG

PROJECT

XHARIEP PIPELINE

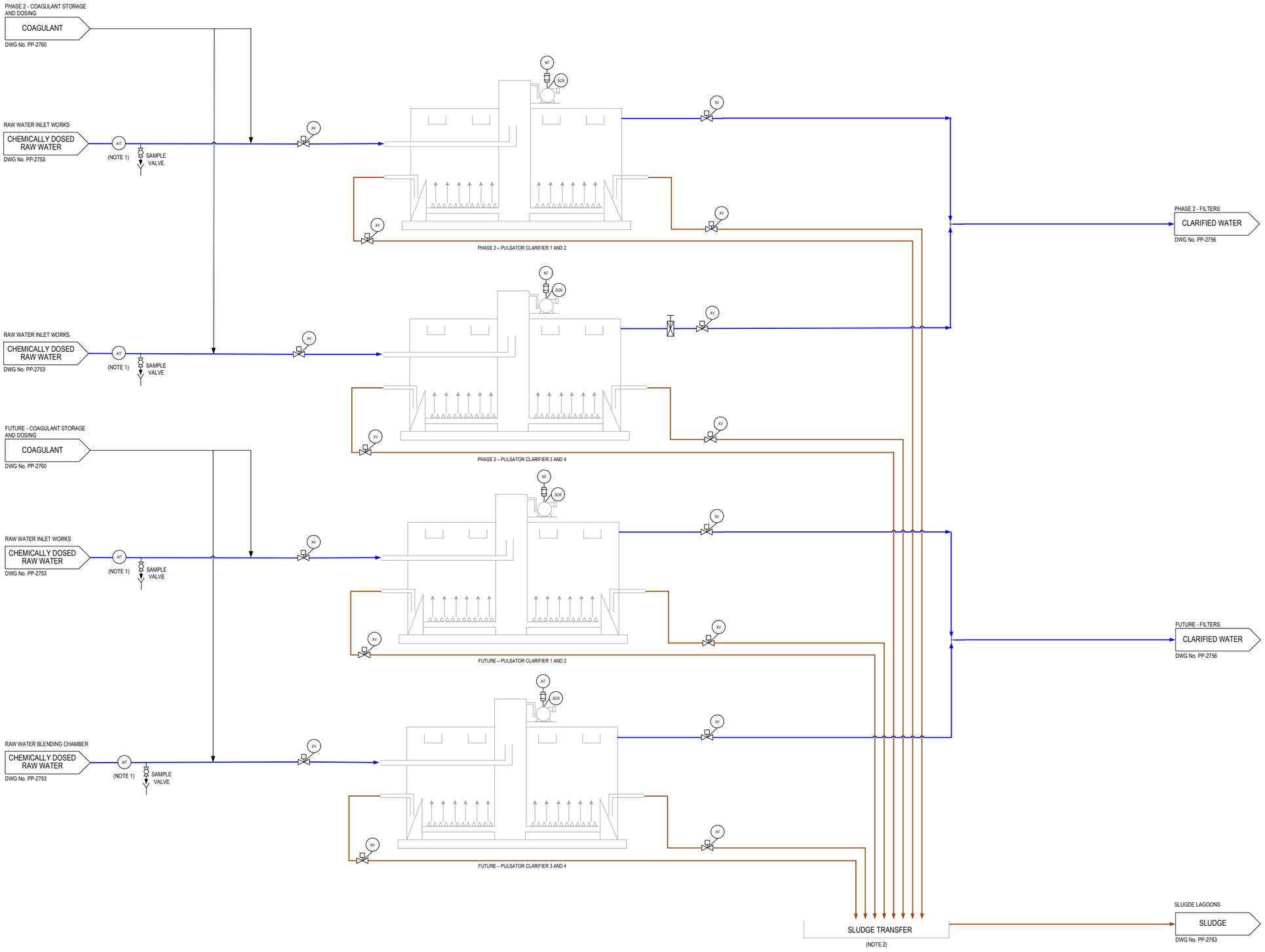
TITLE

WATER TREATMENT WORKS
MECHANICAL FLOW DIAGRAM :
PHASE 1 PULSATOR CLARIFIERS

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
1002533	-	2500	-	MFD	-	PP	-	2754	-	1

https://zutarisa.sharepoint.com/sites/1002533/Shared Documents/05 Deliver/502 Drawings/3. CAD/1. Feasibility Design Drawings/2. Process Drawings (do not use)/1002533-2500-PHSPP-2754 (MFD).vsdx



DISCLAIMER

IF CONSTRUCTION DRAWINGS ARE ISSUED UNSIGNED, THE MASTER WITH THE ORIGINAL SIGNATURE OF APPROVAL WILL BE HELD AT THE ZUTARI OFFICE OF THE APPROVER

NOTES:

1. ANALYSING STATION MONITORING:
- pH
- TURBIDITY (NTU)

KEY:

- MAIN PROCESS LINE
- WASTE LINE
- SECONDARY PROCESS LINE
- OVERFLOW

ZUTARI
IMPACT. ENGINEERED.

CLIENT

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
1	04/12/24	ISSUED FOR INFORMATION	

SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

DRAWN	D. GOHO
DESIGNED	T. CERONIO
REVIEWED	L. KROUWKAMP

APPROVED
DATE
PR TECH ENG

PROJECT

XHARIEP PIPELINE

TITLE

WATER TREATMENT WORKS
MECHANICAL FLOW DIAGRAM :
PHASE 2 & FUTURE PULSATOR CLARIFIERS

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
1002533	-	2500	-	MFD	-	PP	-	2755	-	1

https://zutarilive.sharepoint.com/sites/1002533/Shared Documents/05 Deliver/02 Drawings/3. CAD/1. Feasibility Design Drawings/2. Process Drawings (do not use)/1002533-2500-PFD-PP-2755 [MFD].vsdx

PHASE 1 - PULSATOR CLARIFIERS
CLARIFIED WATER
DWG No. PP-2754

PHASE 1 – RAPID GRAVITY FILTERS (1 TO 20)

PHASE 1 FILTER SUMPS

PHASE 1 - BACKWASH PUMPS

PHASE 1 - RESERVOIR
FILTERED WATER
DWG No. PP-2757

(NOTE 1)
SAMPLE VALVE

SERVICE WATER PUMPSTATION 1
UNCHLORINATED WATER
DWG No. PP-2758

PHASE 2 - PULSATOR CLARIFIERS
CLARIFIED WATER
DWG No. PP-2755

PHASE 2 – RAPID GRAVITY FILTERS (1 TO 10)

PHASE 2 FILTER SUMP

PHASE 2 & FUTURE - BACKWASH PUMPS

PHASE 2 - RESERVOIR
FILTERED WATER
DWG No. PP-2757

(NOTE 1)
SAMPLE VALVE

FUTURE - PULSATOR CLARIFIERS
CLARIFIED WATER
DWG No. PP-2755

FUTURE – RAPID GRAVITY FILTERS (1 TO 10)

FUTURE FILTER SUMP

FUTURE - RESERVOIR
FILTERED WATER
DWG No. PP-2757

(NOTE 1)
SAMPLE VALVE

FILTERS (AIR SCOUR BLOWERS)
BACKWASH AIR
DWG No. PP-2762

BACKWASH TRANSFER

SLUDGE LAGOONS
SPENT BACKWASH WATER
DWG No. PP-2763

DISCLAIMER

IF CONSTRUCTION DRAWINGS ARE ISSUED UNSIGNED, THE MASTER WITH THE ORIGINAL SIGNATURE OF APPROVAL WILL BE HELD AT THE ZUTARI OFFICE OF THE APPROVER

NOTES:

1. ANALYSING STATION MONITORING:
- TURBIDITY (NTU)

KEY:

- MAIN PROCESS LINE
- WASTE LINE
- SECONDARY PROCESS LINE
- OVERFLOW

ZUTARI
IMPACT. ENGINEERED.

CLIENT

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
1	04/12/24	ISSUED FOR INFORMATION	

SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

DRAWN: D. GOHO
DESIGNED: T. CERONIO
REVIEWED: L. KROUWKAMP
APPROVED
DATE
PR TECH ENG

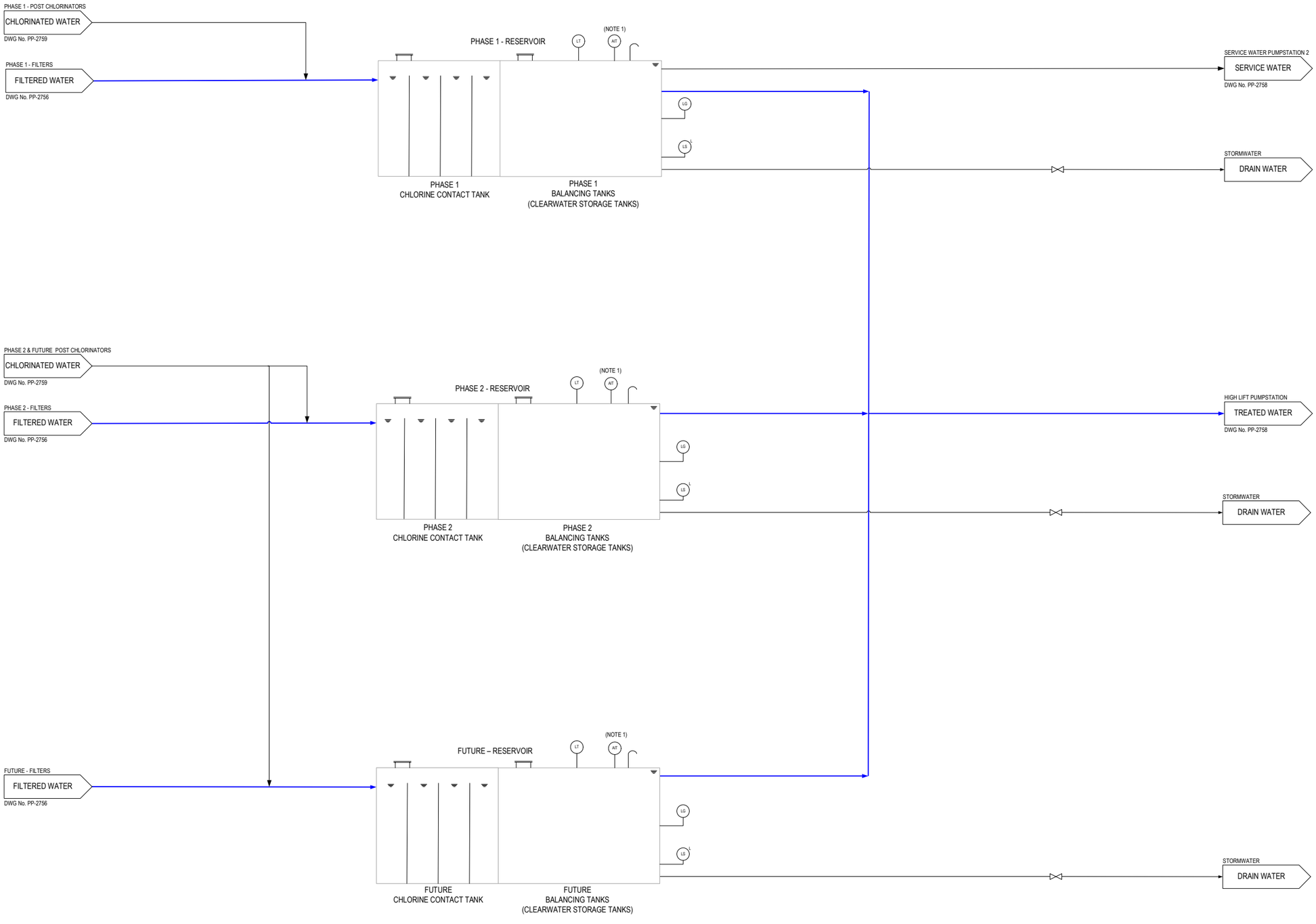
PROJECT
XHARIEP PIPELINE

TITLE
WATER TREATMENT WORKS
MECHANICAL FLOW DIAGRAM :
PHASE 1, PHASE 2 & FUTURE – RAPID GRAVITY SAND FILTERS

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
1002533	-	2500	-	MFD	-	PP	-	2756	-	1

https://zutarilive.sharepoint.com/sites/1002533/Shared Documents/05 Deliver/502 Drawings/3. CAD/1. Feasibility Design Drawings/2. Process Drawings (do not use)/1002533-2500-PP-2756 (MFD).vsdx



DISCLAIMER

IF CONSTRUCTION DRAWINGS ARE ISSUED UNSIGNED, THE MASTER WITH THE ORIGINAL SIGNATURE OF APPROVAL WILL BE HELD AT THE ZUTARI OFFICE OF THE APPROVER

NOTES:

1. ANALYSING STATION MONITORING:
- pH
- TURBIDITY (NTU)
- CHLORINE RESIDUAL

KEY:

- MAIN PROCESS LINE
- WASTE LINE
- SECONDARY PROCESS LINE
- OVERFLOW

ZUTARI
IMPACT. ENGINEERED.

CLIENT

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
1	04/12/24	ISSUED FOR INFORMATION	

SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

DRAWN	APPROVED
D. GOHO	DATE
DESIGNED	
T. CERONIO	
REVIEWED	PR TECH ENG
L. KROUWKAMP	

PROJECT

XHARIEP PIPELINE

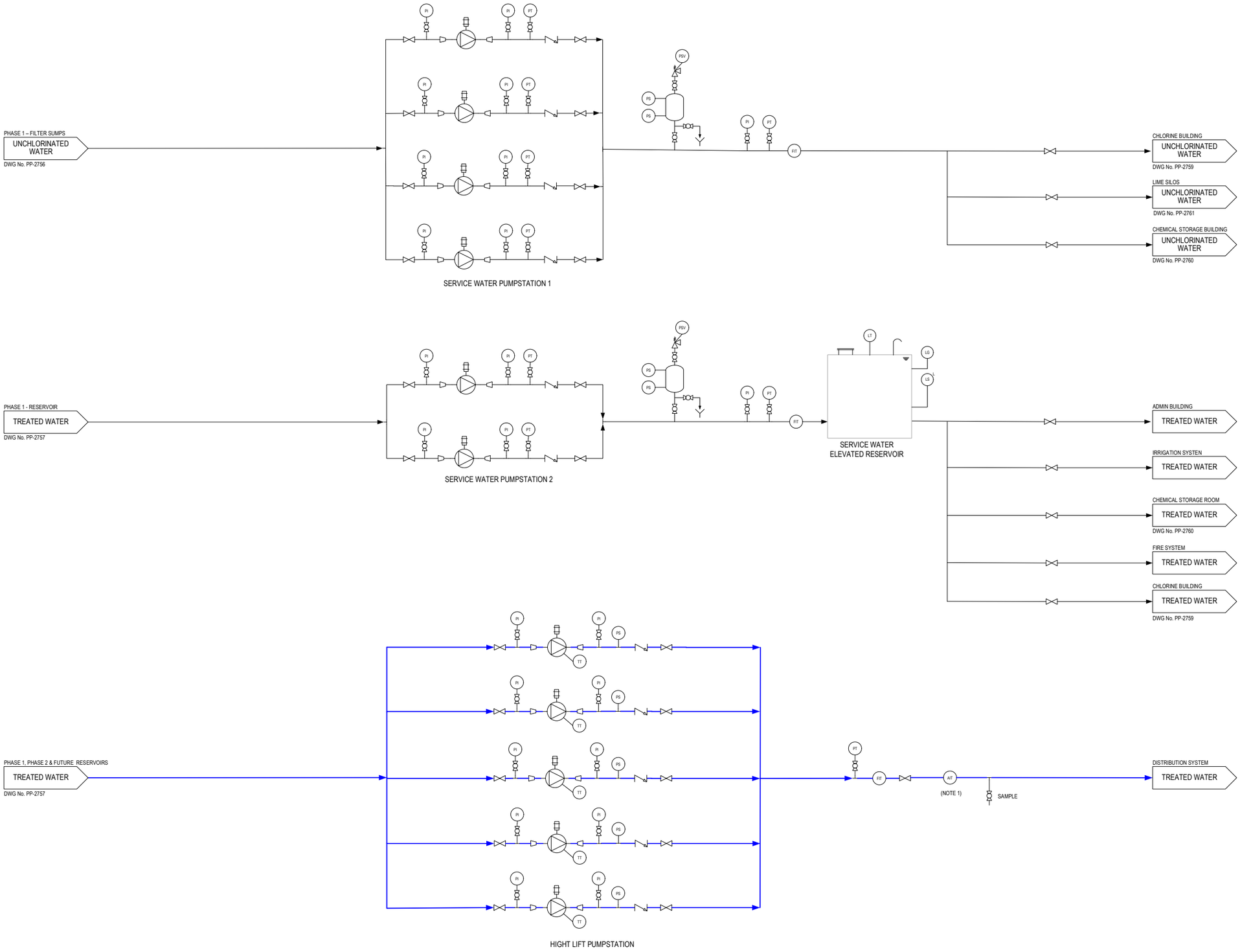
TITLE

WATER TREATMENT WORKS
MECHANICAL FLOW DIAGRAM :
PHASE 1 TO 3 RESERVOIRS

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
1002533	-	2500	-	MFD	-	PP	-	2757	-	1

https://zutarilive.sharepoint.com/sites/1002533Shared Documents/05 Deliver/502 Drawings/3. CAD/1. Feasibility Design Drawings/2. Process Drawings (do not use)/1002533-2500-PHP-2757 (MFD).vsdx



DISCLAIMER

IF CONSTRUCTION DRAWINGS ARE ISSUED UNSIGNED, THE MASTER WITH THE ORIGINAL SIGNATURE OF APPROVAL WILL BE HELD AT THE ZUTARI OFFICE OF THE APPROVER

NOTES:

1. ANALYSING STATION MONITORING:
- CHLORINE RESIDUAL

KEY:

- MAIN PROCESS LINE
- WASTE LINE
- SECONDARY PROCESS LINE
- OVERFLOW

ZUTARI
IMPACT. ENGINEERED.

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water & sanitation
Department:
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REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
1	04/12/24	ISSUED FOR INFORMATION	

SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

DRAWN: D. GOHO
DESIGNED: T. CERONIO
REVIEWED: L. KROUWKAMP
APPROVED
DATE
PR TECH ENG

PROJECT

XHARIEP PIPELINE

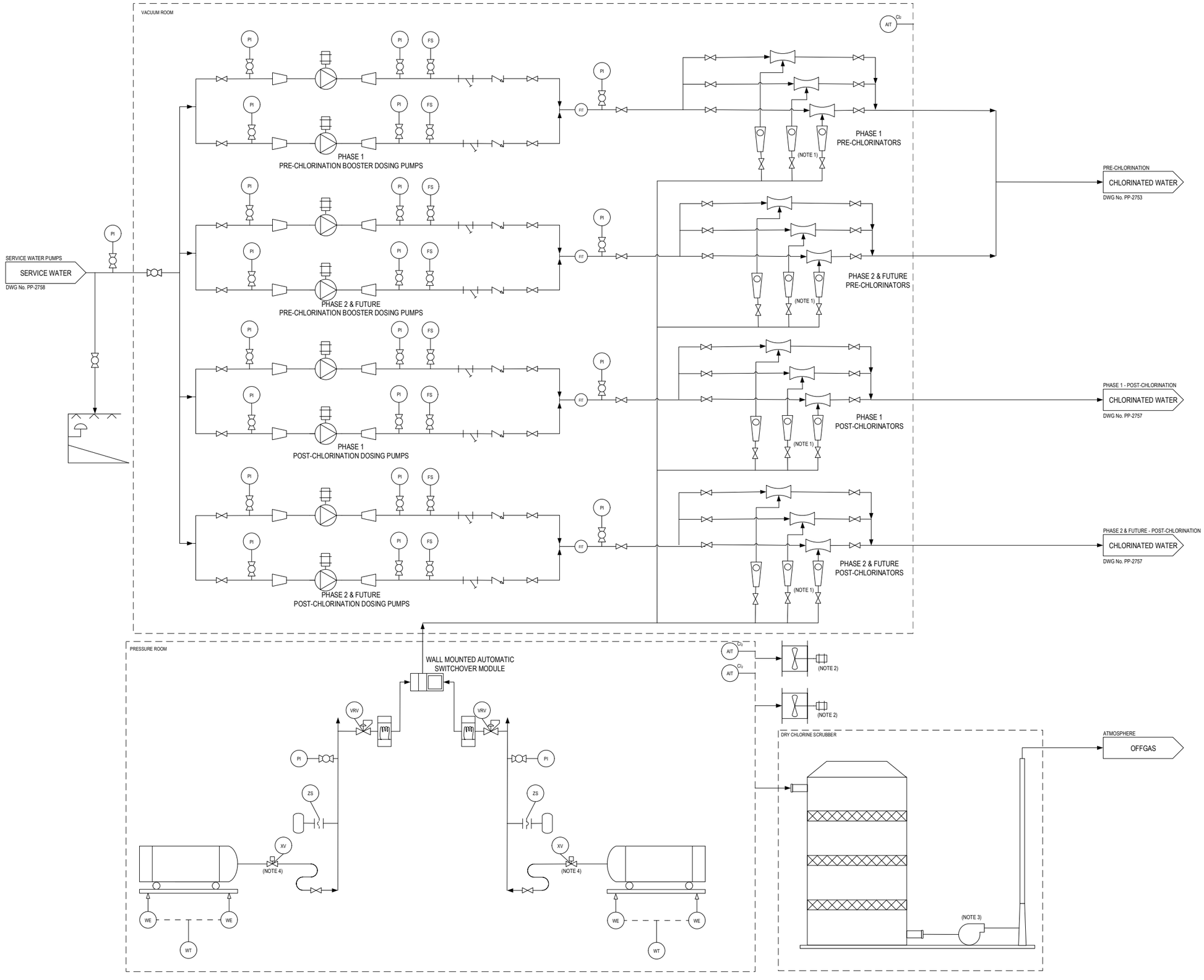
TITLE

WATER TREATMENT WORKS
MECHANICAL FLOW DIAGRAM :
HIGH LIFT AND SERVICE WATER PUMPSTATIONS

DRAWING NUMBER

PROJECT No.	WBS	TYPE	DISC	NUMBER	REV
1002533	2500	MFD	PP	2758	1

https://zutarilive.sharepoint.com/sites/1002533/Shared Documents/05 Deliver/502 Drawings/3. CAD/1. Feasibility Design Drawings/2. Process Drawings (do not use)/1002533-2500-PID-PP-2758 (MFD).vsdx



DISCLAIMER

IF CONSTRUCTION DRAWINGS ARE ISSUED UNSIGNED, THE MASTER WITH THE ORIGINAL SIGNATURE OF APPROVAL WILL BE HELD AT THE ZUTARI OFFICE OF THE APPROVER

NOTES:

1. AUTOMATIC FLOW CONTROL PROPORTIONAL TO INFLUENT FLOW
2. INTERLOCK TO SHUT OFF ON HIGH CHLORINE DETECTION
3. STARTS UP ON HIGH CHLORINE DETECTION
4. VALVES TO CLOSE AUTOMATICALLY WHEN CHLORINE GAS ANALYSER ALARMS

KEY:

- MAIN PROCESS LINE
- WASTE LINE
- SECONDARY PROCESS LINE
- OVERFLOW

ZUTARI
IMPACT. ENGINEERED.

CLIENT

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
1	04/12/24	ISSUED FOR INFORMATION	

SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

DRAWN	APPROVED
D. GOHO	DATE
DESIGNED	
T. CERONIO	
REVIEWED	PR TECH ENG
L. KROUWKAMP	

PROJECT

XHARIEP WTP

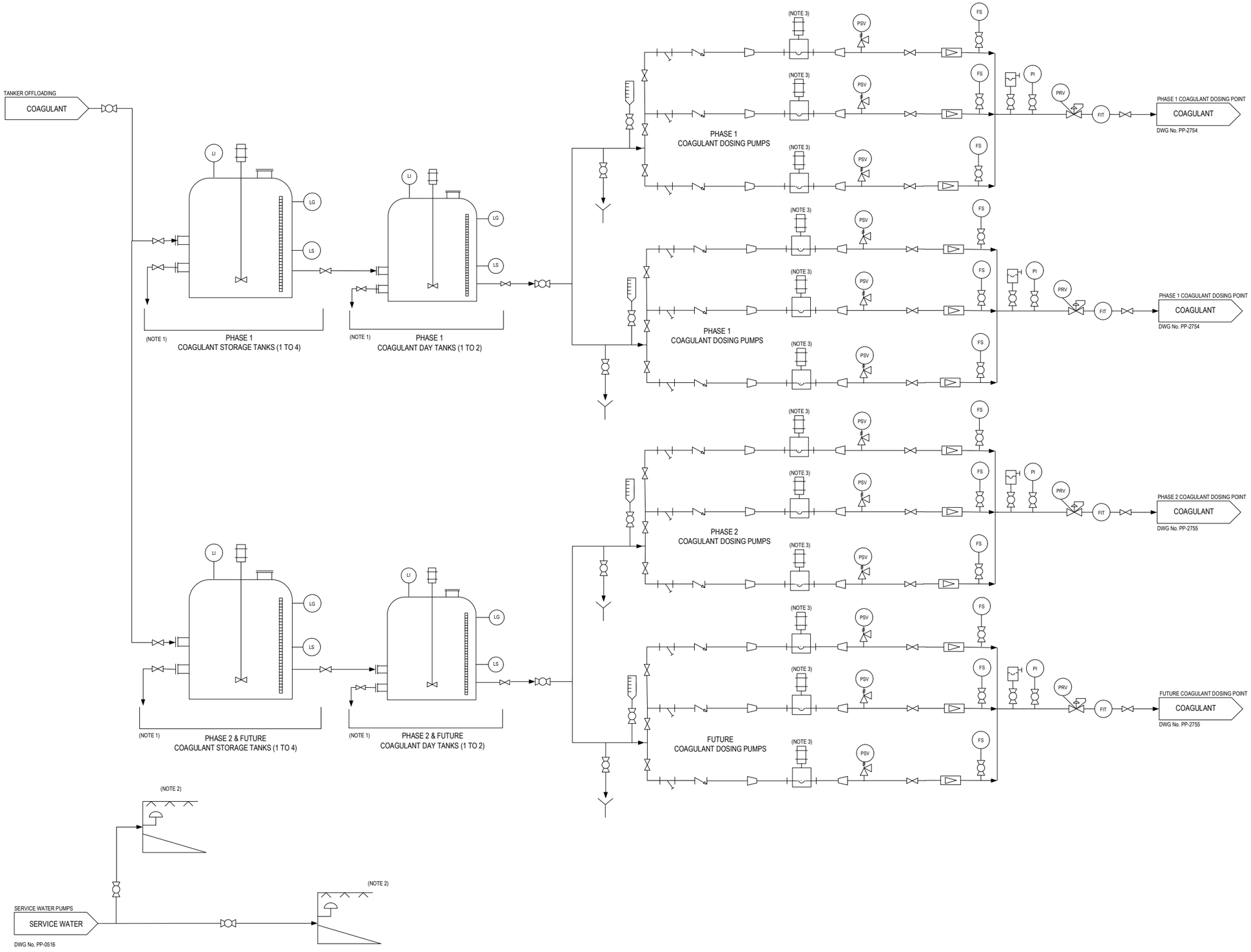
TITLE

WATER TREATMENT WORKS
MECHANICAL FLOW DIAGRAM :
CHLORINE STORAGE AND DOSING

DRAWING NUMBER

PROJECT No.		WBS		TYPE	DISC		NUMBER		REV
1002533	-	2500	-	MFD	PP	-	2759	-	1

https://zutarisa.sharepoint.com/sites/1002533/Shared Documents/05 Deliver/502 Drawings/3. CAD/1. Feasibility Design Drawings/2. Process Drawings (do not use)/1002533-2500-PD-PP-2759 (MFD).vsdx



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DISCLAIMER

IF CONSTRUCTION DRAWINGS ARE ISSUED UNSIGNED, THE MASTER WITH THE ORIGINAL SIGNATURE OF APPROVAL WILL BE HELD AT THE ZUTARI OFFICE OF THE APPROVER

NOTES:

1. TANKS INSTALLED IN COMMON BUNDED AREA.
2. SAFTY SHOWER WITH EYE WASH TO SERVICE CHEMICAL BUILDING
3. AUTOMATIC FLOW CONTROL PROPORTIONAL TO INFLUENT FLOW

KEY:

- MAIN PROCESS LINE
- WASTE LINE
- SECONDARY PROCESS LINE
- OVERFLOW

ZUTARI
IMPACT. ENGINEERED.

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water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
1	04/12/24	ISSUED FOR INFORMATION	

SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

DRAWN	APPROVED
D. GOHO	DATE
DESIGNED	
T. CERONIO	
REVIEWED	PR TECH ENG
L. KROUWKAMP	

PROJECT

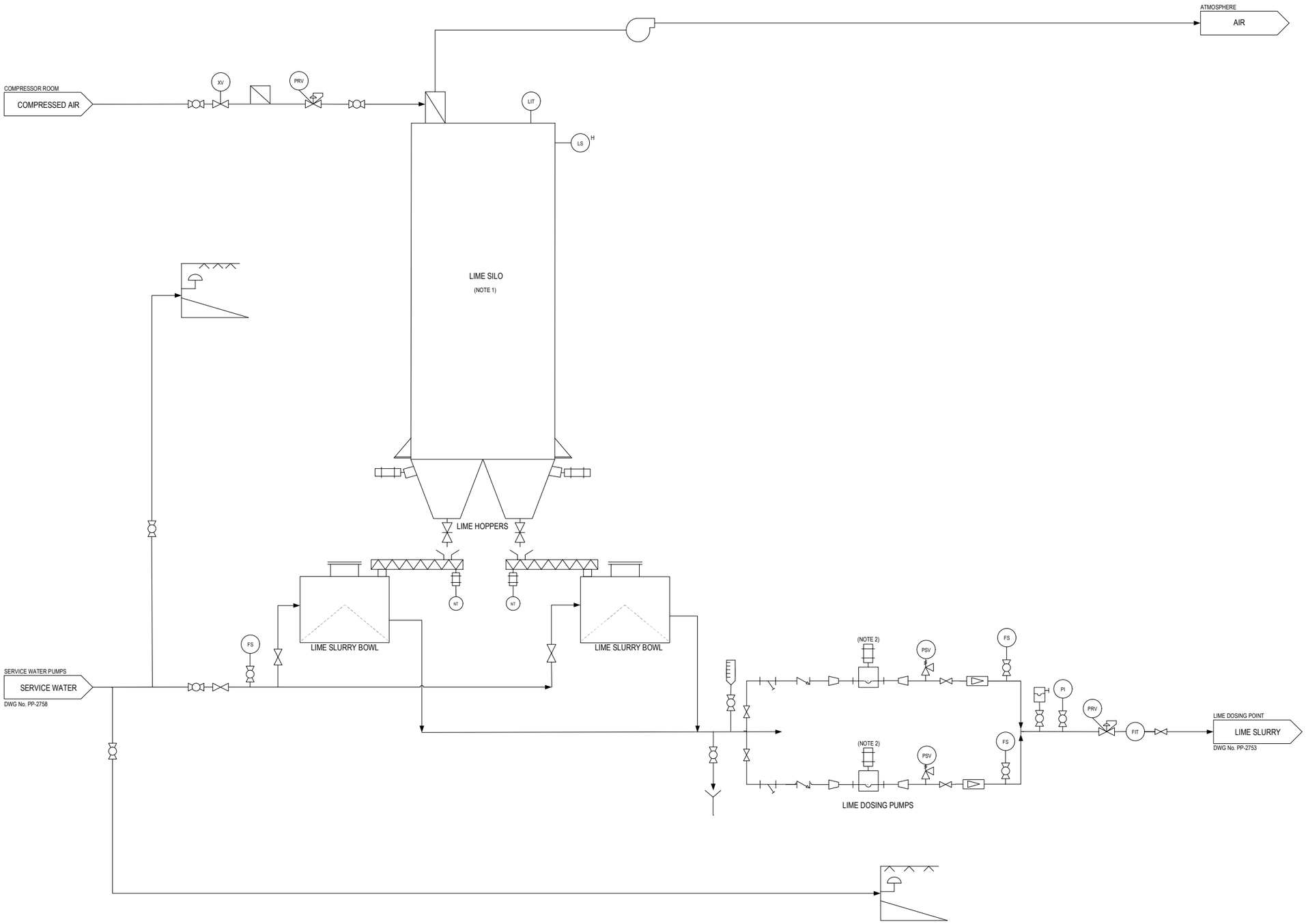
XHARIEP PIPELINE

TITLE

WATER TREATMENT WORKS
MECHANICAL FLOW DIAGRAM :
COAGULANT STORAGE AND DOSING

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
1002533	-	2500	-	MFD	-	PP	-	2760	-	1



DISCLAIMER

IF CONSTRUCTION DRAWINGS ARE ISSUED UNSIGNED, THE MASTER WITH THE ORIGINAL SIGNATURE OF APPROVAL WILL BE HELD AT THE ZUTARI OFFICE OF THE APPROVER

NOTES:

1. TWO LIME SILO SYSTEMS WILL BE INSTALLED IN PHASE 1 AND USE IN PHASE 1 AND PHASE 2. AN ADDITIONAL SILO WILL BE INSTALLED DURING FUTURE EXPENSION.

2. AUTOMATIC SPEED CONTROL PROPORTIONAL TO INFLUENT FLOW

KEY:

- MAIN PROCESS LINE
- WASTE LINE
- SECONDARY PROCESS LINE
- OVERFLOW

ZUTARI
IMPACT. ENGINEERED.

CLIENT

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
1	04/12/24	ISSUED FOR INFORMATION	

SCALE	SIZE
NTS	A1

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

DRAWN	D. GOHO
DESIGNED	T. CERONIO
REVIEWED	L. KROUWKAMP
APPROVED	DATE / PR TECH ENG

PROJECT

XHARIEP PIPELINE

TITLE

WATER TREATMENT WORKS
MECHANICAL FLOW DIAGRAM :
LIME STORAGE AND DOSING

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
1002533	-	2500	-	MFD	-	PP	-	2761	-	1

https://zutarillive.sharepoint.com/sites/1002533/Shared Documents/05 Deliver/502 Drawings/3. CAD/1. Feasibility Design Drawings/2. Process Drawings (do not use)/1002533-2500-PP-PFV-2761(MFD).vsdx

Appendix D: Proposed Site Arrangement Drawings

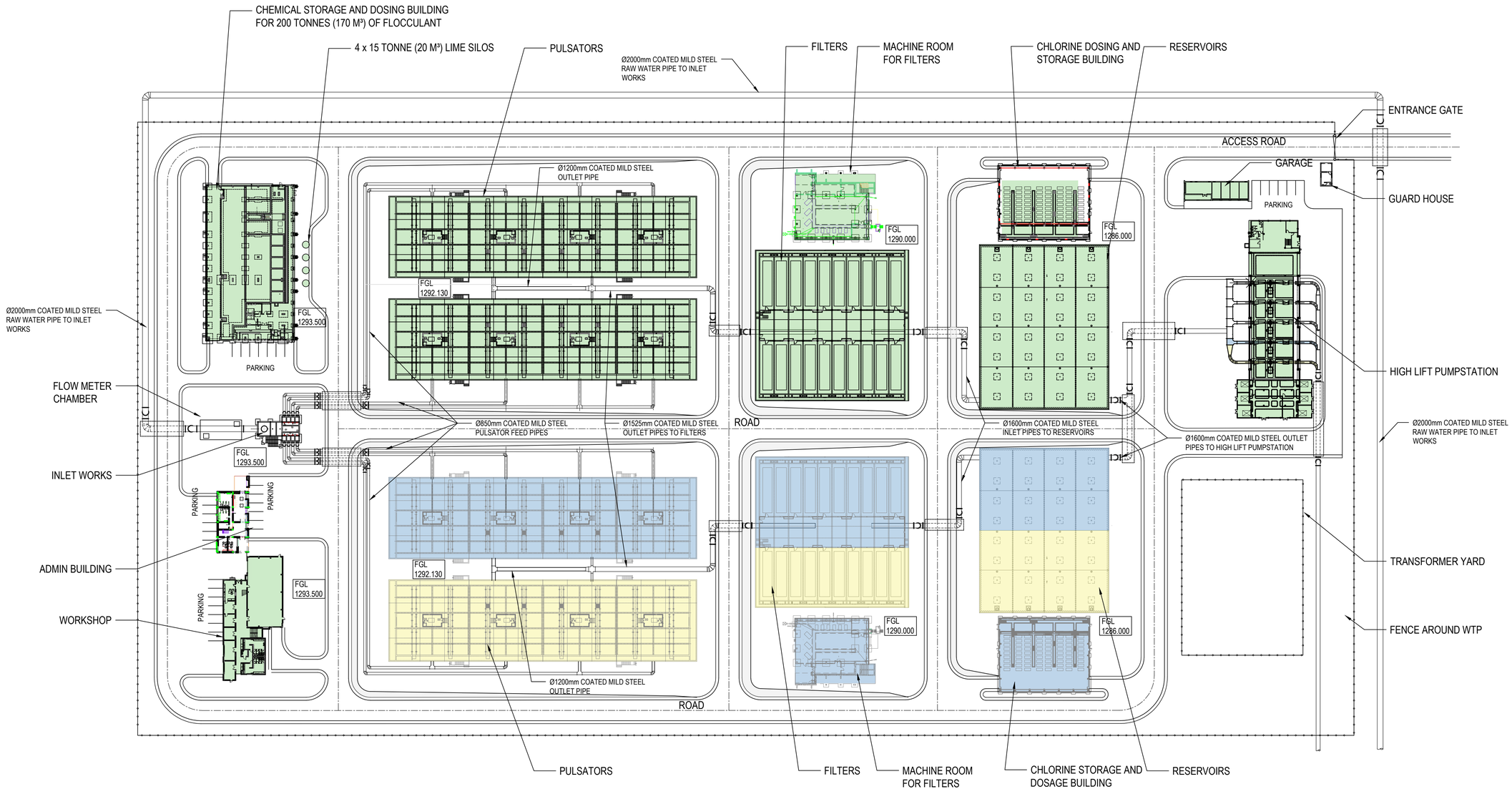
Drawing number	Title
1002533-2500-DRG-CC-2500	Site Location Rev B-Site Location
1002533-2500-DRG-CC-2501	WTW Overall Site
1002533-2500-DRG-CC-2502	WTW Site Layout Rev B-Site Layout-001

GENERAL NOTES:

1. THIS DRAWING IS FOR PREFEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.

LEGEND:

- PHASE 1
- PHASE 2
- FUTURE



0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2502
DESIGN: JB STRYDOM
DRAWN: JB STRYDOM
ZUTARI APPROVER (Pr. Eng): T.C DATE:

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: T. CERONIO DATE:
DESIGN:
DRAWN:
ENGINEER: DATE:
EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE:
DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

PROPOSED XHARIEP WTP WATER TREATMENT WORKS SITE LAYOUT

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100		
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.							REV.	
CALCULATION FILE:		1 OF 1								A	

Filename:
Office: ZAOC1
Plot Date:



GENERAL NOTES:

1. THIS DRAWING IS FOR PREFEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.

LEGEND:

- PHASE 1
- PHASE 2
- FUTURE

Office: ZADC1 Filename:

Plot Date:

0.25 0 0.5 1m

SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2500

DESIGN:

ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN: DRAWN:

ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:

CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

PROPOSED XHARIEP WTP
WATER TREATMENT WORKS
LOCALITY PLAN

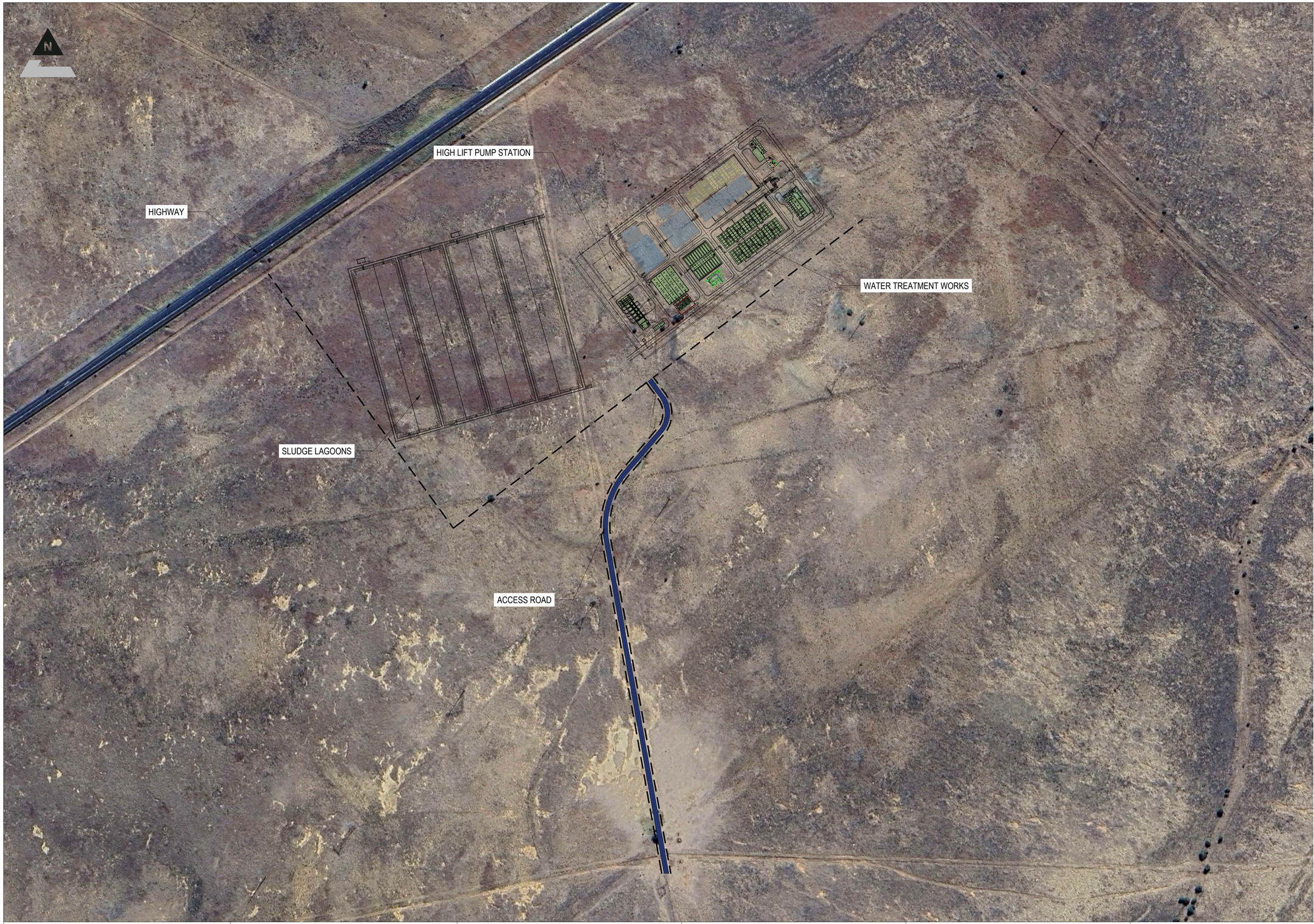
PROVINCE: DISTRICT:

LOCALITY No.: TENDER/ CONTRACT No.

CALCULATION FILE:

KEYCODES: X X X - - OTHER NUMBER 0100

SHEET 1 OF 1 REG. No. REV. A



GENERAL NOTES:

1. THIS DRAWING IS FOR PREFEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.

LEGEND:

- PHASE 1
- PHASE 2
- FUTURE

Office: ZADC1 Filename:

Plot Date:

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SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2501

DESIGN:

ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN:

DRAWN:

ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:

CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

PROPOSED XHARIEP WTP
WATER TREATMENT WORKS
OVERALL SITE LAYOUT

PROVINCE: DISTRICT:

LOCALITY No.: TENDER/ CONTRACT No.

CALCULATION FILE:

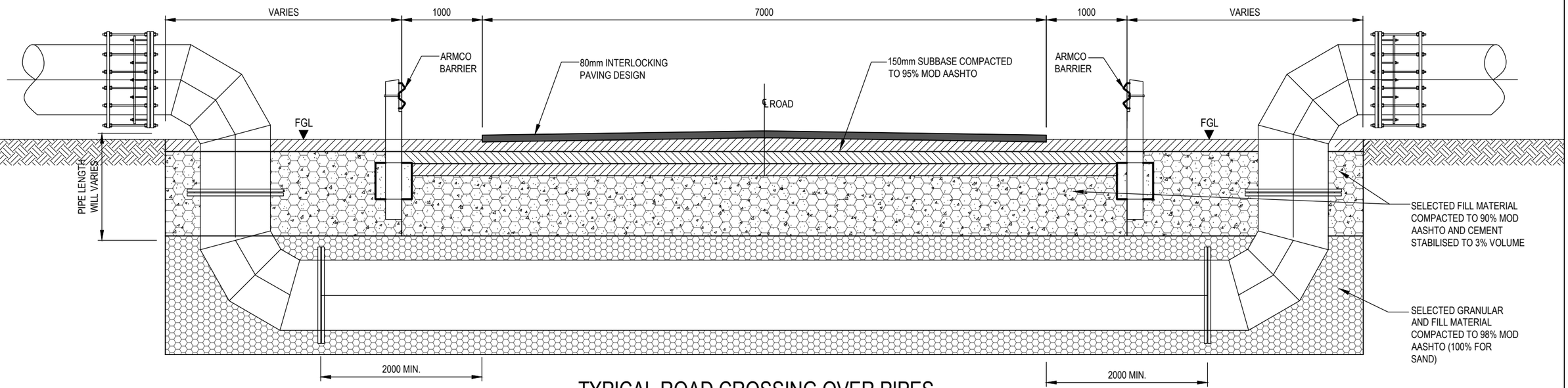
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SHEET 1 OF 1 REG. No.

REV. A

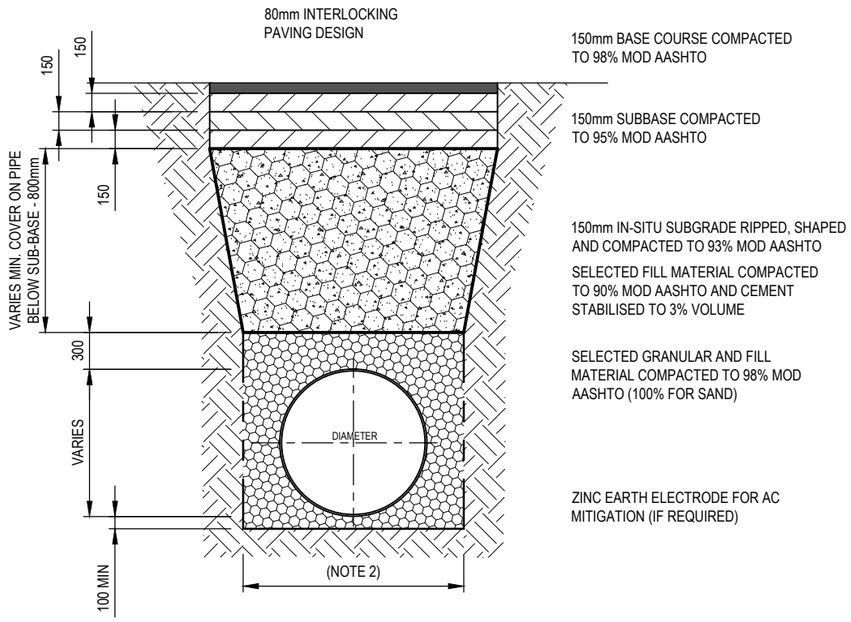
Appendix E:Typical Water Treatment Plant Drawings

Drawing number	Title
1002533-2500-DRG-CC-2510	Typical Workshop Ground Floor Plan & Section
1002533-2500-DRG-CC-2511	Typical Workshop First Floor Plan & Section
1002533-2500-DRG-CC-2512	Typical Admin Building Plans
1002533-2500-DRG-CC-2513	Typical Admin Building Sections
1002533-2500-DRG-CC-2514	Typical Inlet Works Plan and Section
1002533-2500-DRG-CC-2515	Typical Inlet Works Sections
1002533-2500-DRG-CC-2516	Typical Chemical Dosing Building Flloor Plan
1002533-2500-DRG-CC-2517	Typical Chemical Dosing Building Section
1002533-2500-DRG-CC-2518	Typical Pulsators - Layout
1002533-2500-DRG-CC-2519	Typical Pulsators - Sections
1002533-2500-DRG-CC-2520	Typical Chlorine Dosing & Storage Building-Layout
1002533-2500-DRG-CC-2521	Typical Chlorine Dosing & Storage Building-Section
1002533-2500-DRG-CC-2522	Typical Filters - Layout
1002533-2500-DRG-CC-2524	Typical Reservoir - Layout
1002533-2500-DRG-CC-2525	Typical Reservoir Sections
1002533-2500-DRG-CC-2526	Typical Filter Pump Room Layouts
1002533-2500-DRG-CC-2527	Typical Filter Pump Room Layouts
1002533-2500-DRG-CC-2528	Typical Filter Pump Room Sections
1002533-2500-DRG-CC-2529	Typical Guard House
1002533-2500-DRG-CC-2550	Typical Sludge Lagoons Layout & Details
1002533-2500-DRG-CC-2551	Typical Sludge Lagoon Layout
1002533-2500-DRG-CC-2552	Typical Sludge Lagoons Sections & Details
1002533-2500-DRG-CC-2555	Typical Water Recovery Pump Station Plan
1002533-2500-DRG-CC-2556	Typical Water Recovery Pump Station Sections
1002533-2500-DRG-CC-2560	Typical Chlorine Booster & Storage Building @ CH151005 Plan
1002533-2500-DRG-CC-2561	Typical Chlorine Booster & Storage Building @ CH151005 Section
1002533-2500-DRG-CC-2570	Typical Flow Meter Chamber
1002533-2850-DRG-CC-2880	Typical Pipe and Road Crossing Detail



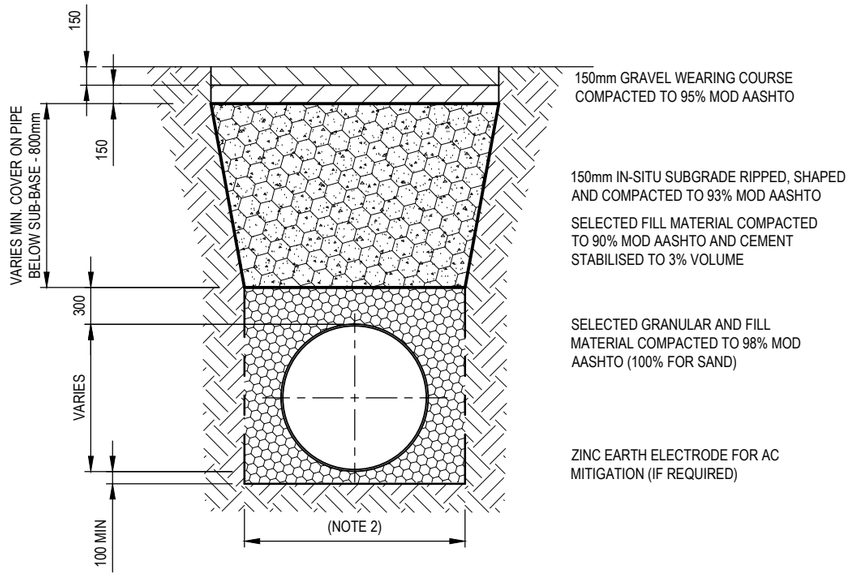
TYPICAL ROAD CROSSING OVER PIPES

SCALE 1 : 25



TYPICAL SECTION THROUGH TRENCH BELOW PREMIX ROAD SURFACE

SCALE 1 : 25



TYPICAL SECTION THROUGH TRENCH BELOW GRAVEL ROAD SURFACE

SCALE 1 : 25

Plot Date: 2/12/2024 7:32:26 am Office: ZACPT Filename: C:\USERS\JOHANNES.STRYDOM\DCIACCDOCS\ZUTARI\1002533 - XHARIEP PIPELINE FS_2023\PROJECT FILES\2_DELI\1_WIP\3_TREATMENT\2. STANDARD DRAWINGS\1002533-2850-DRG-CC-2880_TYPICAL PIPE AND ROAD CROSSING DETAIL.DWG

ZUTARI
IMPACT. ENGINEERED.

CLIENT

water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DISCLAIMER

IF CONSTRUCTION DRAWINGS ARE ISSUED UNSIGNED, THE MASTER WITH THE ORIGINAL SIGNATURE OF APPROVAL WILL BE HELD AT THE ZUTARI OFFICE OF THE APPROVER

REV	DATE	REVISION DETAILS	APPROVED
A	12/12/24	ISSUE FOR INFORMATION	NAME

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DRAWN	JB STRYDOM
DESIGNED	JB STRYDOM
REVIEWED	T CER0NIO

PRELIMINARY
NOT FOR CONSTRUCTION

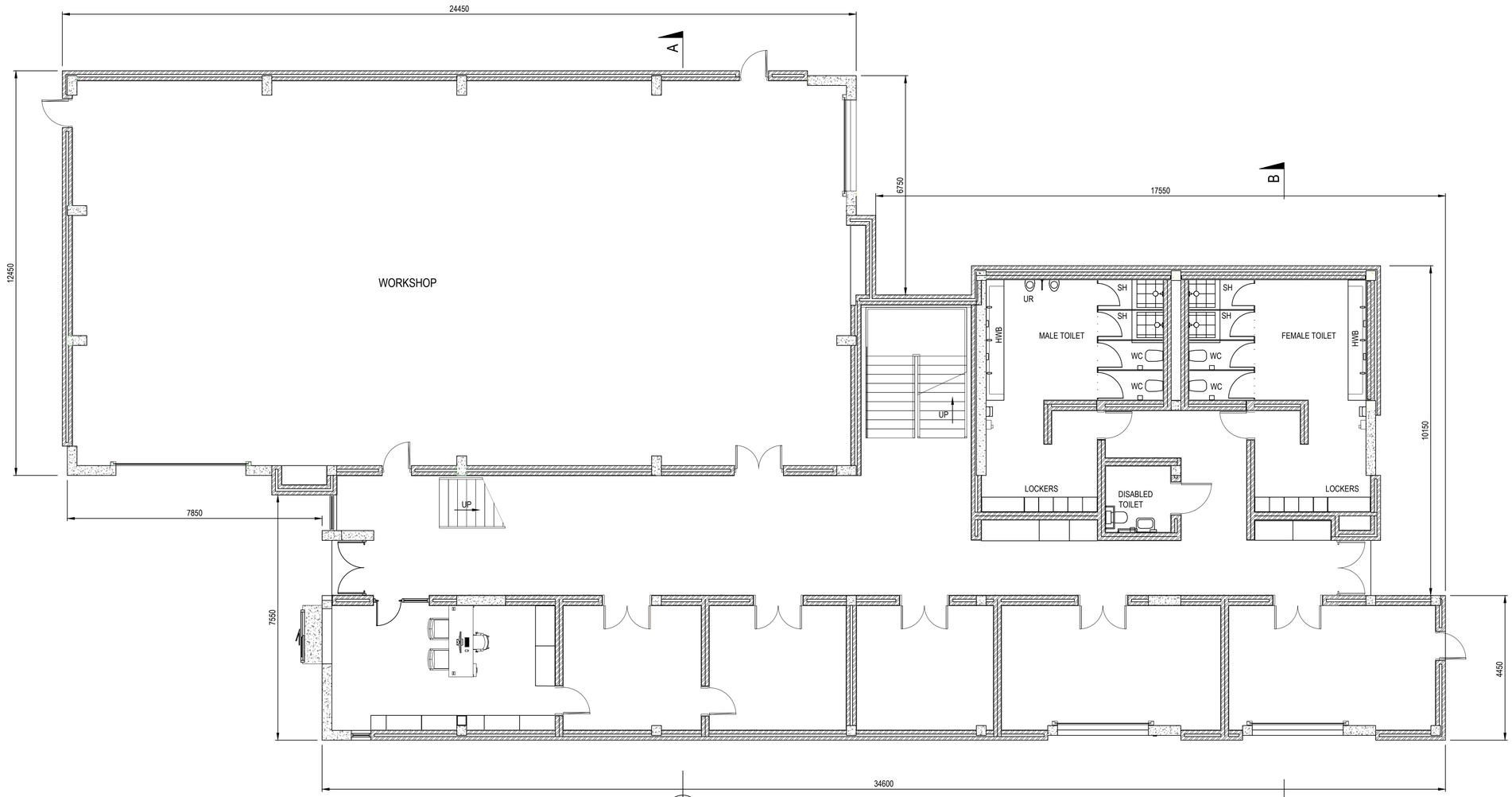
APPROVED
DATE
APPDATE
APPSIGN
APP
CERTNAME
CERTTYPE
CERTNO

PROJECT	XHARIEP PIPELINE FEASIBILITY STUDY
TITLE	TYPICAL PIPE AND ROAD CROSSING DETAIL

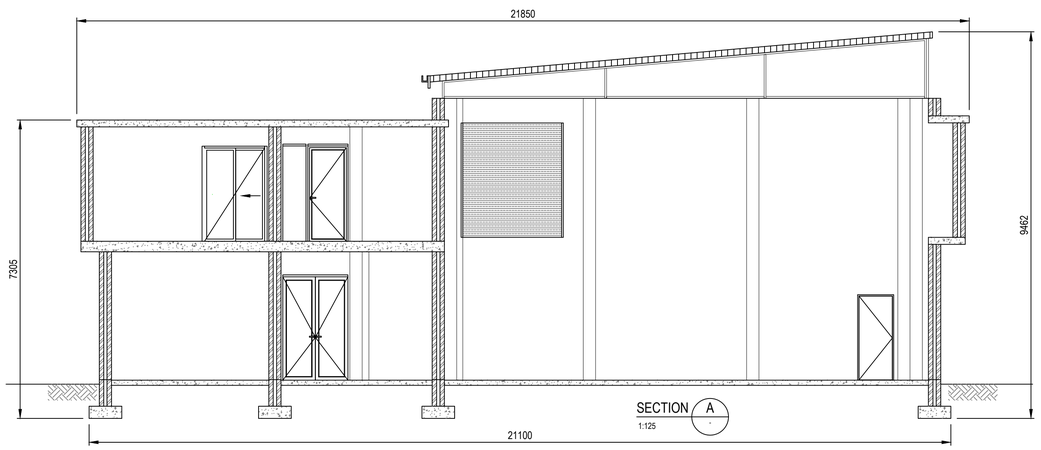
DRAWING No.	PROJECT No.	WBS	TYPE	DISC	NUMBER	REV
	1002533	2850	DRG	CC	2880	A

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



PLAN ON GROUND FLOOR
SCALE 1:75



SECTION A
1:125

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS			
SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2510

ZUTARI APPROVER (Pr. Eng): T.C DATE:

DESIGN:

DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION				
MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE:

DESIGN:

DRAWN:

ENGINEER: DATE:

EXT. APPROVAL / DESIGN CHECKED: DATE:

CHIEF ENGINEER / APP (Pr. Eng): DATE:

DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

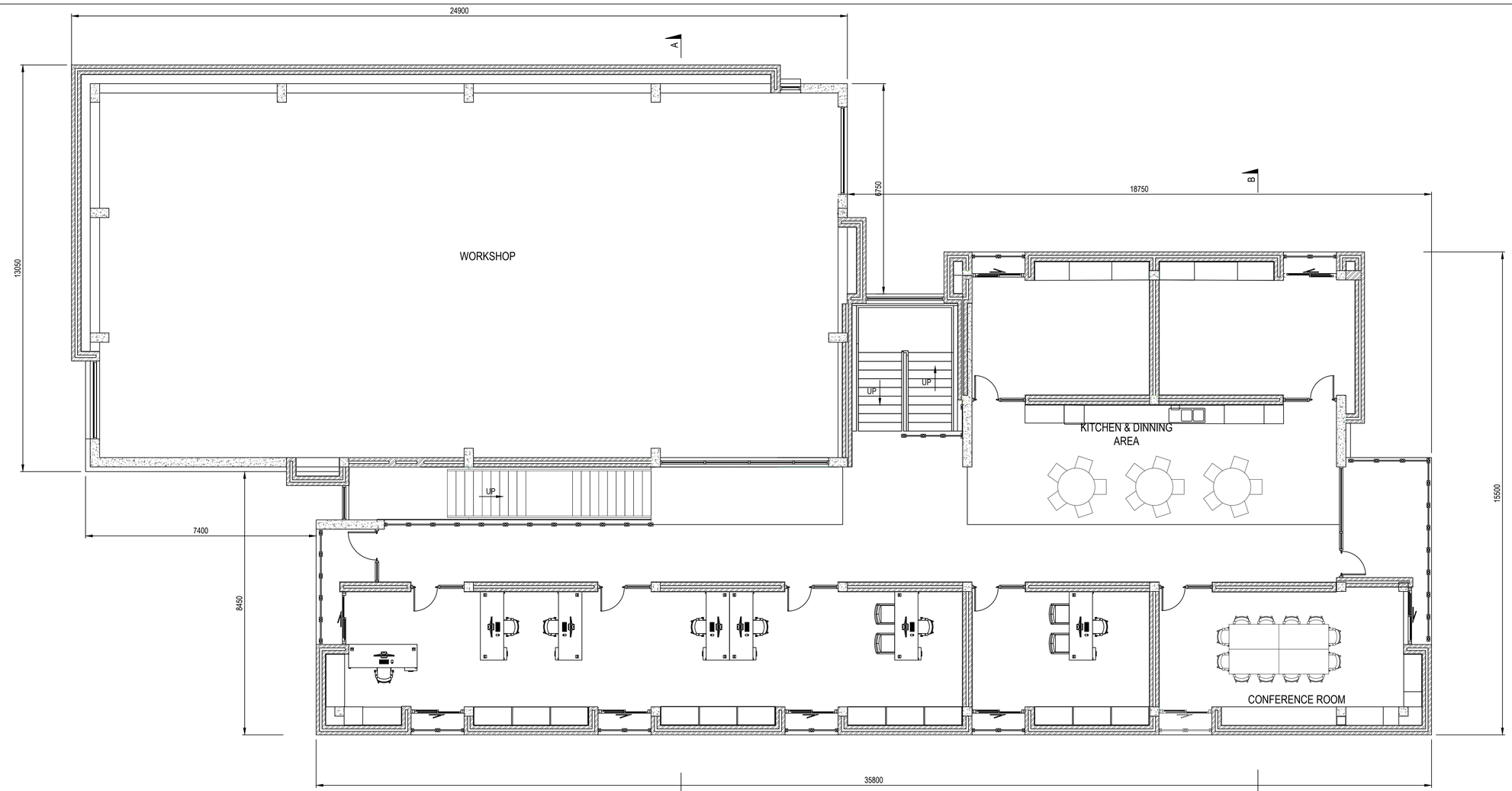
PROPOSED XHARIEP WTP
WORKSHOP
PLAN & SECTIONS

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100		
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.							REV.	
CALCULATION FILE:		1 of 1								A	

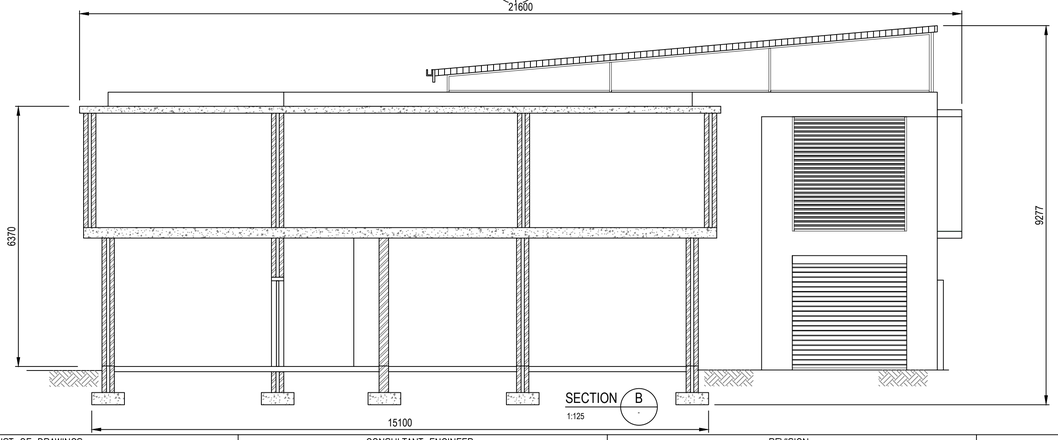
Office: ZADC1 Filename:
Plot Date:

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



PLAN ON FIRST FLOOR
SCALE 1:75



SECTION B
1:125

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

Office: ZADCI Filename:
Plot Date:

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2511

DESIGN:

ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

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PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN:

DRAWN:

ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:

CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

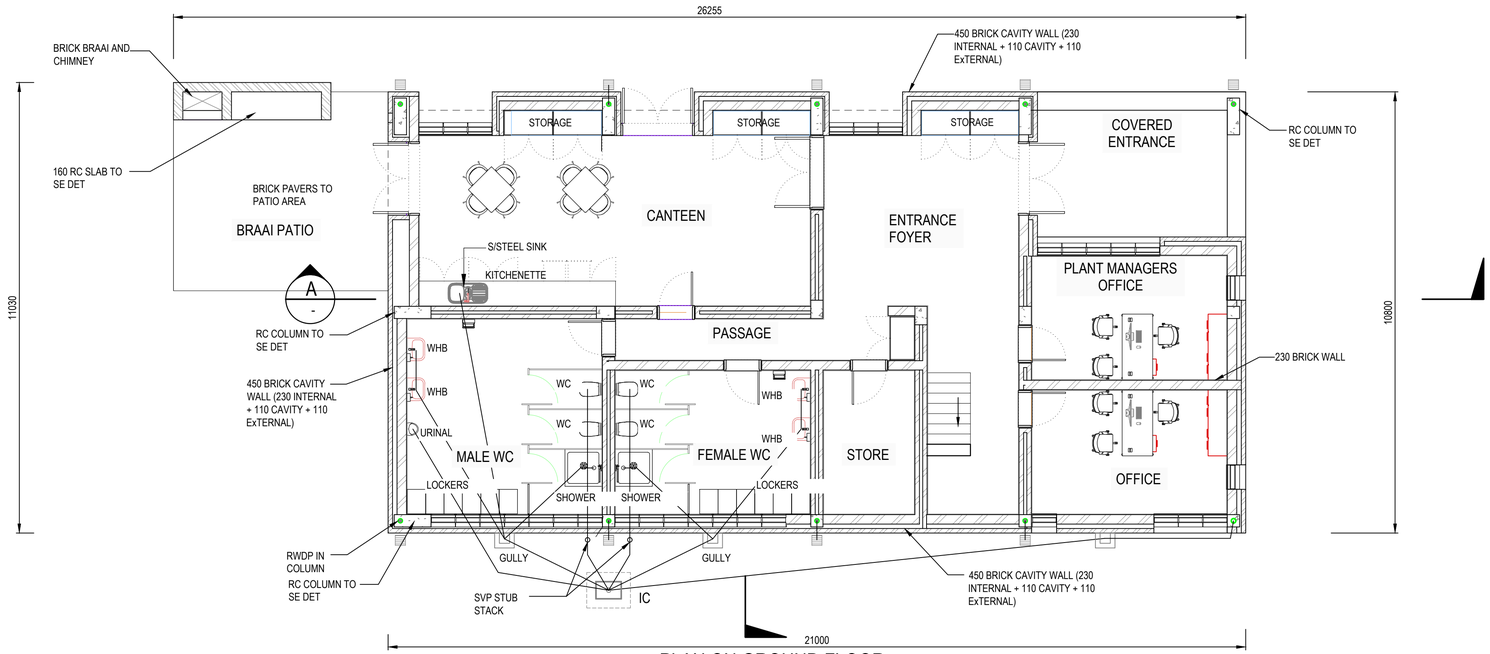
XHARIEP PIPELINE FEASIBILITY STUDY

PROPOSED XHARIEP WTP
WORKSHOP
PLAN & SECTIONS

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100			
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.							REV.		
CALCULATION FILE:		1 of 1								A		

GENERAL NOTES:

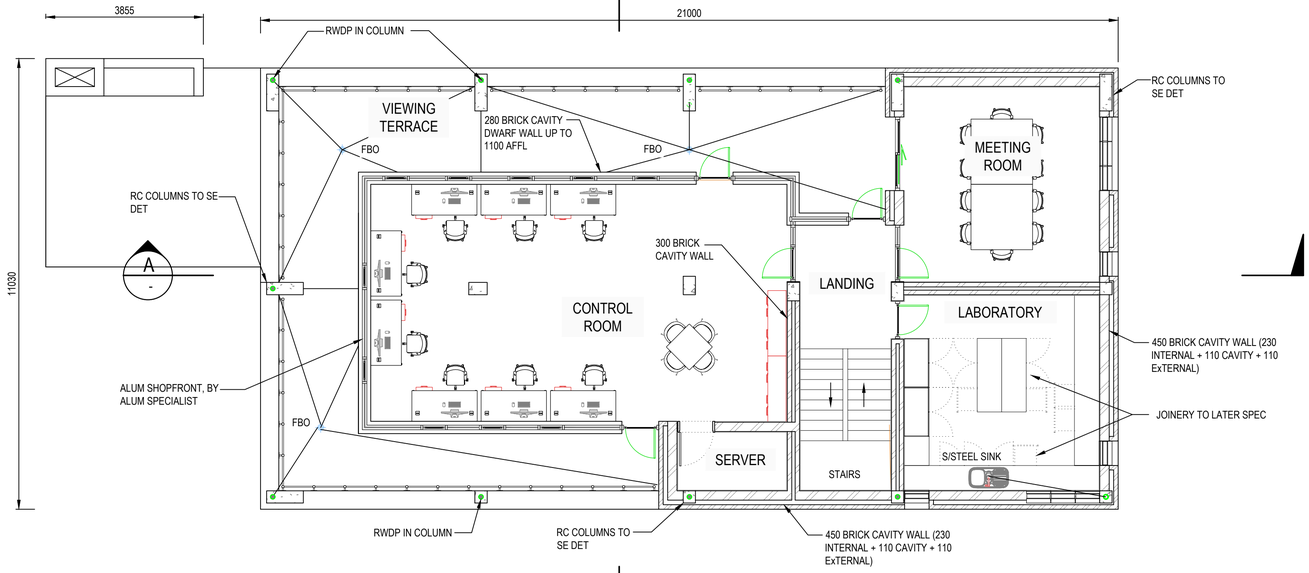
1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



PLAN ON GROUND FLOOR

SCALE 1 : 75

B
-



PLAN ON FIRST FLOOR

SCALE 1 : 75

0.25 0 0.5 1m

SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2512

DESIGN:

ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

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ENGINEERING SERVICES
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PRETORIA 0001

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PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN: DRAWN:

ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:

CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

PROPOSED XHARIEP WTP ADMIN BUILDING PLANS

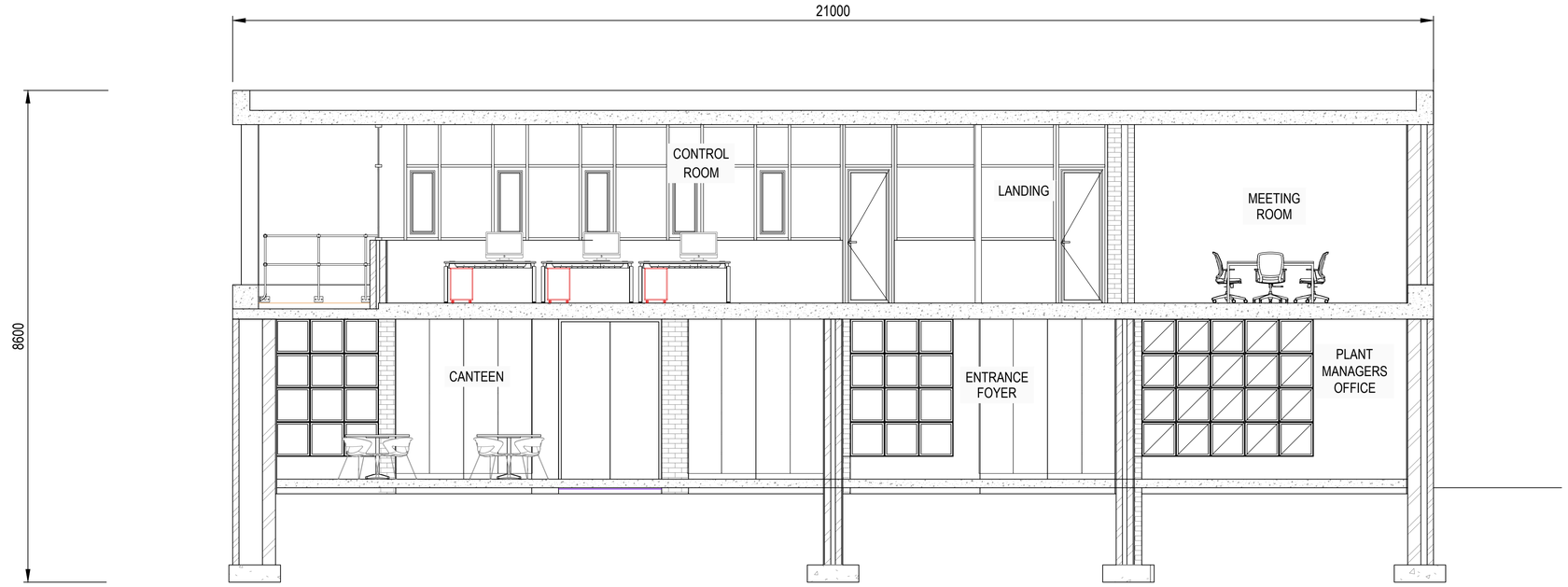
PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	-	-	OTHER NUMBER	0100
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.						REV.
CALCULATION FILE:		1 OF 1							A

Office: ZADC1 Filename:

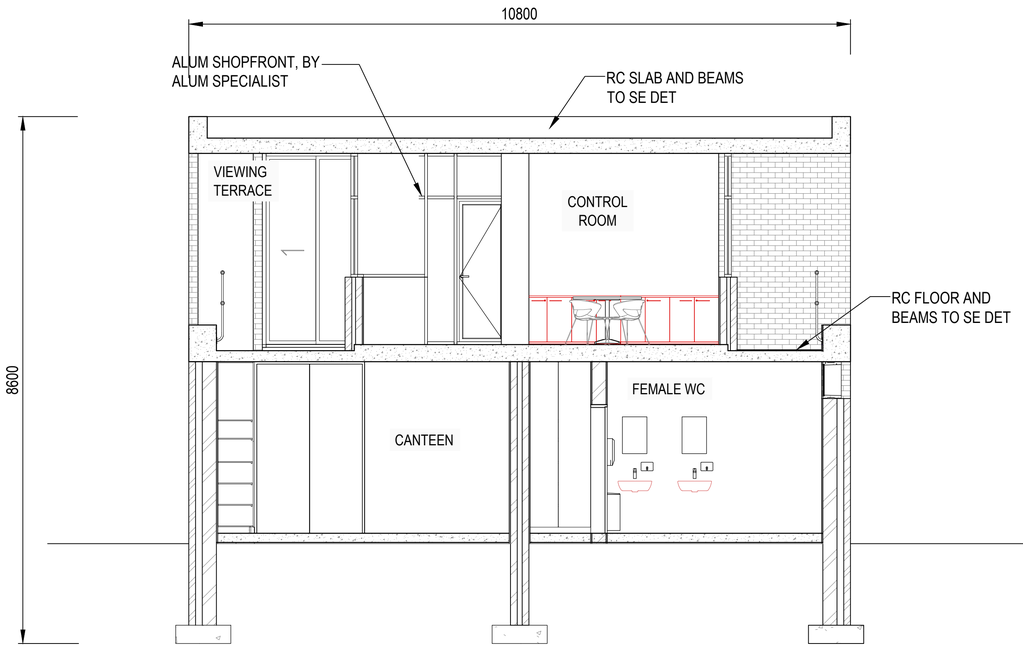
Plot Date:

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



SECTION A
1:75



SECTION B
1:75

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2513
DESIGN:
ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN: DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

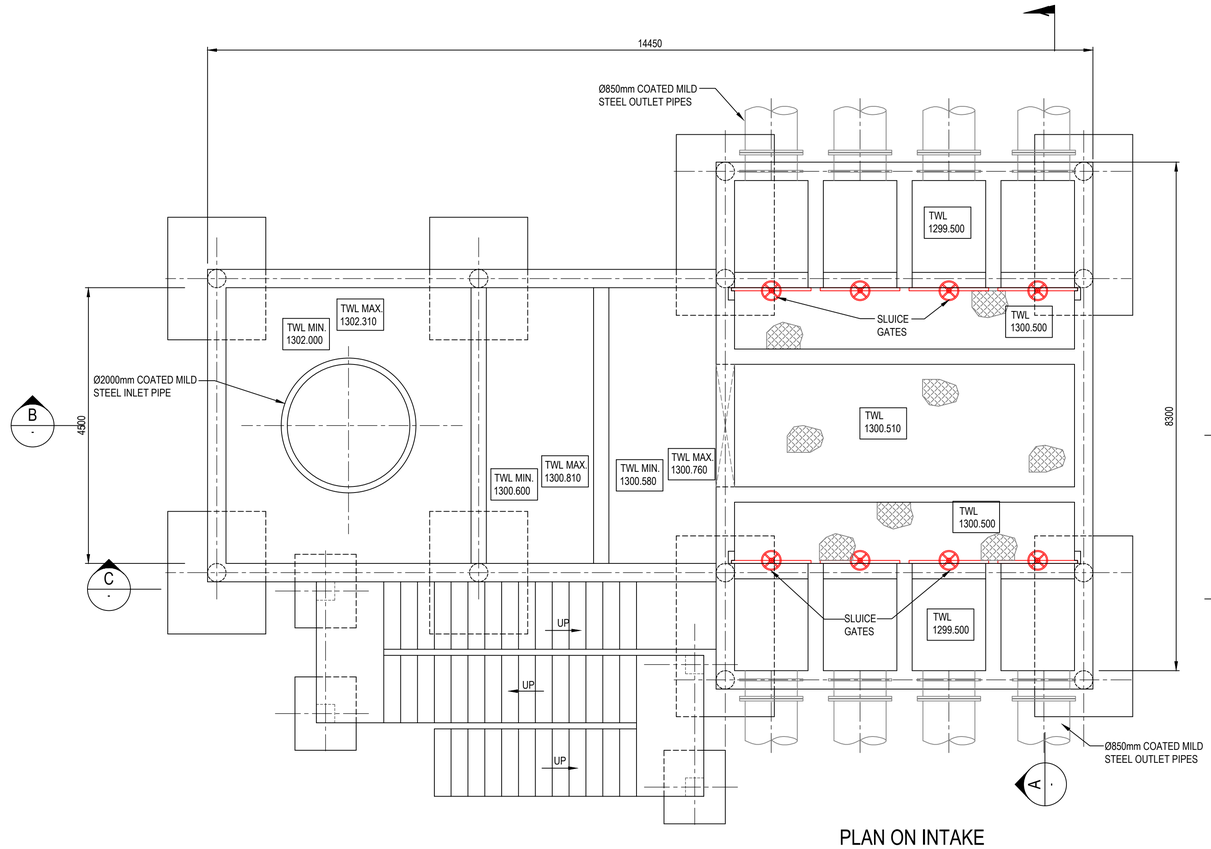
PROPOSED XHARIEP WTP
ADMIN BUILDING
SECTIONS

PROVINCE: DISTRICT: KEYCODES: X X X - - OTHER NUMBER 0100
LOCALITY No.: TENDER/ CONTRACT No. SHEET 1 OF 1 REG. No. REV. A
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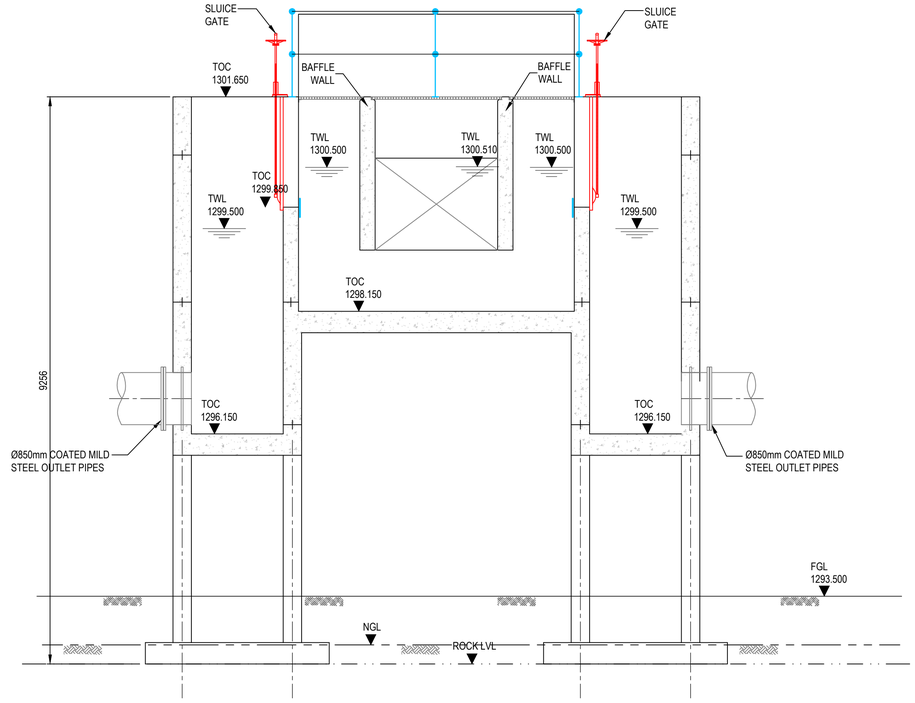
Office: ZADC1 Filename:
Plot Date:

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



PLAN ON INTAKE
SCALE 1 : 50



SECTION A
1:50

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2514

DESIGN:

ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

DESIGN:
CHECKED: DATE: DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

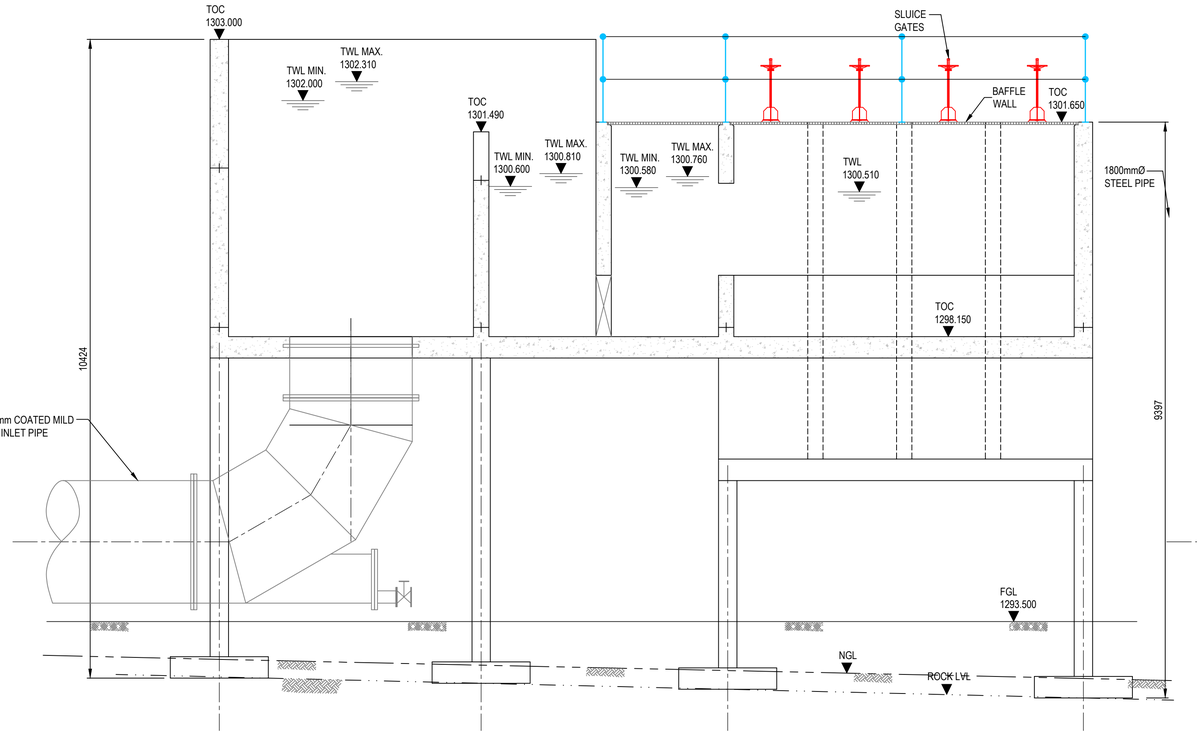
PROPOSED XHARIEP WTP
TYPICAL DETAILS
RAW WATER INLET
PLAN AND SECTION

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100	
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.							REV.
CALCULATION FILE:		1 OF 1								A

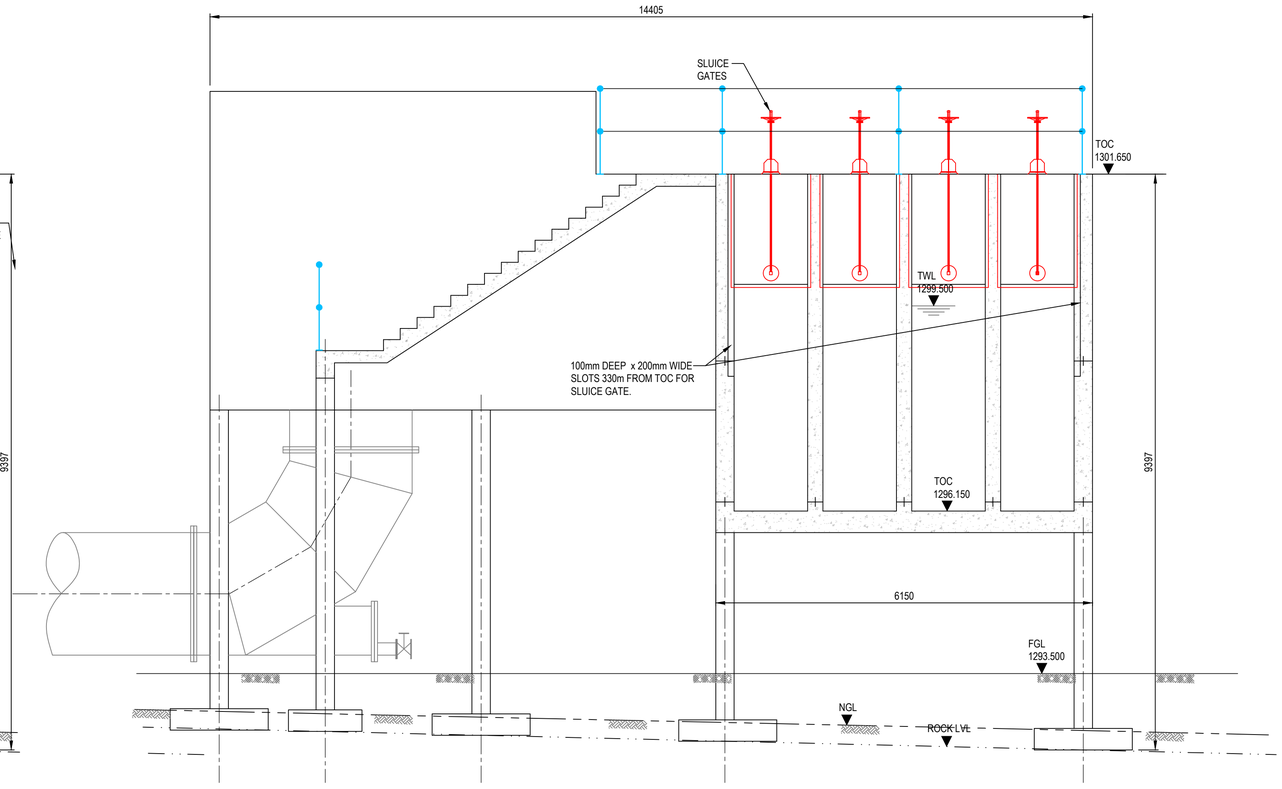
Plot Date: 13/12/2024 12:15:51 pm Office: ZAC1 Filename: C:\USERS\JACHIN.RABICHAND\ONEDRIVE - ZUTARI\WORK\KHARIEP\DRAWINGS\CIVIL\3D FILES\1002533-2500-DRG-CC-2514 INLET WORKS - DIVISION STRUCTURE.DWG

GENERAL NOTES:

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SECTION B
1:50



SECTION C
1:50

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2515

DESIGN:

ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

DESIGN:
CHECKED: DATE: DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

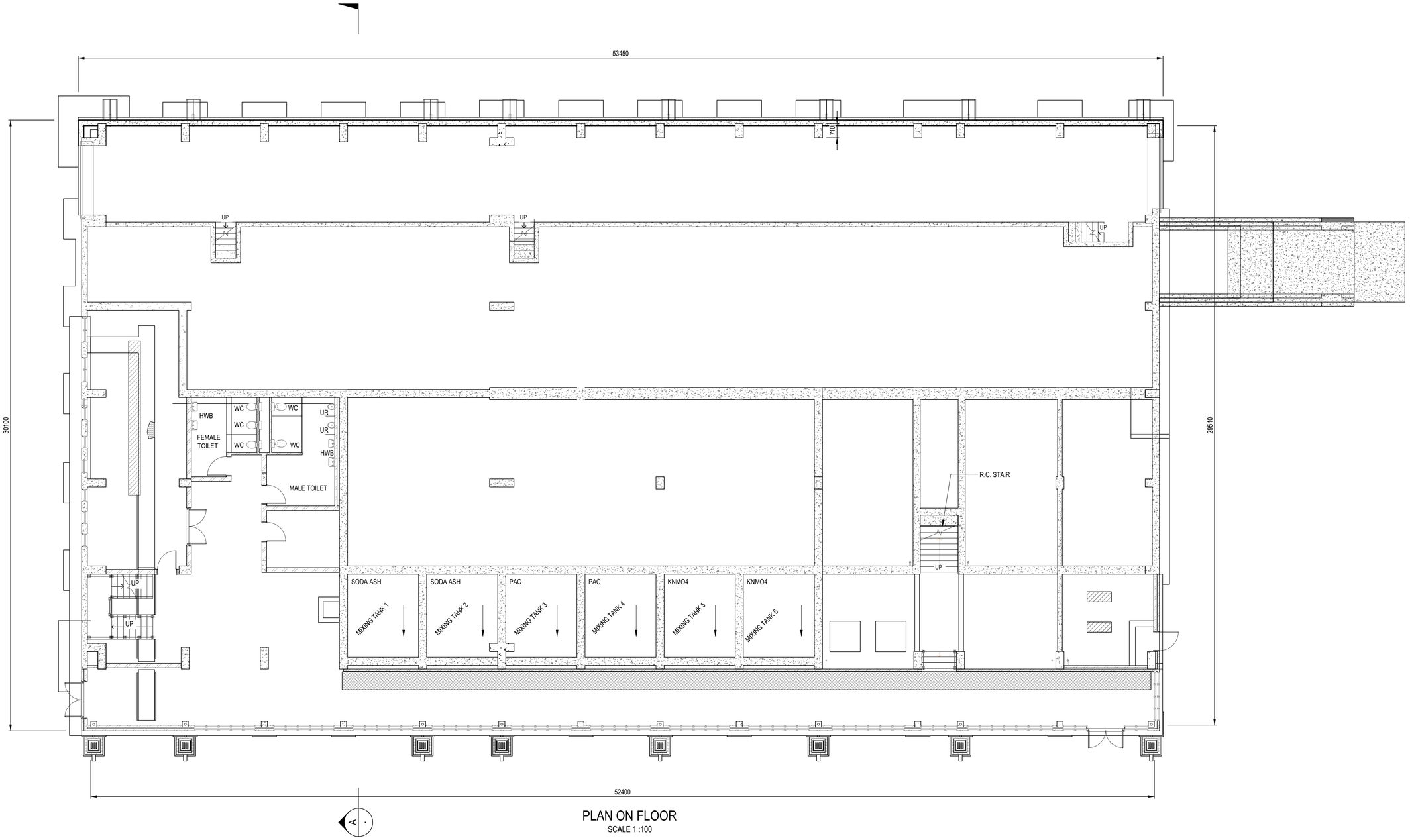
PROPOSED XHARIEP WTP
TYPICAL DETAILS
RAW WATER INLET
SECTIONS

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.						REV.
CALCULATION FILE:		1 of 1							A

Plot Date: 13/12/2024 12:17:27 pm Office: ZADC1 Filename: C:\USERS\SACHIN.NAIK\CHANDON\ONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\30 FILES\1002533-2500-DRG-CC-2514 INLET WORKS - DIVISION STRUCTURE.DWG

GENERAL NOTES:

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PLAN ON FLOOR
SCALE 1 :100

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2516
DESIGN:
ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA
HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001
SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN: DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

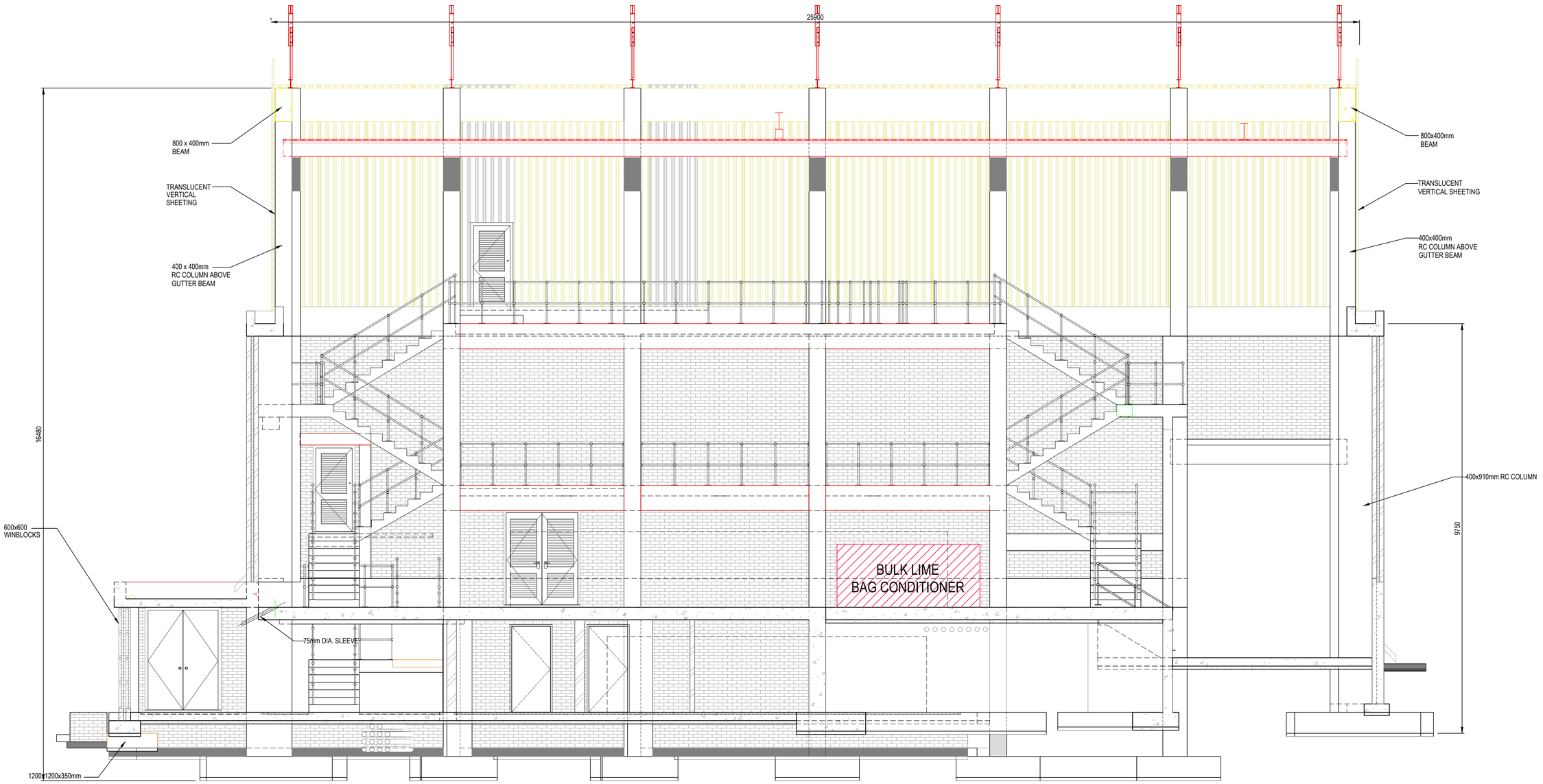
PROPOSED XHARIEP WTP
CHEMICAL DOSING & STORAGE BUILDING
PLAN ON GROUND FLOOR

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100		
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.							REV.	
CALCULATION FILE:		1 of 1								A	

Plot Date: 13/12/2024 1:32:37 pm Offset: 2\ACI Filename: C:\USERS\SACHIN.RABICHAND\DESKTOP\XHARIEP\DRAWINGS\CIVIL\3D FILES\1002533-2500.DRG-CC-2516 - CHEMICAL DOSING & STORAGE BUILDING.DWG

GENERAL NOTES:

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SECTION A
1:50

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2517
DESIGN:
ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN: DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

PROPOSED XHARIEP WTP CHEMICAL DOSING BUILDING SECTIONS

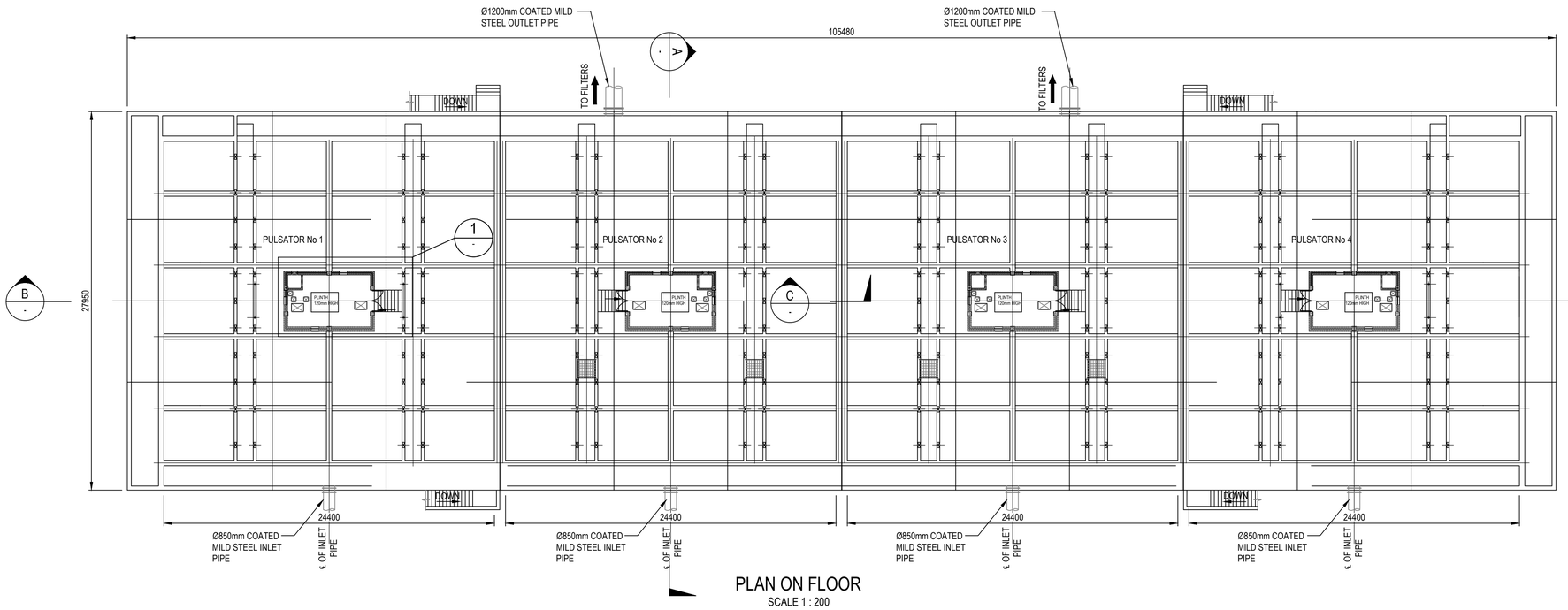
PROVINCE:	DISTRICT:	KEYCODES: X X X - - OTHER NUMBER 0100
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET 1 of 1
CALCULATION FILE:		REG. No.

REV. A

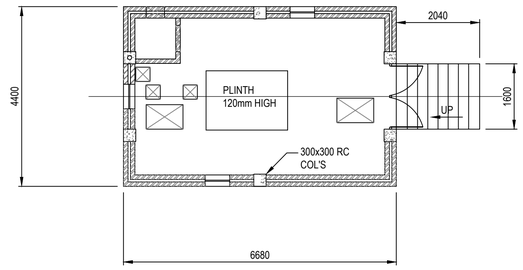
Plot Date: 17/12/2024 14:36 pm Office: ZADC1 Filename: C:\USERS\ASCHIN.RABICHAND\ONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\30-FILES\1002533-2500\DRG-CC-2516 - CHEMICAL DOSING & STORAGE BUILDING.DWG

GENERAL NOTES:

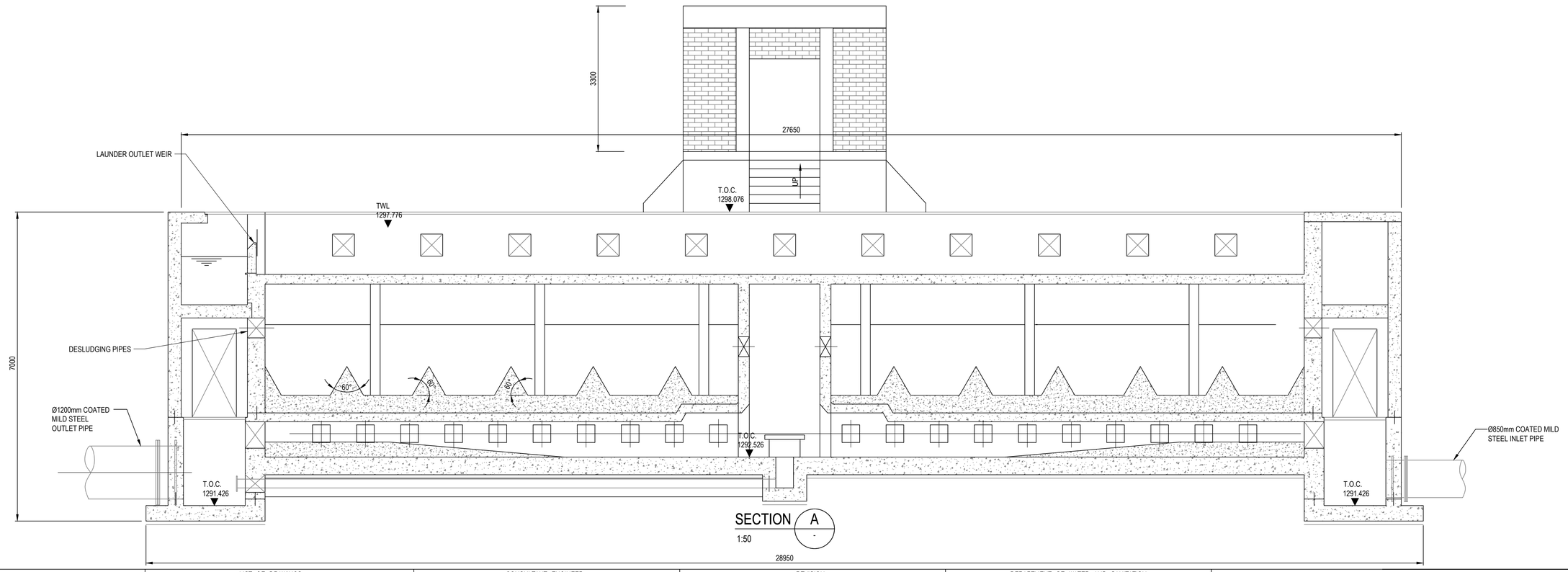
1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



PLAN ON FLOOR
SCALE 1 : 200



DETAIL 1
1:75



SECTION A
1:50

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2518

DESIGN:

ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN: DRAWN:

ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:

CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

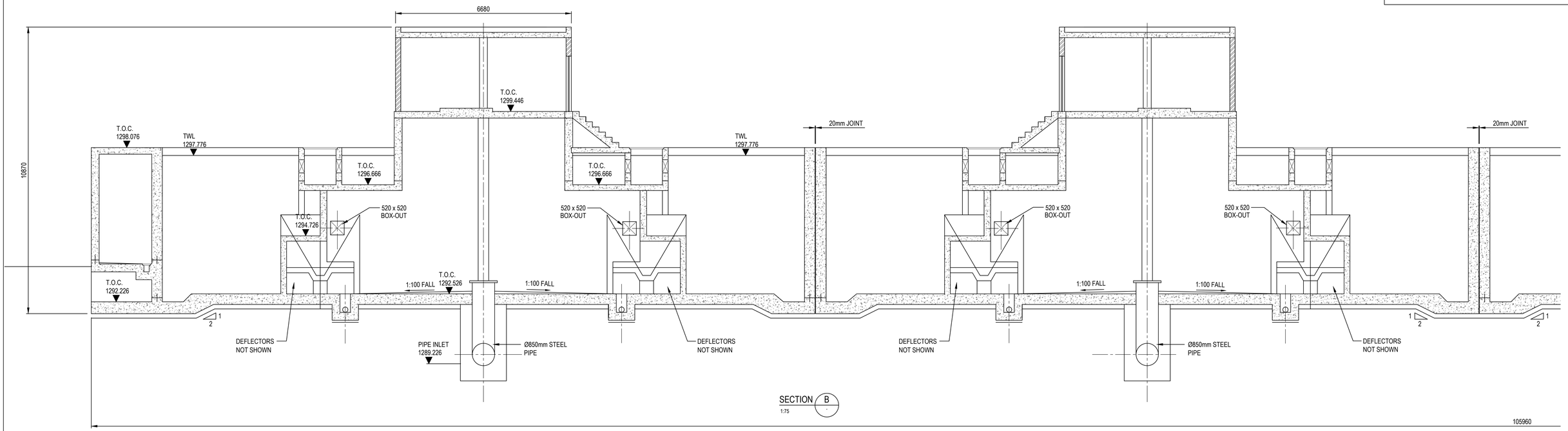
PROPOSED XHARIEP WTP
PULSATOR
PLAN AND SECTION

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100				
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.										REV.
CALCULATION FILE:		1 of 1											A

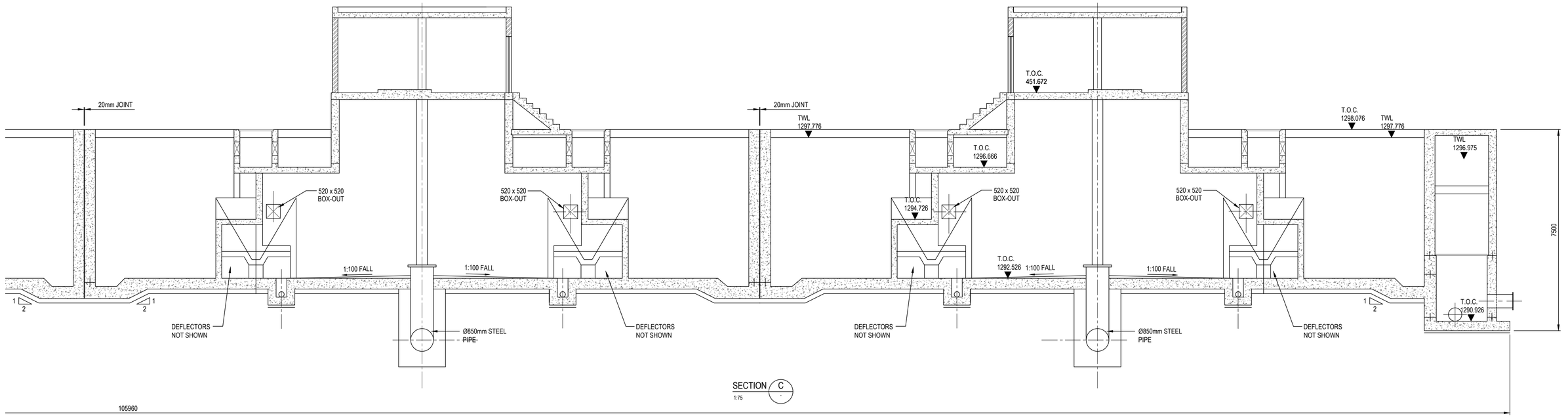
Plot Date: 13/12/2024 2:31:11 pm Office: ZADC1 Filename: C:\SERS\SAOHN\RABCHAND\ONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\3D FILES\002533-2500-DRG-CC-2518 - PULSATORS.DWG

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



SECTION B
1:75



SECTION C
1:75

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS			
SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2519

ZUTARI APPROVER (Pr. Eng): T.C DATE:

DESIGN:

DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION					
MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN:

DRAWN:

ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:

CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

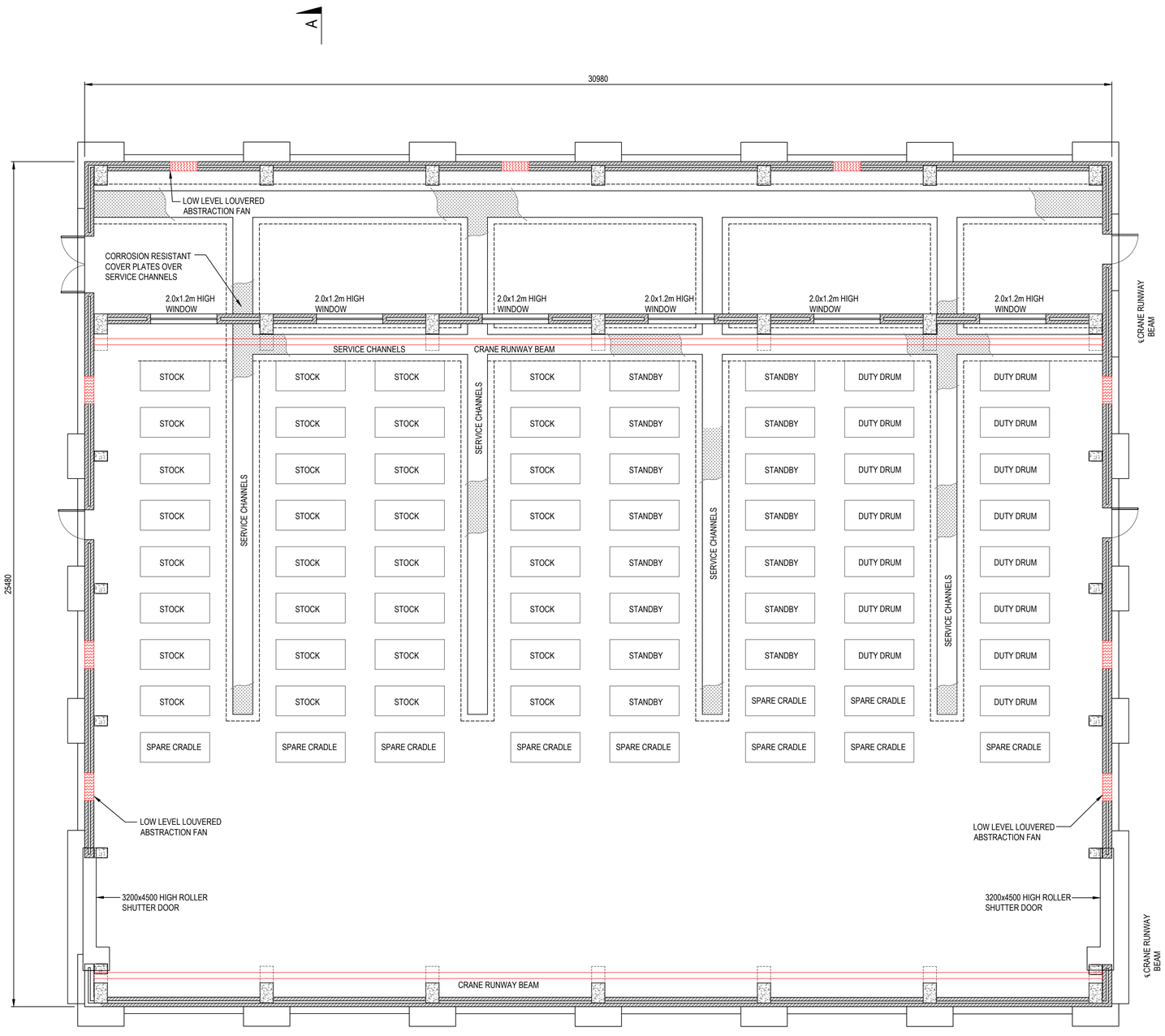
PROPOSED XHARIEP WTP PULSATOR SECTION

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100	
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	1 of 1	REG. No.						REV. A
CALCULATION FILE:										

Plot Date: 13/12/2024 2:51:43 pm Office: ZADC1 Filename: C:\USERS\SHOHN.RABIECHANDONE\DRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\30 FILES\1002533-2500-DRG-CC-2519 - PULSATORS SECTIONS.DWG

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



PLAN ON FLOOR
SCALE 1 : 75

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2520

DESIGN:

ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

DESIGN:
CHECKED: DATE: DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

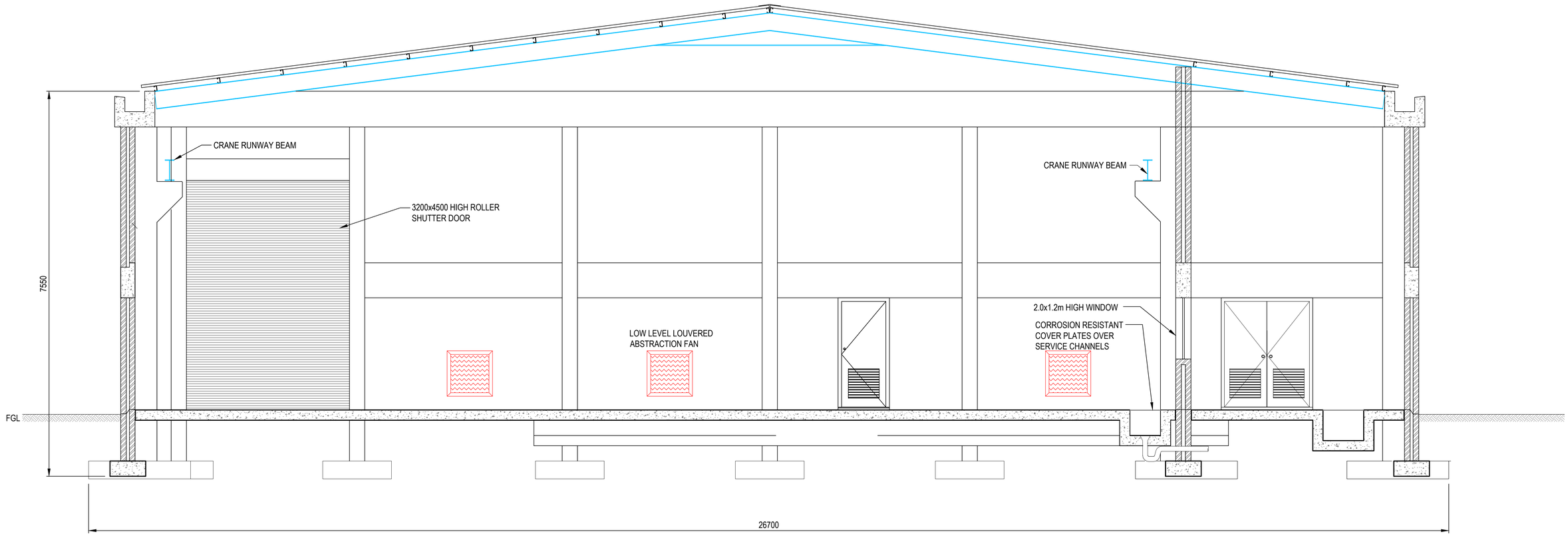
PROPOSED XHARIEP WTP
CHLORINE BUILDING
PLAN & SECTIONS

PROVINCE: DISTRICT: KEYCODES: X X X - - OTHER NUMBER 0100
LOCALITY No.: TENDER/ CONTRACT No. SHEET 1 OF 1 REG. No. REV. A
CALCULATION FILE:

Plot Date: 17/12/2024 14:53 pm Offset: 2AC1 Filename: C:\USERS\SACHIN.RAMCHAND\ONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\3D FILES\1002533-2500-DRG-CC-2520 CHLORINE DOSING & STORAGE BUILDING.DWG

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



SECTION A
1:50 DRG

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2521
DESIGN:
ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN:
DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

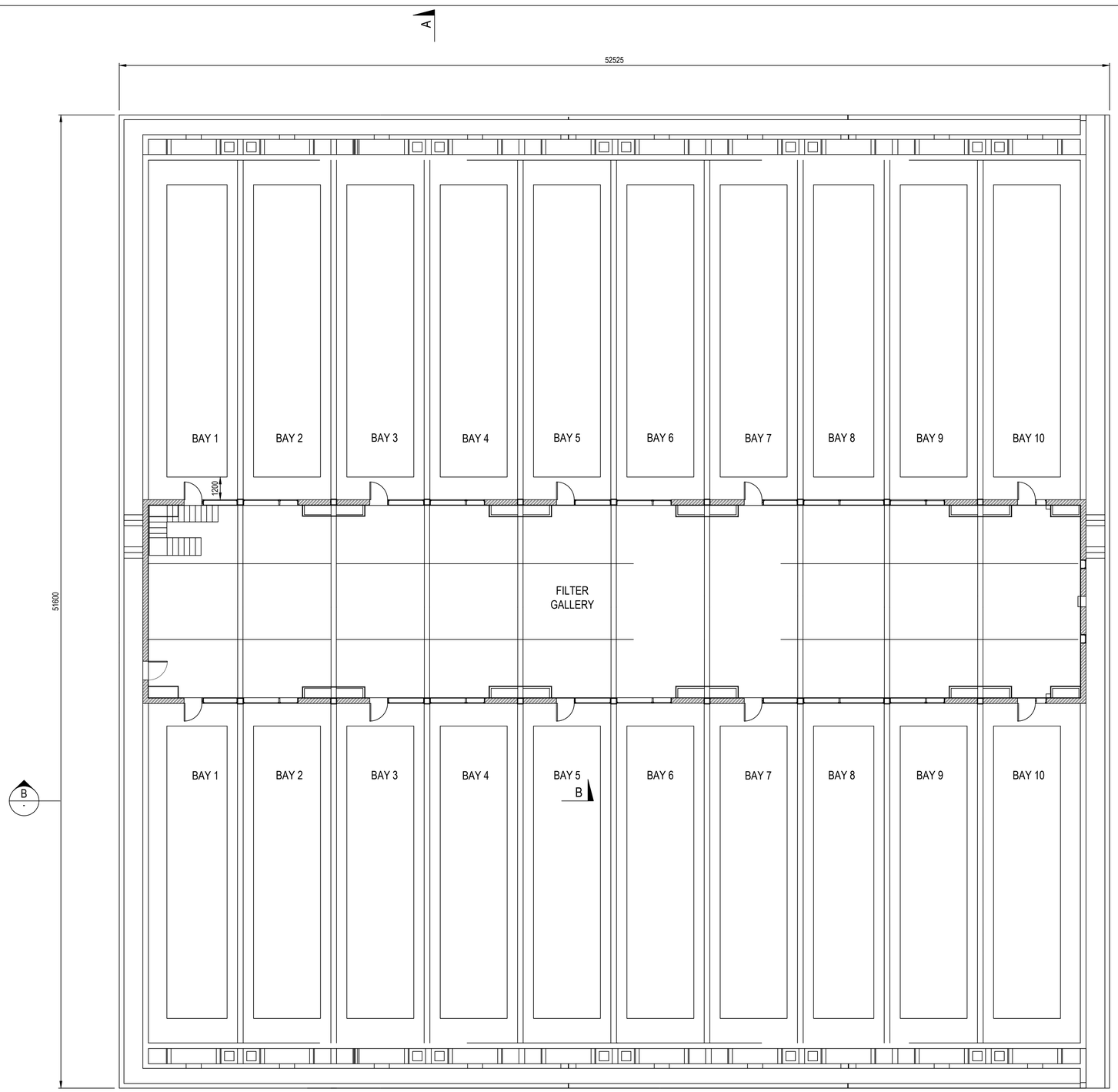
PROPOSED XHARIEP WTP CHLORINE BUILDING SECTIONS

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.						REV.
CALCULATION FILE:		1 of 1							A

Plot Date: 17/12/2024 1:48:47 pm Office: ZADC1 Filename: C:\USERS\ASCHIN.RABICHAND\ONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\3D FILES\1002533-2500-DRG-CC-2521 CHLORINE DOSING & STORAGE BUILDING.DWG

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



PLAN ON FLOOR
SCALE 1 : 125

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2522
DESIGN:
ZUTARI APPROVER (Pr. Eng): T.C DATE:
DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN: DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

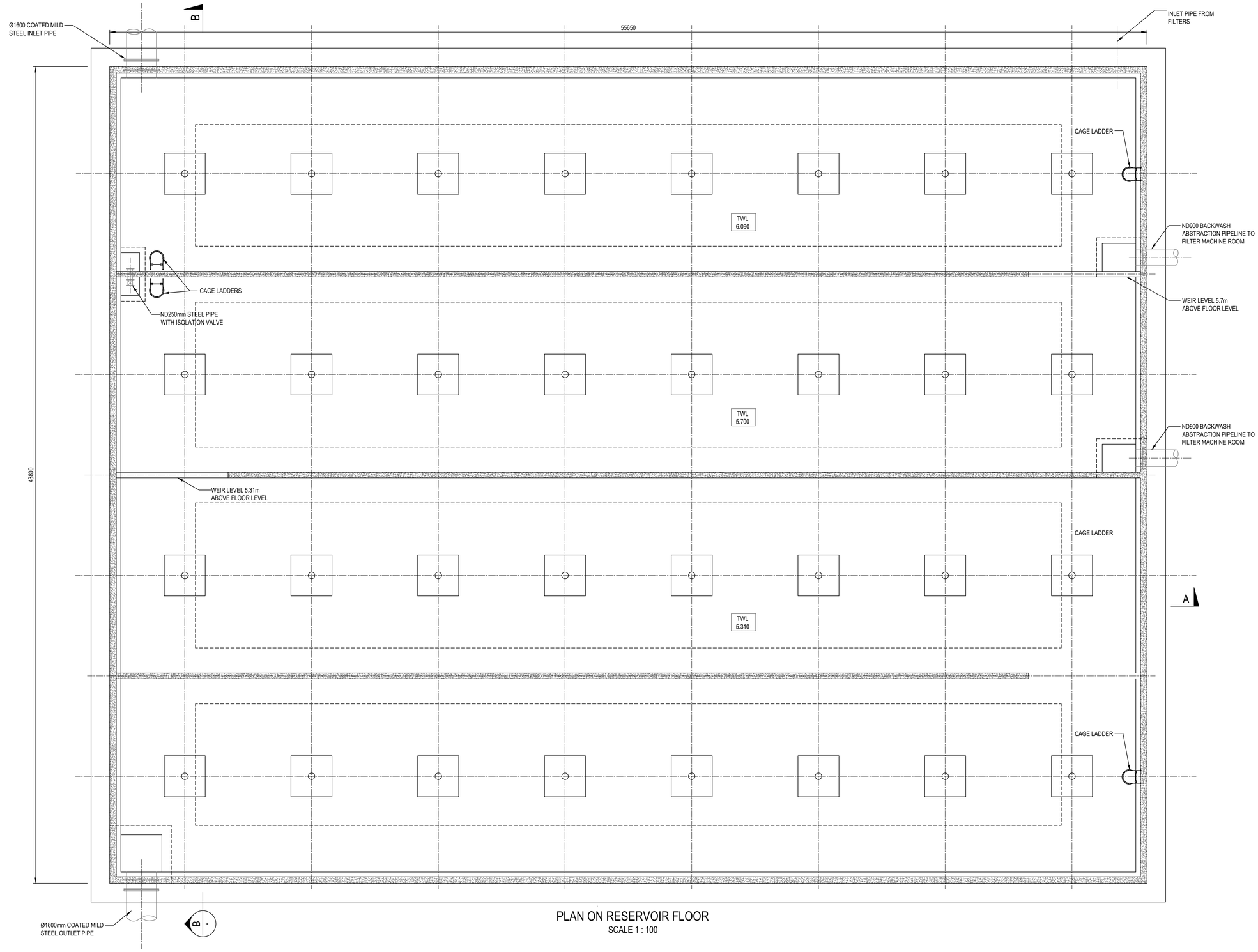
PROPOSED XHARIEP WTP WATER TREATMENT FILTERS PLAN VIEW

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100		
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.							REV.	
CALCULATION FILE:		1 OF 1								A	

Filename: Office: ZADC1 Plot Date:

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



PLAN ON RESERVOIR FLOOR
SCALE 1 : 100

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS			
SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2524

DESIGN:

ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION				
MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
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PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN:

ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE: DRAWN:

CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

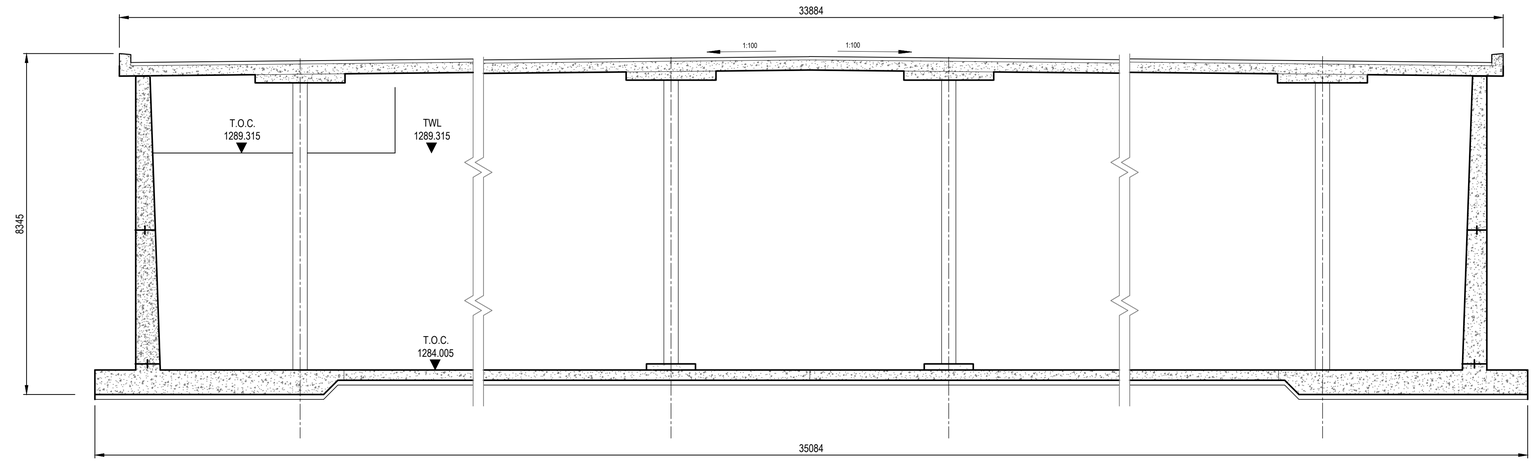
PROPOSED XHARIEP WTP RESERVOIR PLAN

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.						REV.
CALCULATION FILE:		1 of 1							A

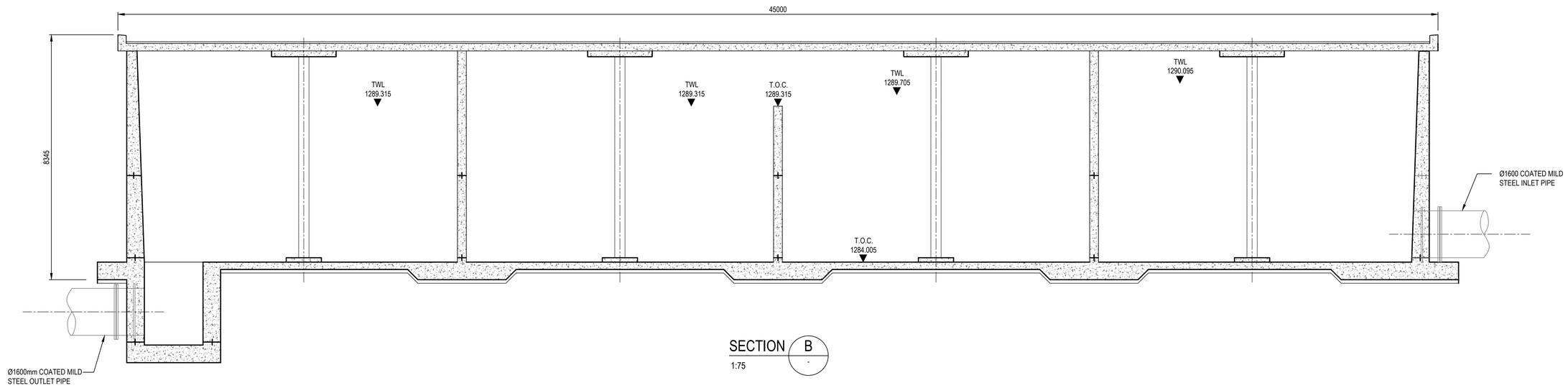
Plot Date: 17/12/2024 2:29:29 pm Office: ZADC1 Filename: C:\USERS\ACHIN.RABICHAND\ONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\3-FILES\1002533-2500-DRG-CC-2524 - RESERVOIR LAYOUT.DWG

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



SECTION A
1:75



SECTION B
1:75

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2525

DESIGN:

ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN: DRAWN:

ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:

CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

PROPOSED XHARIEP WTP RESERVOIR SECTIONS

PROVINCE: DISTRICT:

LOCALITY No.: TENDER/ CONTRACT No.

CALCULATION FILE:

KEYCODES: X X X - - OTHER NUMBER 0100

SHEET 1 of 1

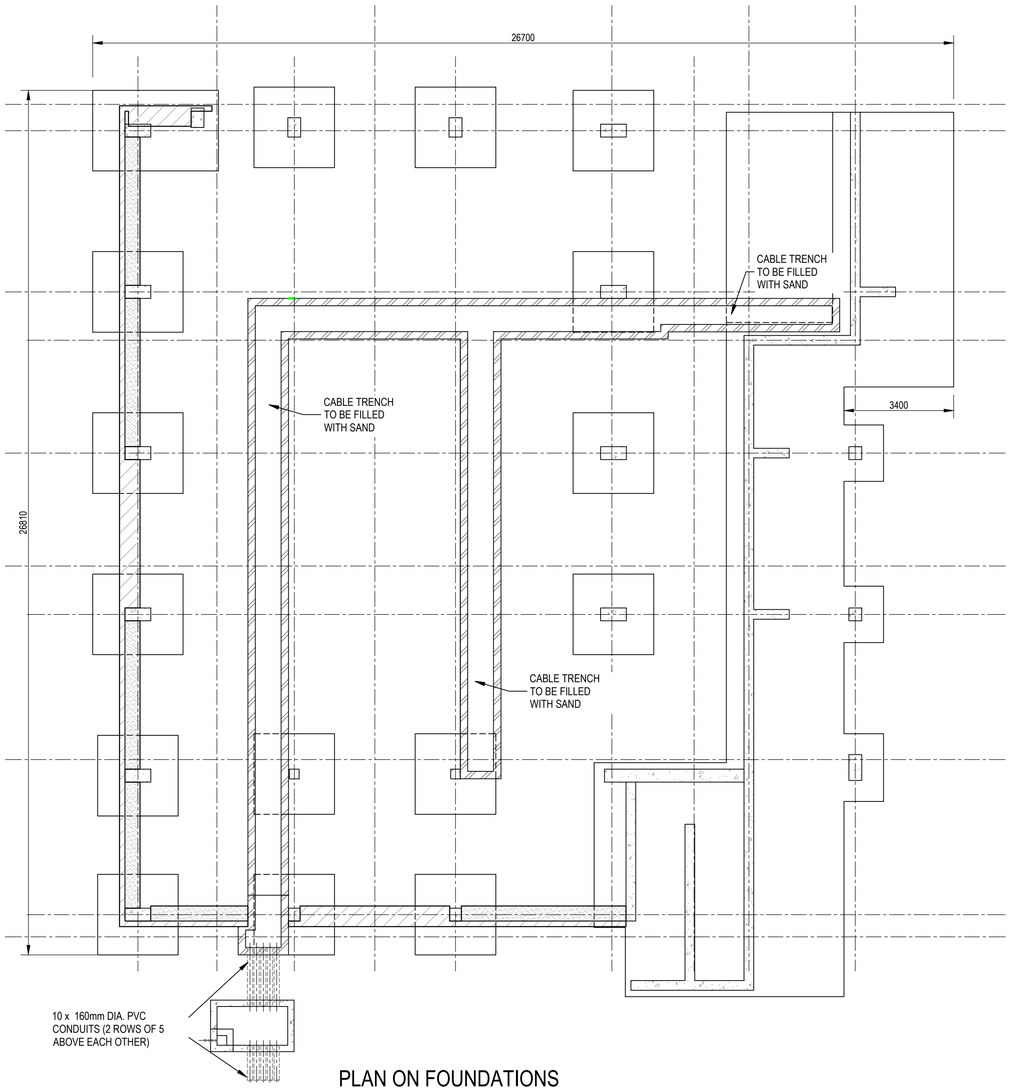
REG. No.

REV. A

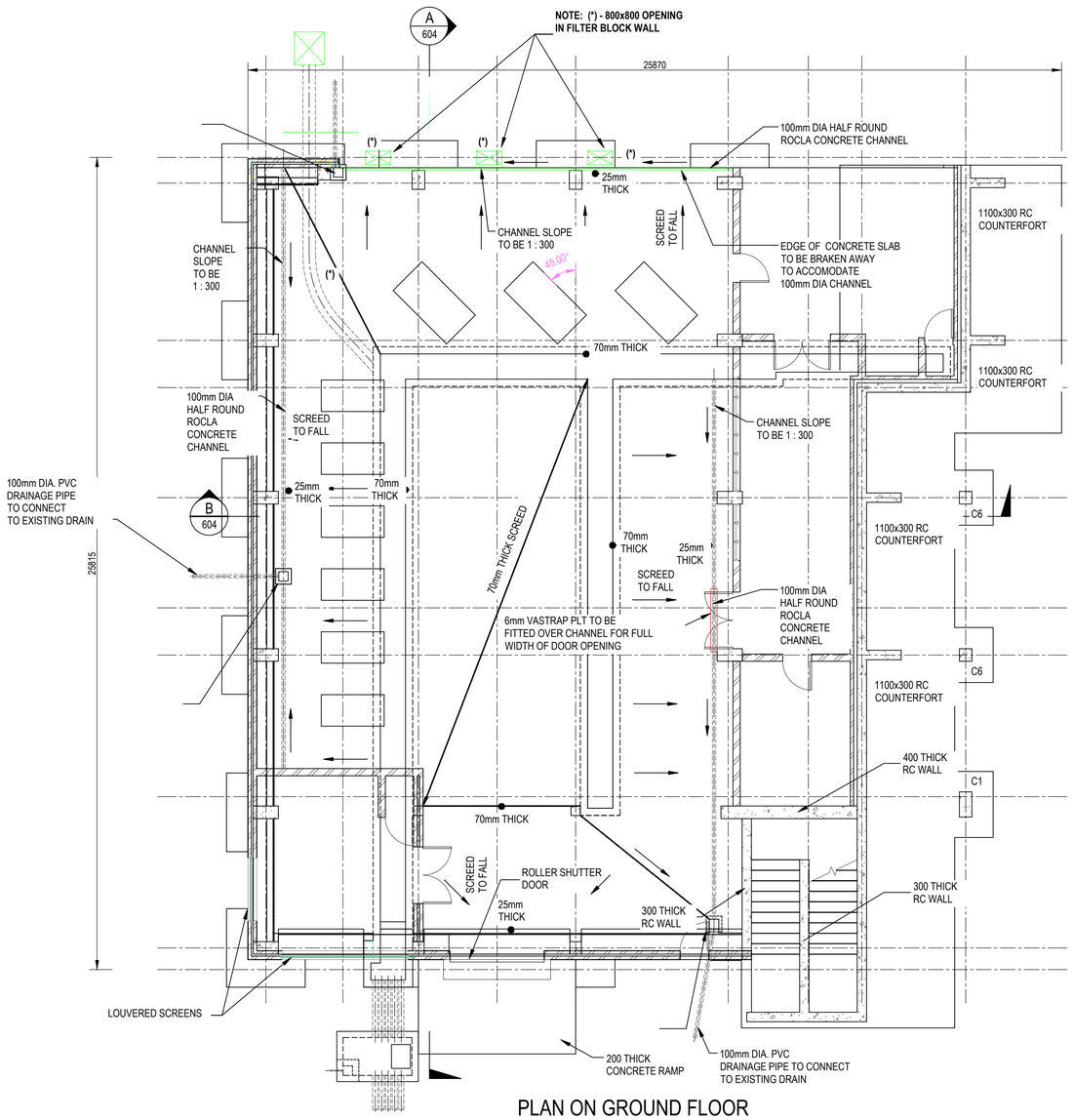
Plot Date: 18/12/2024 9:01:10 am Offset: 2400 Filename: C:\USERS\ASHIN.RABICHAND\ONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\3D FILES\1002533-2500-DRG-CC-2525 - RESERVOIR SECTIONS.DWG

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



PLAN ON FOUNDATIONS
SCALE 1 : 50



PLAN ON GROUND FLOOR
SCALE 1 : 50

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2526
DESIGN: JB STRYDOM
ZUTARI APPROVER (Pr. Eng): T.C DATE:
DRAWN: JB STRYDOM

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA
HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001
SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: T. CERONIO DATE:
DESIGN:
DRAWN:
ENGINEER: DATE:
EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE:
DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

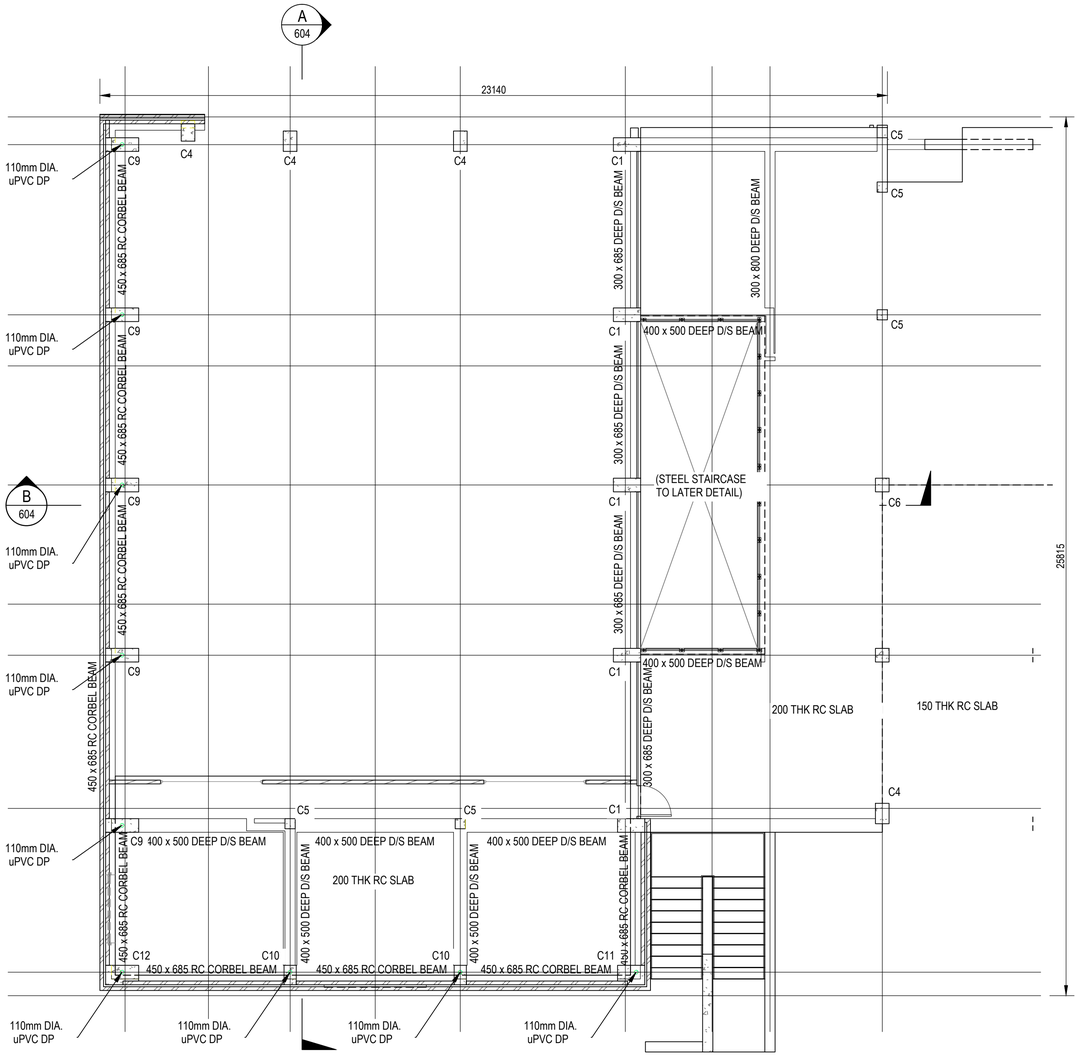
PROPOSED XHARIEP WTP FILTER PUMPSTATION FOUNDATION AND GROUND FLOOR LAYOUTS

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.						REV.
CALCULATION FILE:		1 of 1							A

Plot Date: 20/12/2024 8:45:06 am Office: ZAOC1 Filename: C:\USERS\ASHIN.RABICHAND\ONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\3D FILES\1002533-2500.DRG-CC-2526 - FILTER PUMP ROOM LAYOUTS.DWG

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



PLAN ON FIRST FLOOR

SCALE 1 : 50



PLAN ON SECOND FLOOR

SCALE 1 : 50

0.25 0 0.5 1m

SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS			
SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2527

DESIGN: JB STRYDOM

ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN: JB STRYDOM

ZUTARI IMPACT. ENGINEERED.

REVISION				
MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: T. CERONIO DATE: DESIGN: DRAWN:

ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:

CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

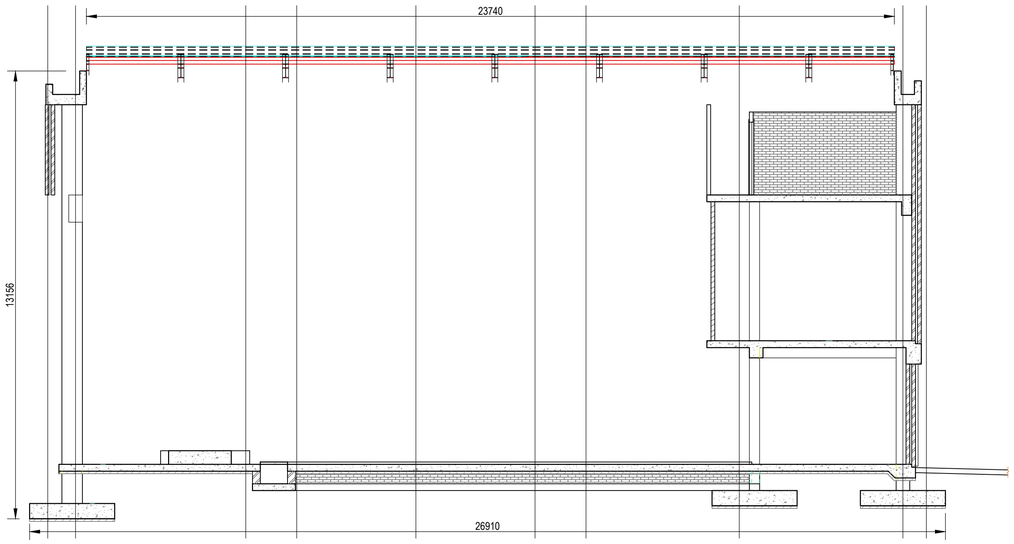
PROPOSED XHARIEP WTP FILTER PUMPSTATION FIRST AND SECOND FLOOR LAYOUTS

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100		
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.							REV.	
CALCULATION FILE:		1 of 1								A	

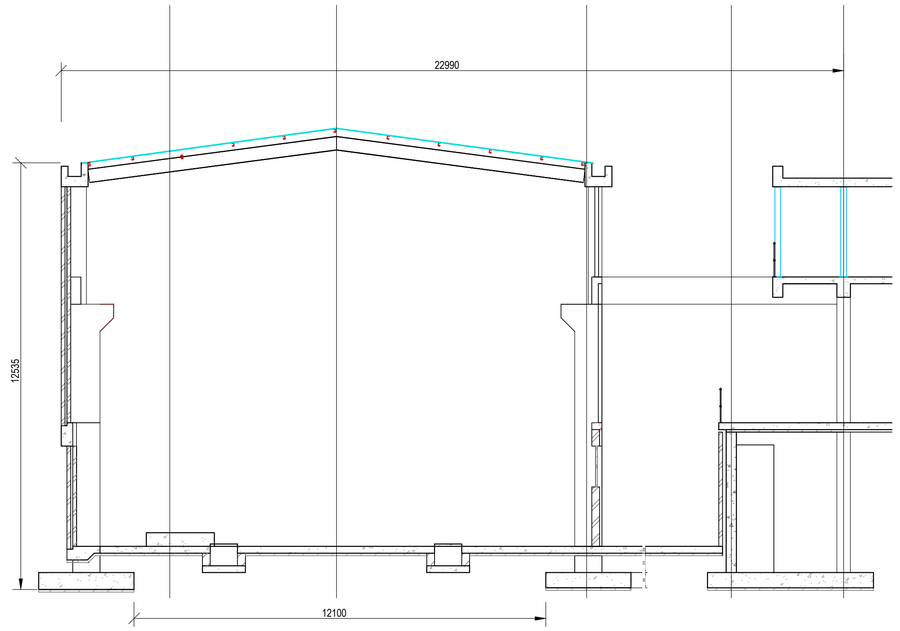
PlotDate: 20/12/2024 8:48:22 am Office: ZADC1 Filename: C:\USERS\SACHIN.RAJBOHANDON\DESKTOP\DRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\3D FILES\1002533-2500.DRG-CC-2526 - FILTER PUMP ROOM LAYOUTS.DWG

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



SECTION A
1:50



SECTION B
1:50

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2528
DESIGN: JB STRYDOM
ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN: JB STRYDOM

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

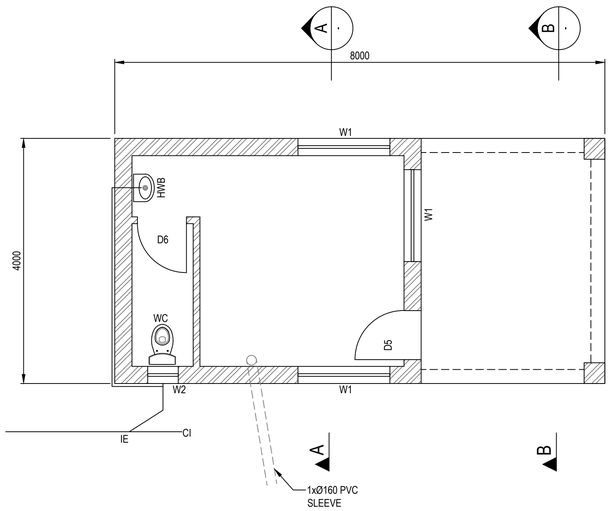
CHECKED: T. CERONIO DATE: DESIGN:
DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

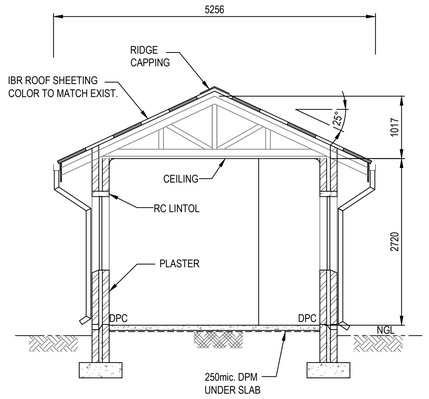
PROPOSED XHARIEP WTP FILTER PUMPSTATION SECTIONS

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.						REV.
CALCULATION FILE:		1 OF 1							A

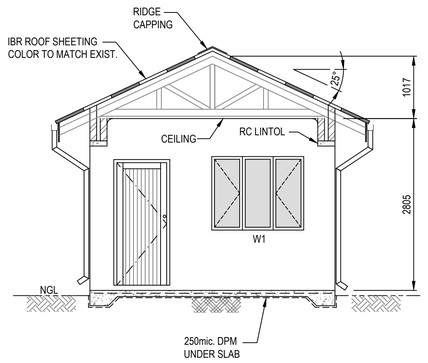
Plot Date: 20/12/2024 8:48:48 am Office: ZADC1 Filename: C:\USERS\SACHIN.RAB\CHANDONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL3D FILES\1002533-2500.DRG-CC-2528 - FILTER PUMP ROOM LAYOUTS.DWG



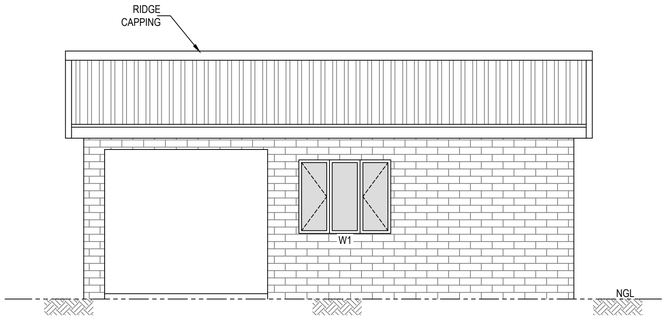
PLAN ON GUARD HOUSE
SCALE 1:50



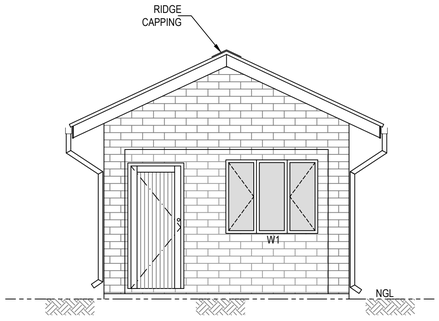
SECTION A
1:50



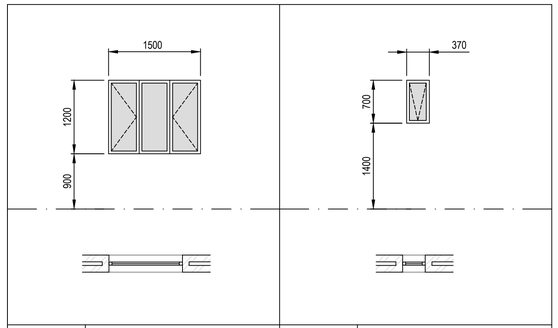
SECTION B
1:50



SIDE ELEVATION
SCALE 1 : 50



SIDE ELEVATION
SCALE 1 : 50



WINDOW NO	W1	WINDOW NO	W2
WINDOW TYPE	AWNING WINDOW	WINDOW TYPE	AWNING WINDOW
WINDOW FRAME	ALUMINIUM SECTION AS PER NUKLIP 44MM OR SIMILAR APPROVED	WINDOW FRAME	ALUMINIUM SECTION AS PER NUKLIP 44MM OR SIMILAR APPROVED
FRAME FINISH	POWDER COATED - DARK BROWN ALUMINIUM AS PER AAAMSA COLOUR ANP 9089	FRAME FINISH	POWDER COATED - DARK BROWN ALUMINIUM AS PER AAAMSA COLOUR ANP 9089
LEAF FINISH	POWDER COATED ALUMINIUM FRAME WITH CLEAR GLAZING.	LEAF FINISH	POWDER COATED ALUMINIUM FRAME. GLASS TO BE FROSTED
	TOUGHENED SAFETY GLASS .GLASS THICKNESS IN ACCORDANCE WITH TABLE 1(PART N: GLAZING) OF SANS 10400.		TOUGHENED SAFETY GLASS .GLASS THICKNESS IN ACCORDANCE WITH TABLE 1(PART N: GLAZING) OF SANS 10400. GLASS TO BE FROSTED
	PRECAST CONCRETE LINTELS		PRECAST CONCRETE LINTELS
IRONMONGERY	WINDOW SECTION INCLUDING HANDLES, ANCHORS AND SLIDE RESISTANT HINGE MECHANISM AND SEALED WITH NEOPRENE SEALANT AS TO MANUFACTURERS SPECIFICATIONS	IRONMONGERY	WINDOW SECTION INCLUDING HANDLES, ANCHORS AND SLIDE RESISTANT HINGE MECHANISM AND SEALED WITH NEOPRENE SEALANT AS TO MANUFACTURERS SPECIFICATIONS

GENERAL NOTES:

1. BOUNDARY BEACONS TO BE EXPOSED & MARKED.
2. SOIL POISONING IN ACCORDANCE WITH SABS 0124 REQUIRED.
3. DO NOT SCALE DRAWINGS, USE FIGURED DIMENSIONS ONLY.
4. ALL DIMENSIONS ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.
5. ALL DIMENSIONS, LEVELS TO BE VERIFIED ON SITE AND ANY DISCREPANCIES TO NOTIFIED TO ENGINEER.
6. ALL SLABS, BEAMS, COLUMNS, FOUNDATIONS, STAIRS & REINFORCED CONCRETE TO BE ACCORDING TO ENGINEERS DETAILS.
7. THESE DRAWINGS TO BE READ IN CONJUNCTION WITH MECHANICAL, CIVIL AND ELECTRICAL ENGINEERS DRAWINGS.
8. ALL BUILDING WORK TO COMPLY WITH SABS 0400 AND LOCAL MUNICIPAL BY-LAWS.
9. ALL GLAZING THICKNESS TO COMPLY WITH PART NN2.
10. PUBLIC SAFETY: ALL HANDRAILS & BALUSTRADES TO BE 1.0m HIGH AND TO COMPLY WITH REQUIREMENTS OF DD2 OF NBR.
11. ALL STAIRS TO COMPLY WITH PART M OFSABS 0400.
12. CERTIFICATE OF STABILITY TO BE ISSUED ON COMPLETION.

BUILDING NOTES:

WALLS:

1. PLASTER & PAINT, INSIDE WALLS 10mm THK. OUTSIDE WALLS TO BE FACE BRICK TO MATCH EXIST. BUILDINGS
2. ALL WALLS TO BE BUILT WITH CLAY BRICKS, DAGHA CONSISTING OF 1 PART CEMENT, 0.8 PARTS BUILDERS LIME & 6 PARTS CLEAN BUILDING SAND.
3. PROVIDE PRECAST LINTOLS ABOVE ALL DOORS, WINDOWS AND OPENINGS, U.O.S. LINTOLS TO COMPLY WITH SANS 10400 PART 'K'.
4. PROVIDE BRICKFORCE EVERY 3rd BRICK COURSE AND EVERY 2nd BRICK COURSE ABOVE DOORS, WINDOWS & OPENINGS.
5. PROVIDE BUTTERFLY TIES AT 1000Mmm HORIZONTAL & 450mm VERTICAL.
6. PROVIDE WEEP HOLES AT 1.0m INTERVALS AT ALL FLOOR SLAB LEVELS, OVER DOOR, WINDOWS.
7. PROVIDE 375 MICRON DPC UNDER, AROUND & ABOVE WINDOWS, TO COMPLY WITH SANS 10400 PART 'K'.
8. EXTERNAL SILLS TO BE PLASTERED AT AN ANGLE & TO RECEIVE DPC AROUND WINDOW.

CONCRETE:

1. CONCRETE GRADE FOR FOUNDATIONS, COLUMNS, BEAMS, STAIRS & FLOOR SLABS TO ENGINEERS SPEC'S.
2. BLINDING TO BE GRADE 10MPa/19mm AT 28 DAYS.

STEELWORK:

1. ALL STRUCTURAL STEEL, CAST-IN ITEMS, GRATING, HANDRAILING TO BE HOT DIPPED GALVANIZED AFTER MANUFACTURING.
2. STEELWORK TO SABS 1431 AND TO BE GRADE 300WA.
3. BOLTS TO BE GRADE 8.8 TO SABS 1282
4. NO WELDING, CUTTING OR DRILLING TO BE PERMITTED AFTER STEEL HAVE BEEN GALVANIZED.
5. A MINIMUM OF 5mm SHALL PROTRUDE BEYOND NUTS AFTER FITTING.
6. ALL GRATING TO BE BANDED AROUND EDGES.
7. ALL BOLTS, NUTS WASHERS TO BE GALVANIZED U.O.S.

ELECTRICAL:

1. ALL ELECTRICAL WORK ARE TO COMPLY TO LOCAL AUTHORITY BY-LAWS AND REFER TO ELECTRICAL DRAWINGS FOR INSTALLATION.

STORMWATER:

1. ALL STORMWATER TO MAIN STORMWATER PIPE, PIPE SIZES, GRADIENTS 7 MATERIALS FOR STORMWATER RETICULATION SYSTEM TO COMPLY TO SANS PART 'R'.
2. ALL LOCAL AUTHORITY, ESKOM & TELKOM REQUIREMENTS TO BE ESTABLISHED AND ADHERED TO.

ROOF NOTES:

1. SHEETING: FIBRE-CEMENT (BIG SIX PROFILE) SHEETING.
2. 114 x 38 SA PINE RAFTER @ 1100c/c (MAX.) WITH 76 x 50 INTERNALS.
3. 75 x 50 SA PINE PURLINS @1250c/c MAX.
4. 114 x 38 SA PINE WALL PLATES.
5. 225 x 12 FC FASCIA & BARDGE BOARDS WITH JOINERS.
6. GYPSUM RHINO BOARD CEILING.
7. 75mm CORNICE.
8. 100mm THICK CELLULOSE FIBRE INSULATION (THERMAGAURD OR SIMILAR APPROVED) .
9. 100 x 75mm ALUMINIUM GUTTERS AND DOWNPIPES.

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2529
DESIGN: JB STRYDOM
ZUTARI APPROVER (Pr. Eng): T.C DATE:
DRAWN: JB STRYDOM

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

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REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

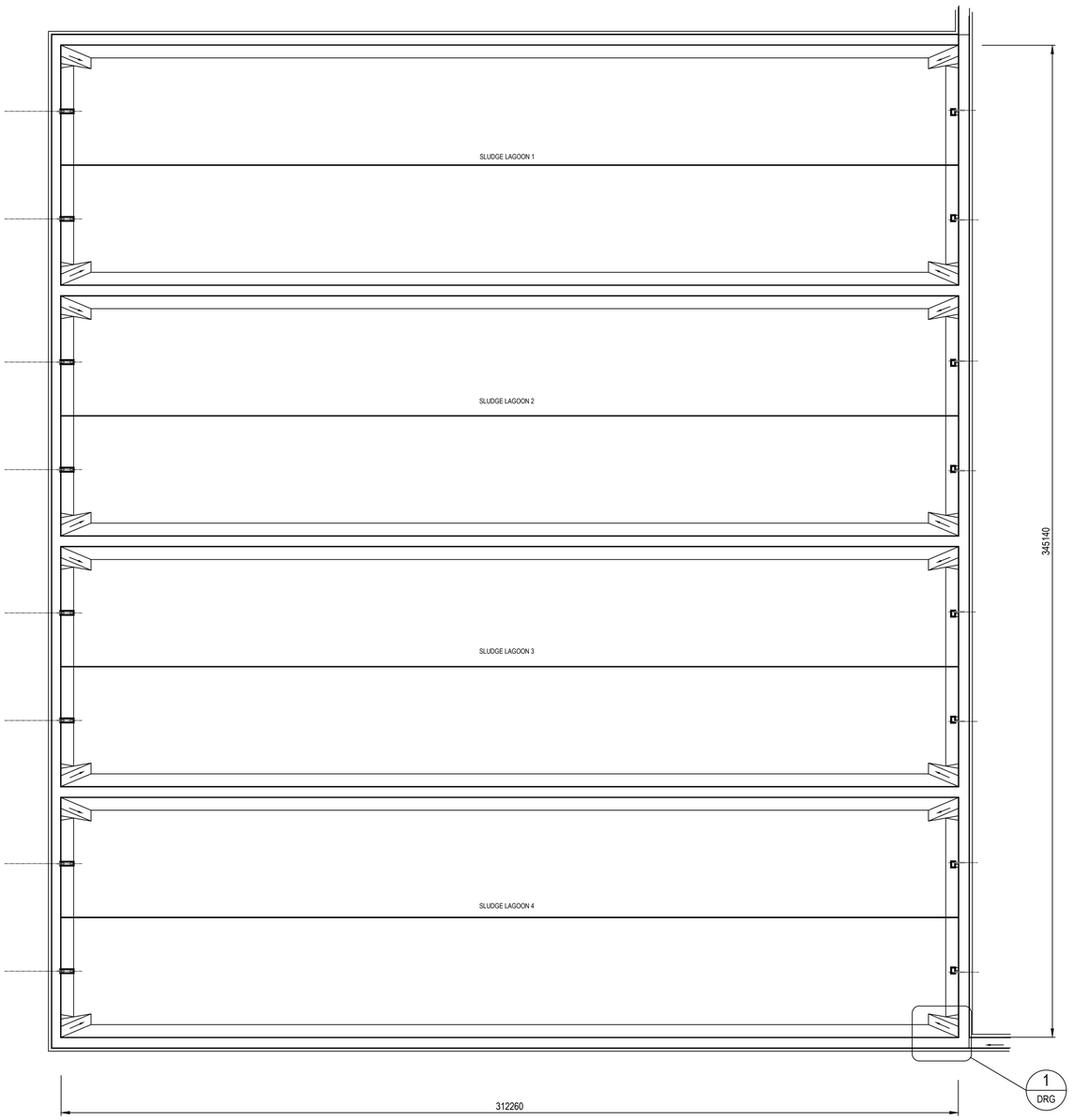
CHECKED: T. CERONIO DATE:
DESIGN:
DRAWN:
ENGINEER: DATE:
EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE:
DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

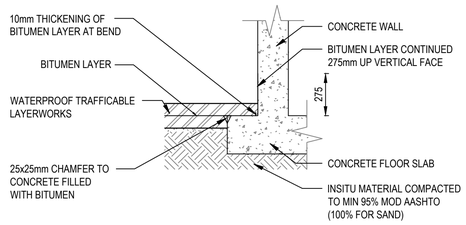
PROPOSED XHARIEP WTP
GUARD HOUSE
PLAN, SECTIONS & ELEVATIONS

PROVINCE: DISTRICT:
KEYCODES: X X X - - OTHER NUMBER 0100
LOCALITY No.: TENDER/ CONTRACT No.
SHEET 1 OF 1
REG. No.
REV. A
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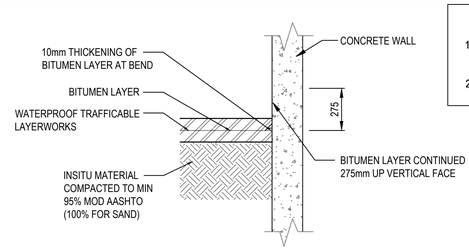
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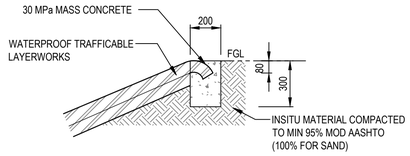
SLUDGE LAGOONS LAYOUT
SCALE 1 : 1000



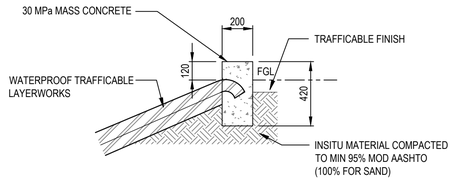
WATER PROOFING DETAIL AT FOOTING
SCALE 1 : 20



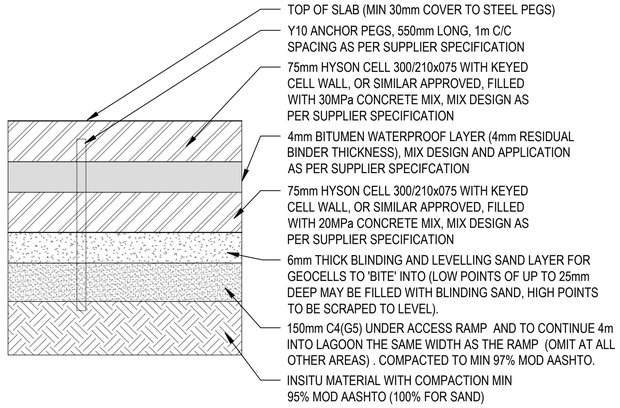
WATER PROOFING DETAIL AT WALL OF STRUCTURE
SCALE 1 : 20



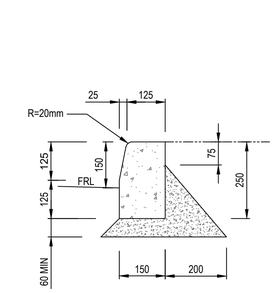
TUCK-IN TERMINATION AT BEAM
SCALE 1 : 20



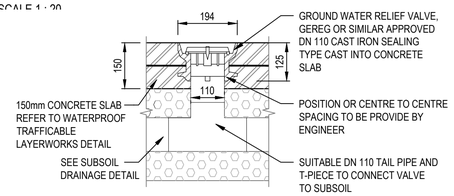
TUCK-IN TERMINATION AT BARRIER BEAM
SCALE 1 : 20



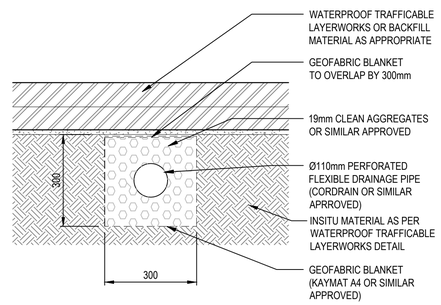
WATERPROOF TRAFFICABLE LAYERWORKS DETAIL
SCALE 1 : 20



BARRIER KERB DETAIL
SCALE 1:10



GROUND WATER RELIEF VALVE DETAIL
SCALE 1 : 10



SUB DRAINAGE DETAIL
SCALE 1 : 10

GENERAL NOTES:
1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2550
DESIGN: JB STRYDOM
ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN: D SYMPATHIE GOHO

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
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DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: T. CERONIO DATE: DESIGN: DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

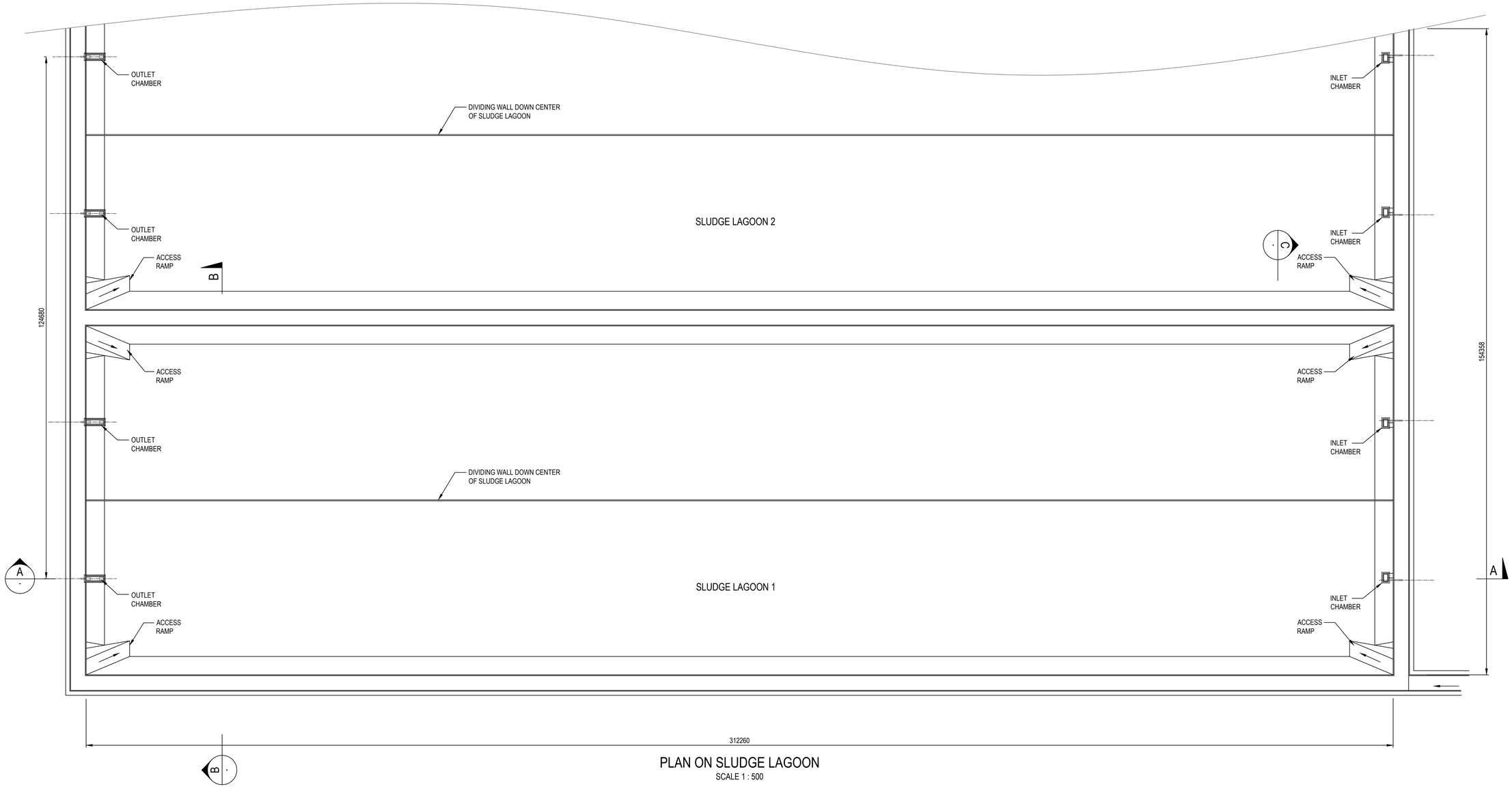
PROPOSED XHARIEP WTP SLUDGE LAGOONS LAYOUT & DETAILS

PROVINCE: DISTRICT: KEYCODES: X X X - - OTHER NUMBER 0100
LOCALITY No.: TENDER/CONTRACT No. SHEET 1 of 1 REG. No. REV. A
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GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



PLAN ON SLUDGE LAGOON
SCALE 1 : 500

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2551
DESIGN: JB STRYDOM
ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN: D SYMPATHIE GOHO

ZUTARI IMPACT. ENGINEERED.

REVISION

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CHECKED: T. CERONIO DATE: DESIGN: DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

PROPOSED XHARIEP WTP TYPICAL SLUDGE LAGOON LAYOUT

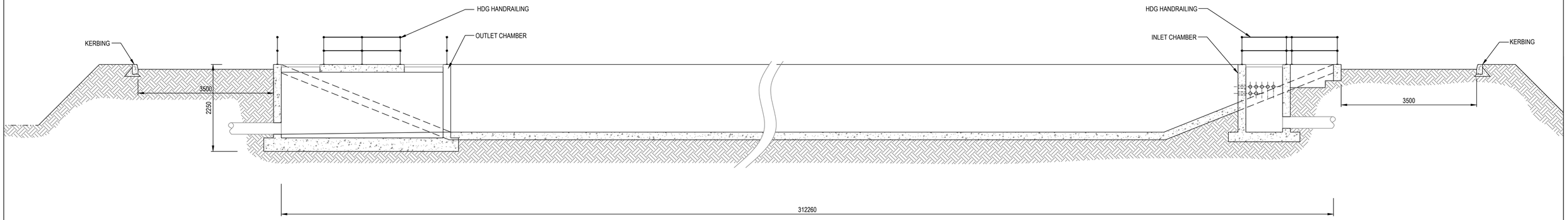
PROVINCE: DISTRICT:
LOCALITY No.: TENDER/ CONTRACT No.
CALCULATION FILE:

KEYCODES: X X X - - OTHER NUMBER 0100
SHEET 1 OF 1
REG. No.
REV. A

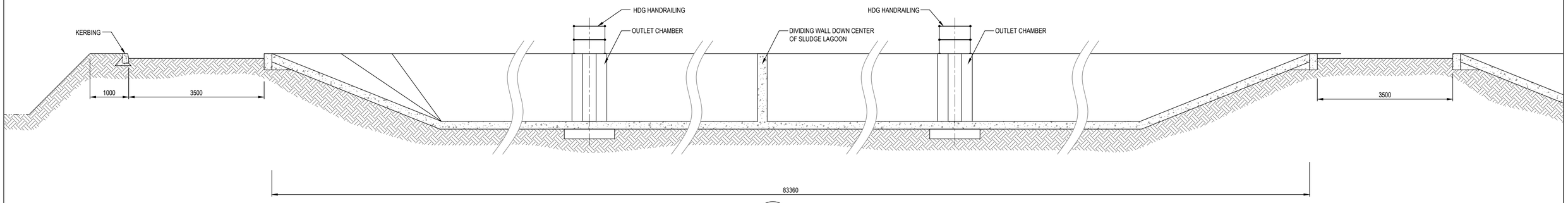
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GENERAL NOTES:

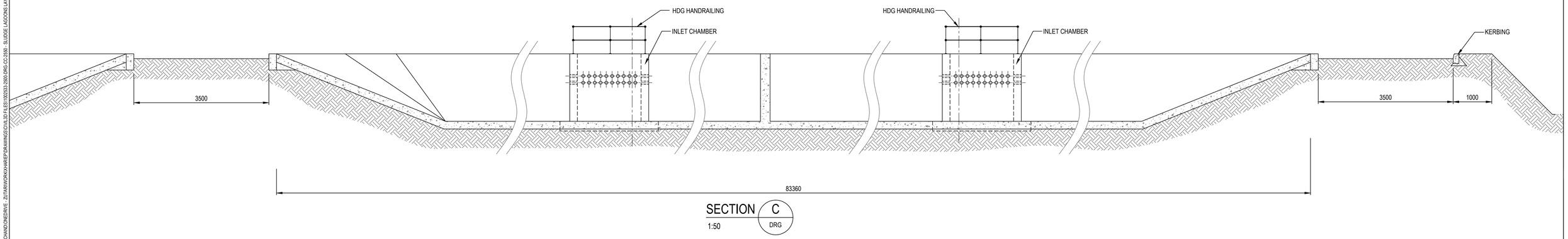
1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



SECTION A (DRG) 1:50



SECTION B (DRG) 1:50



SECTION C (DRG) 1:50

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2552
DESIGN: JB STRYDOM
ZUTARI APPROVER (Pr. Eng): T.C DATE:
DRAWN: D SYMPATHIE GOHO

ZUTARI IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

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REPUBLIC OF SOUTH AFRICA

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PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: T. CERONIO DATE:
DESIGN:
DRAWN:
ENGINEER: DATE:
EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE:
DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

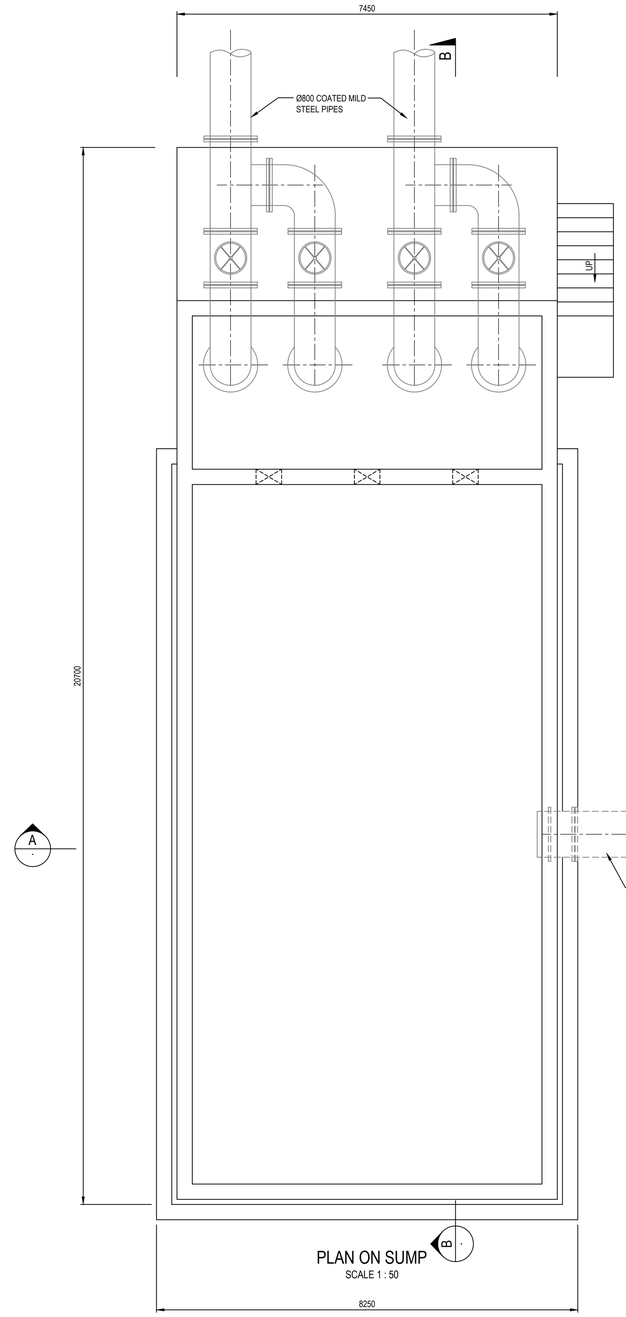
PROPOSED XHARIEP WTP
TYPICAL SLUDGE LAGOON
SECTION AND DETAILS

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100	
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.							REV.
CALCULATION FILE:		1 OF 1								A

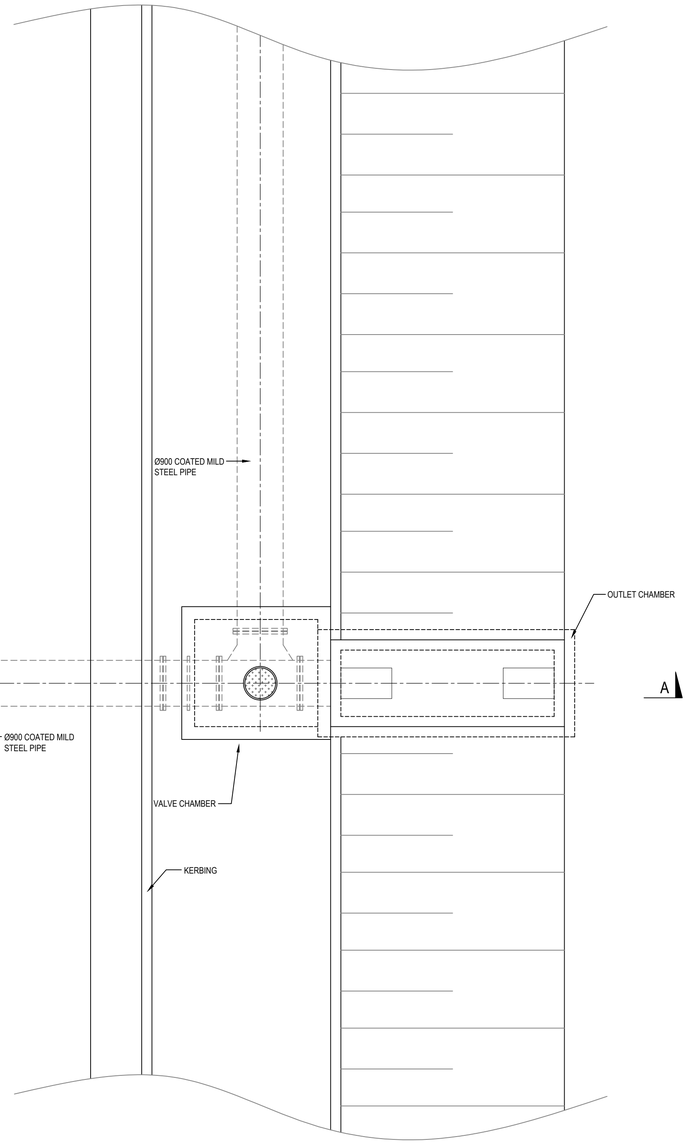
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NOTES:

1. ALL BURIED PIPEWORK TO BE BUTTWELD HDPE.
2. FOR GROUND PREPARATION AROUND CONCRETE SLAB, PROVIDE 3 x 150 G7 COMPACTED TO 100% MOD AASHTO FOR SAND AND 98% FOR GRAVEL.
3. SUBMERSIBLE PUMPS AND DISCHARGE PIPEWORK TO BE INSTALLED BY MECHANICAL CONTRACTOR.
4. HDPE PIPES TO BE PE100 WITH A MINIMUM RATING OF PN6.
5. LIFTING EQUIPMENT FOR PUMPS TO BE SUPPLIED AND INSTALLED BY OTHERS. NOT SHOWN ON DRAWING FOR CLARITY.
6. PUDDLE PIPES FOR PUMP DISCHARGE LINES TO BE CAST IN BY MECHANICAL CONTRACTOR.



PLAN ON SUMP
SCALE 1 : 50



0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2555
DESIGN: JB STRYDOM
ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN: JB STRYDOM

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: T. CERONIO DATE: DESIGN:
DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

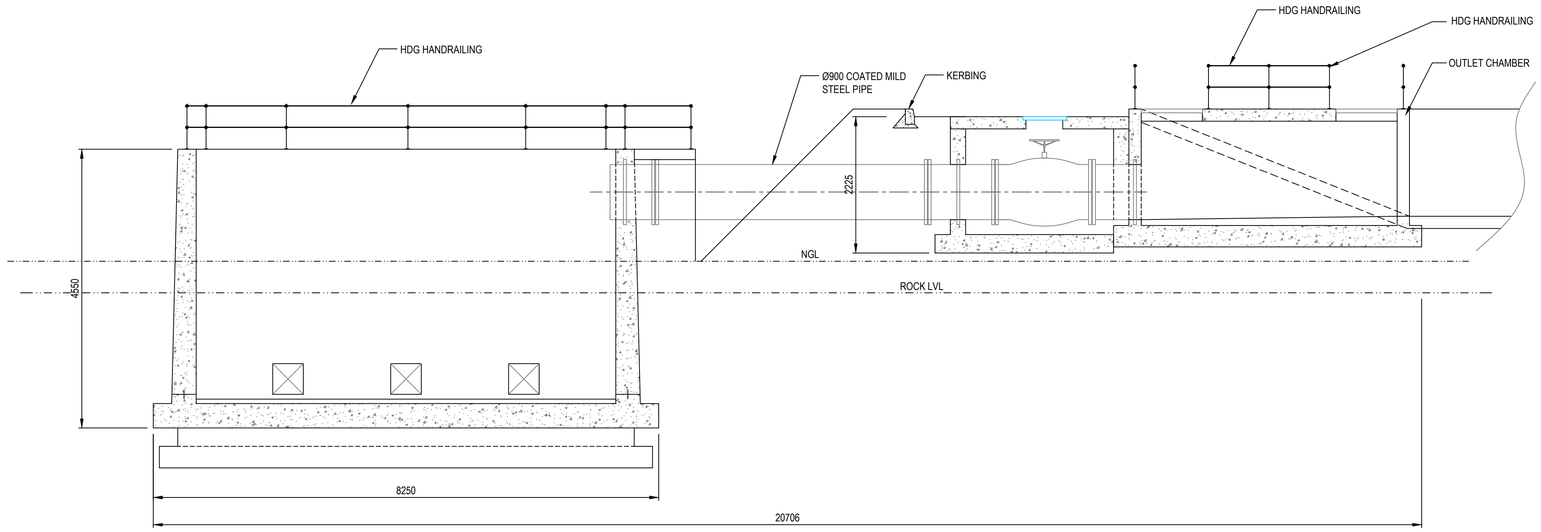
PROPOSED XHARIEP WTP
WATER RECOVERY PUMP STATION
PLANS, SECTIONS AND DETAILS

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.						REV.
CALCULATION FILE:		1 OF 1							A

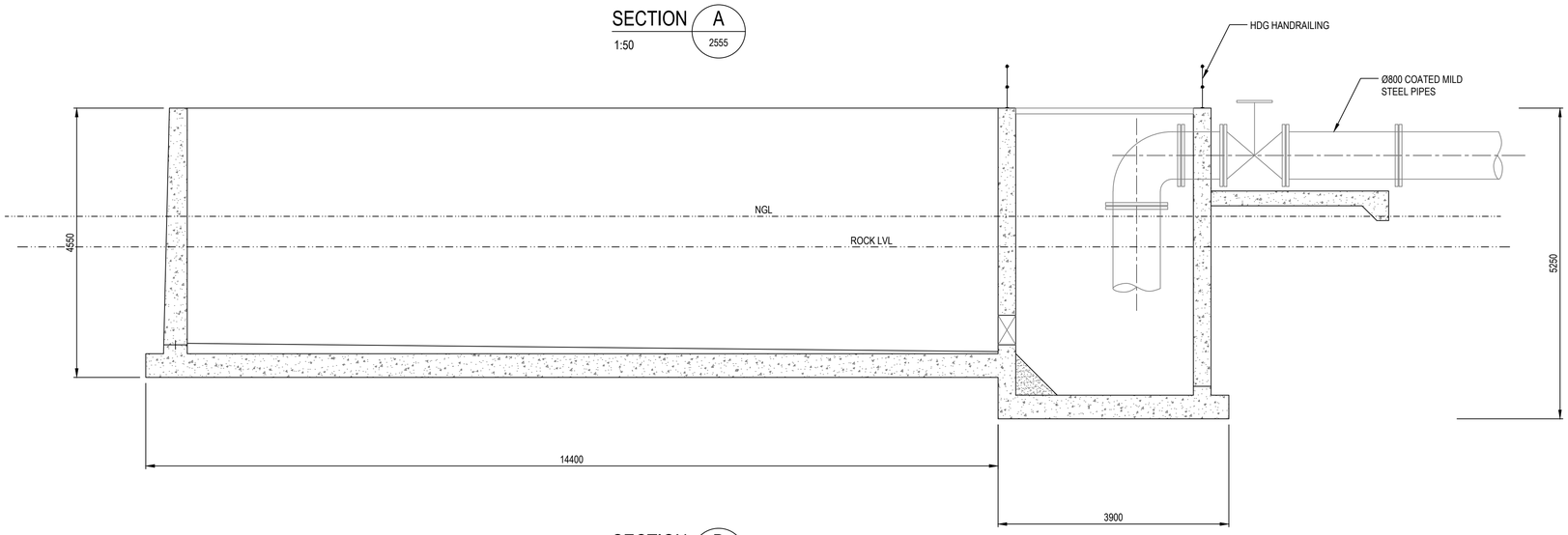
Plot Date: 20/12/2024 9:32:30 am Office: ZADC1 Filename: C:\USERS\SACHIN.RABCHAND\ONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\3D FILES\1002533-2500-DRG-CC-2555 WATER RECOVERY PUMP STATION.DWG

NOTES:

1. ALL BURIED PIPEWORK TO BE BUTTWELD HDPE.
2. FOR GROUND PREPARATION AROUND CONCRETE SLAB, PROVIDE 3 x 150 G7 COMPACTED TO 100% MOD AASHTO FOR SAND AND 98% FOR GRAVEL.
3. SUBMERSIBLE PUMPS AND DISCHARGE PIPEWORK TO BE INSTALLED BY MECHANICAL CONTRACTOR.
4. HDPE PIPES TO BE PE100 WITH A MINIMUM RATING OF PN6.
5. LIFTING EQUIPMENT FOR PUMPS TO BE SUPPLIED AND INSTALLED BY OTHERS. NOT SHOWN ON DRAWING FOR CLARITY.
6. PUDDLE PIPES FOR PUMP DISCHARGE LINES TO BE CAST IN BY MECHANICAL CONTRACTOR.



SECTION A
1:50
2555



SECTION B
1:50
2555

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2556
DESIGN: JB STRYDOM
ZUTARI APPROVER (Pr. Eng): T.C DATE:
DRAWN: JB STRYDOM

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: T. CERONIO DATE:
DESIGN:
DRAWN:
ENGINEER: DATE:
EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE:
DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

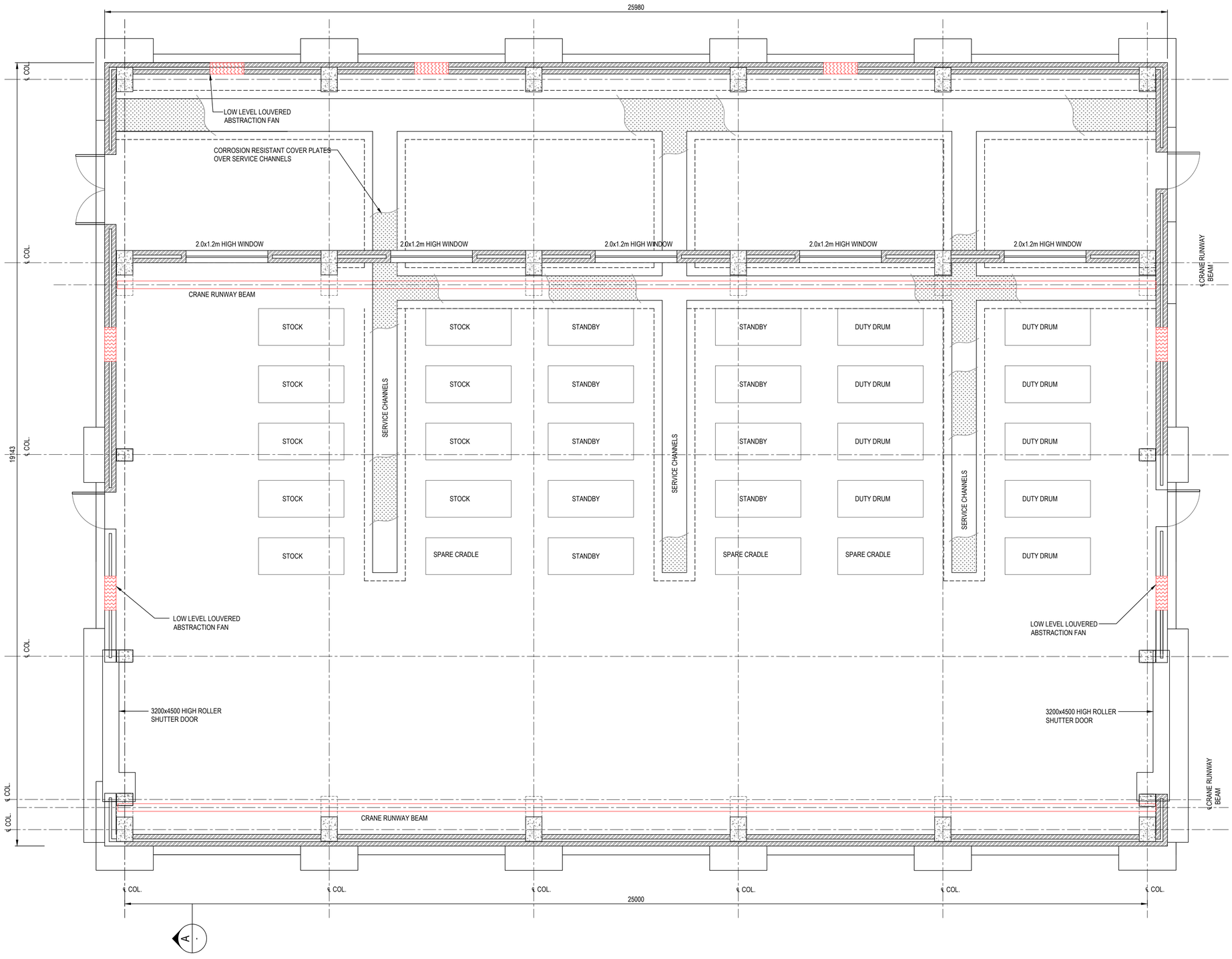
PROPOSED XHARIEP WTP
WATER RECOVERY PUMP STATION
SECTIONS AND DETAILS

PROVINCE: DISTRICT:
LOCALITY No.: TENDER/ CONTRACT No.
CALCULATION FILE:
KEYCODES: X X X - - OTHER NUMBER 0100
SHEET 1 OF 1
REG. No.
REV. A

Plot Date: 20/12/2024 9:32:30 am Office: ZADC1 Filename: C:\USERS\SACHIN.RABCHAND\ONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\3D FILES\1002533-2500-DRG-CC-2556 WATER RECOVERY PUMP STATION.DWG

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



PLAN ON FLOOR
SCALE 1 : 75

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2560
DESIGN: T. KOENA
ZUTARI APPROVER (Pr. Eng): T.C DATE:
DRAWN:

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: T. CERONIO DATE:
DESIGN:
DRAWN:
ENGINEER: DATE:
EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE:
DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

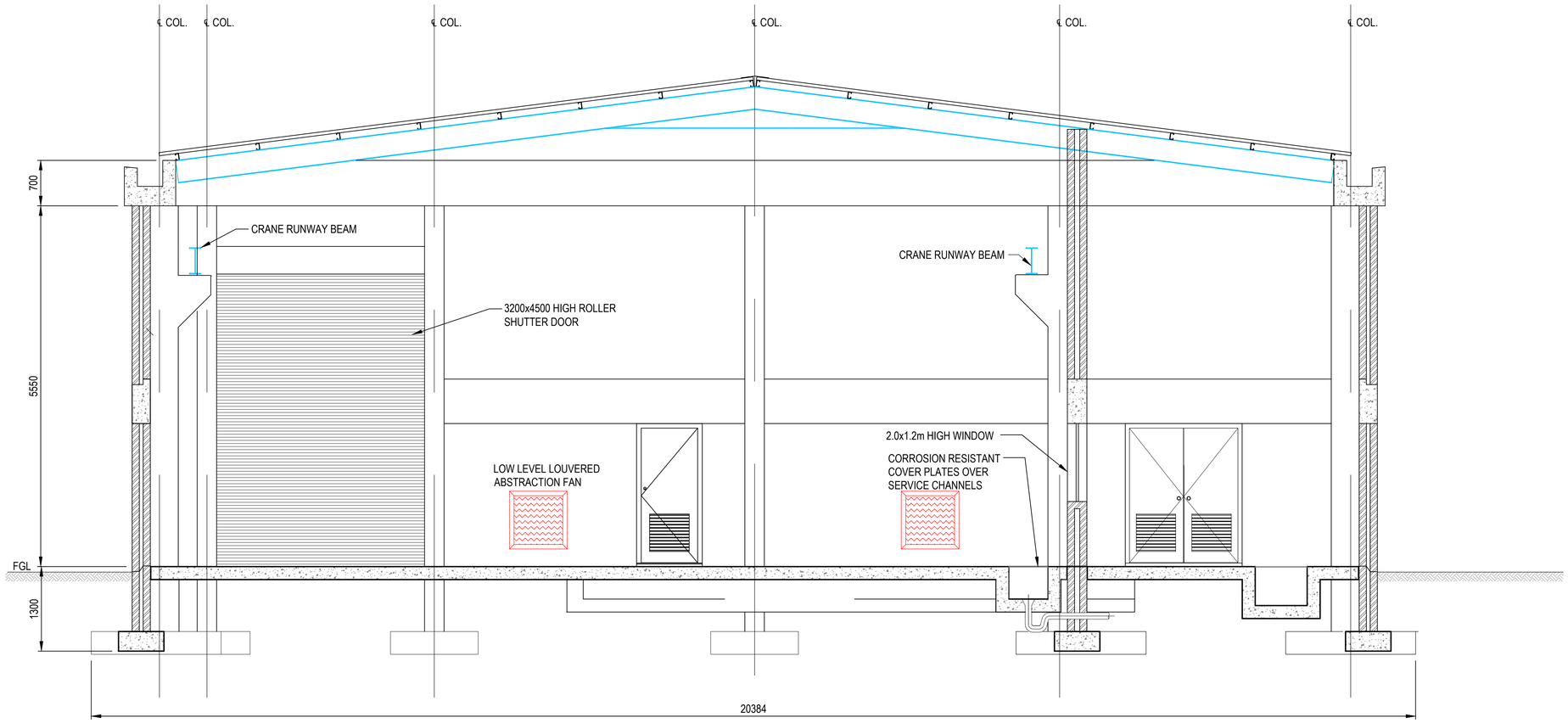
PROPOSED XHARIEP WTP
CHLORINE BOOSTER & STORAGE BUILDING
@ CH151005
PLAN

PROVINCE:	DISTRICT:	KEYCODES:	X	X	X	–	–	OTHER NUMBER	0100	
LOCALITY No.:	TENDER/ CONTRACT No.	SHEET	REG. No.							REV.
CALCULATION FILE:		1 OF 1								A

Plot Date: 20/12/2024 9:39:25 am Office: ZAC1 Filename: C:\USERS\JASON.ROBICHAND\ONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\3D FILES\1002533-2500-DRG-CC-2560 CHLORINE BOOSTER & STORAGE BUILDING @ CH151005.DWG

GENERAL NOTES:

1. THIS DRAWING IS FOR FEASIBILITY STUDY PURPOSES ONLY AND DOES NOT REPRESENT THE FINAL DESIGN.
2. THIS DRAWING MUST NOT BE SCALED.



SECTION A
1:50 DRG

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2561
DESIGN: T. KOENA
ZUTARI APPROVER (Pr. Eng): T.C DATE: DRAWN:

ZUTARI IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
ENGINEERING SERVICES
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

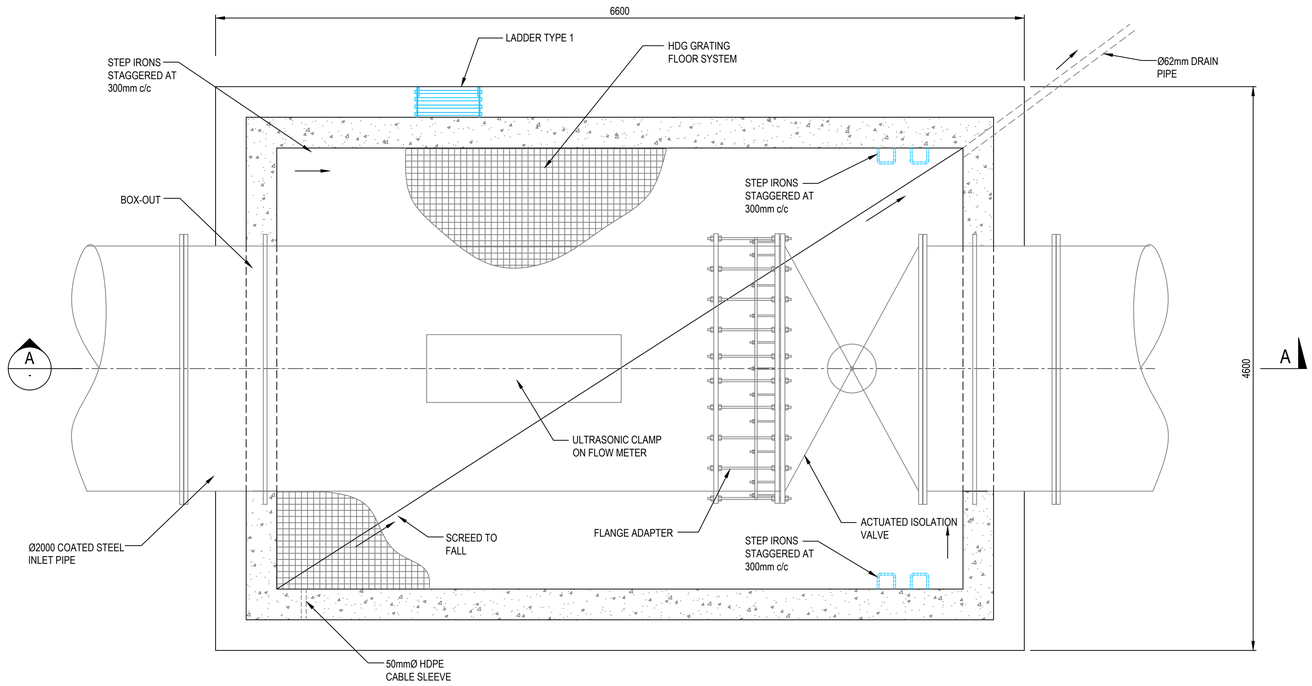
DESIGN:
CHECKED: T. CERONIO DATE: DRAWN:
ENGINEER: DATE: EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

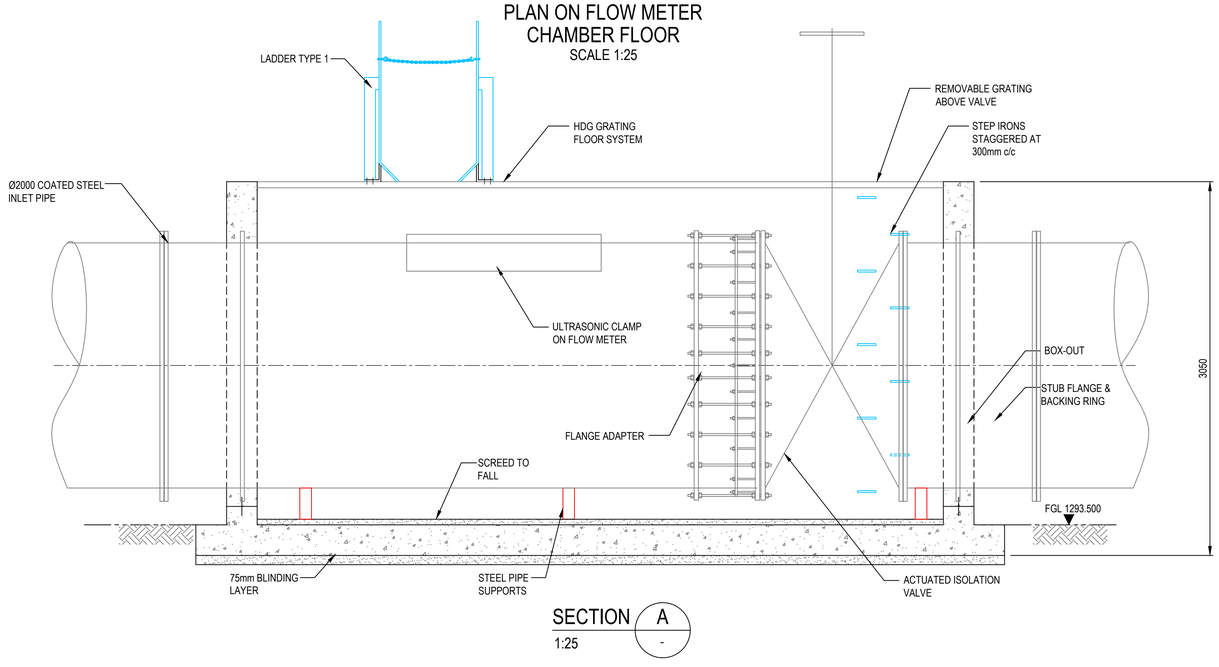
PROPOSED XHARIEP WTP CHLORINE BOOSTER & STORAGE BUILDING @CH11005 PLAN

PROVINCE: | DISTRICT: | KEYCODES: X X X - - | OTHER NUMBER 0100
LOCALITY No.: | TENDER/ CONTRACT No. | SHEET 1 OF 1 | REG. No. | REV. A
CALCULATION FILE:

Plot Date: 20/12/2024 9:58:48 am Office: ZAC1 Filename: C:\USERS\SACHIN.RABICHAND\ONEDRIVE - ZUTARI\WORK\KHARIEP\DRAWINGS\CIVIL\3D FILES\1002533-2500-DRG-CC-2560 CHLORINE BOOSTER & STORAGE BUILDING @ CH11005.DWG



PLAN ON FLOW METER CHAMBER FLOOR
SCALE 1:25



SECTION A
1:25

NOTES:

1. ALL WORK MUST BE DONE IN ACCORDANCE WITH THE STANDARD SPECIFICATION SABS 1200.
2. CONTRACTOR TO CHECK ALL SETTING OUT INFORMATION ON SITE AND NOTIFY THE ENGINEER OF ANY IRREGULARITIES PRIOR TO CONSTRUCTION.
3. ALL MODIFICATIONS TO EXISTING SERVICES AND DEVIATIONS FROM THE DESIGN TO BE AS PER INSTRUCTION FROM THE ENGINEER ONLY.
4. THE ENGINEER'S DRAWINGS SHALL BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECT'S, CONSULTANT'S AND SPECIALIST'S DRAWINGS. ANY DISCREPANCIES SHALL BE REFERRED TO THE ENGINEER PRIOR TO CONSTRUCTION.
5. ALL CONCRETE USED TO BE CLASS 25 / 19 MPa.
6. MINIMUM COVER FOR STEEL REINFORCEMENT TO BE 40mm.
7. CONCRETE BASE TO BE PLACED ON 300mm THICK IN SITU (100% FOR SAND) COMPACTED MATERIAL TO 90% MOD AASHTO DENSITY
8. SEE 2041 CT DRAWING SERIES FOR JOINT DETAILS. JOINT DETAIL REFERENCES INDICATED BY F OR W, FOLLOWED BY A NUMBER.
9. PUDDLE PIPES TO BE MANUFACTURED FROM GRADE 304L STAINLESS STEEL TO SUIT THE PIPE.
10. MECHANICAL EQUIPMENT SHOWN IN RED.

0.25 0 0.5 1m
SCALE 1:25

THE MASTER HELD AT ZUTARI BEARS THE ORIGINAL SIGNATURE OF APPROVAL

LIST OF DRAWINGS

SHEET	DESCRIPTION	OTHER No.	REG. No.
1			

CONSULTANT ENGINEER

ZUTARI DRG No.: 1002533-2500-DRG-CC-2570
DESIGN: JB STRYDOM
ZUTARI APPROVER (Pr. Eng): T.C DATE:
DRAWN: L. KROUWKAMP

ZUTARI
IMPACT. ENGINEERED.

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWS
A	13/12/2024	ISSUED FOR INFORMATION	T.C	

DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

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PRIVATE BAG X313
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SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: T. CERONIO DATE:
DESIGN:
DRAWN:
ENGINEER: DATE:
EXT. APPROVAL / DESIGN CHECKED: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE:
DIRECTOR (Pr. Eng): DATE:

XHARIEP PIPELINE FEASIBILITY STUDY

PROPOSED XHARIEP WTP FLOW METER CHAMBER PLAN & SECTIONS

PROVINCE: DISTRICT:
KEYCODES: X X X - - OTHER NUMBER 0100
LOCALITY No.: TENDER/ CONTRACT No.
SHEET 1 OF 1
REG. No.
REV. A
CALCULATION FILE:

Plot Date: 20/12/2024 10:05:22 am Office: ZADC1 Filename: C:\USERS\SACHIN.RABICHAND\ONEDRIVE - ZUTARI\WORK\XHARIEP\DRAWINGS\CIVIL\3D FILES\1002533-2500-DRG-CC-2570-FLOW METER CHAMBER.DWG

Appendix F: Preliminary Mechanical Load List

Item no.	Phase	Equipment Item	Medium	Density (kg/m³)	Flow or Volume	Units	Operation	Qty.	Pressure Difference	Units (bar, m, kPa)	Efficiency	Absorbed Power (kW) Per Unit	Rated (kW) Per Unit	Starter Type	Voltage (V)	Phase (1 /3)	IP Rating	Standby Power (Y/N)	Power by GenSet (kW)
1		**INLET WORKS**																	
1.1		**Inlet**																	
1.1.1	**Phase 1**	Actuator	-	-	-	-	Duty	1	-	-	-	22.00	30	-	-	-	-	N	-
1.1.2	**Phase 1**	Instrumentation	-	-	-	-	Duty	1	-	-	-	1.50	1.50	-	-	-	-	N	-
											Subtotal (Phase 1)	**23.50**	**31.50**	**kW**		**30.72**	**kVa**		
											INLET WORKS LOAD TOTAL (Phase 1)	**24**	**32**	**kW**		**31**	**kVa**		
											INLET WORKS LOAD TOTAL (Phase 1 & 2)	**24**	**32**	**kW**		**31**	**kVa**		
2		**FLOCCULATION AND CLARIFICATION**																	
2.1		**Pulsator Clarifiers**																	
2.1.1	**Phase 1**	Pulsator #1-8	Water	1000	1270	m³/hr	Duty	8	-	-	-	-	-	-	-	-	-	-	-
2.1.2	**Phase 2**	Pulsator #9-12	Water	1000	1270	m³/hr	Duty	4	-	-	-	-	-	-	-	-	-	-	-
2.1.3	**Phase 3**	Pulsator 13-16	Water	1000	1270	m³/hr	Future	4	-	-	-	-	-	-	-	-	-	-	-
2.1.4	**Phase 1**	Pulsator fan #1-8	Air	1.63	1200	m³/hr	Duty	8	7.5	kPa	75.00%	3.50	5.5	FSD	400 V	3 Phase	IP 68	N	-
2.1.5	**Phase 2**	Pulsator fan #9-12	Air	1.63	1200	m³/hr	Duty	4	7.5	kPa	75.00%	3.50	5.5	FSD	400 V	3 Phase	IP 68	N	-
2.1.6	**Phase 3**	Pulsator fan 13-16	Air	1.63	1200	m³/hr	Future	4	7.5	kPa	75.00%	3.50	5.5	FSD	400 V	3 Phase	IP 68	N	-
2.1.7	**Phase 1**	Sludge waste valves	-	-	-	-	Duty	24	-	-	-	1.50	1.50	-	-	-	-	N	-
2.1.8	**Phase 2**	Sludge waste valves	-	-	-	-	Duty	12	-	-	-	1.50	1.50	-	-	-	-	N	-
2.1.9	**Phase 3**	Sludge waste valves	-	-	-	-	Future	4	-	-	-	1.5	1.5	-	-	-	-	N	-
2.1.10	**Phase 1**	Solenoids	-	-	-	-	Duty	8	-	-	-	1	1.5	-	-	-	-	N	-
2.1.11	**Phase 2**	Solenoids	-	-	-	-	Duty	4	-	-	-	1	1.5	-	-	-	-	N	-
2.1.12	**Phase 3**	Solenoids	-	-	-	-	Future	4	-	-	-	1	1.5	-	-	-	-	N	-
											Subtotal (Phase 1)	**72.00**	**92.00**	**kW**		**94.12**	**kVa**		
											Subtotal (Phase 1 & 2)	**108.00**	**138.00**	**kW**		**141.18**	**kVa**		
											FLOCCULATION AND CLARIFICATION LOAD TOTAL (Phase 1)	**72**	**92**	**kW**		**94**	**kVa**		
											FLOCCULATION AND CLARIFICATION LOAD TOTAL (Phase 1 & 2)	**108**	**138**	**kW**		**141**	**kVa**		
3		**RAPID GRAVITY SAND FILTERS**																	
3.1		**RGSF and ancillary equipment**																	
3.1.1	**Phase 1**	Rapid gravity sand filters #1-20	Water	1000	508	m³/hr	Duty	20	-	-	-	-	-	-	-	-	-	-	-
3.1.2	**Phase 2**	Rapid gravity sand filters #21-30	Water	1000	508	m³/hr	Duty	10	-	-	-	-	-	-	-	-	-	-	-
3.1.3	**Phase 3**	Rapid gravity sand filters #31-40	Water	1000	508	m³/hr	Future	10	-	-	-	-	-	-	-	-	-	-	-
3.1.4	**Phase 1**	Sluice gates for inlet and washwater outlet	-	-	-	-	Duty	2	-	-	-	6	7.5	-	-	-	-	Y	15
3.1.5	**Phase 1**	Sluice gates for inlet and washwater outlet	-	-	-	-	Standby	38	-	-	-	6	7.5	-	-	-	-	*Y*	285
3.1.6	**Phase 2**	Sluice gates for inlet and washwater outlet	-	-	-	-	Duty	2	-	-	-	6	7.5	-	-	-	-	Y	15
3.1.7	**Phase 2**	Sluice gates for inlet and washwater outlet	-	-	-	-	Standby	18	-	-	-	6	7.5	-	-	-	-	*Y*	135
3.1.8	**Phase 3**	Sluice gates for inlet and washwater outlet	-	-	-	-	Future	20	-	-	-	6	7.5	-	-	-	-	Y	150
3.1.9	**Phase 1**	Actuated valves	-	-	-	-	Duty	3	-	-	-	1	4	-	-	-	-	N	-
3.1.10	**Phase 1**	Actuated valves	-	-	-	-	Standby	57	-	-	-	1	4	-	-	-	-	N	-
3.1.11	**Phase 2**	Actuated valves	-	-	-	-	Duty	3	-	-	-	1	4	-	-	-	-	N	-
3.1.12	**Phase 2**	Actuated valves	-	-	-	-	Standby	27	-	-	-	1	4	-	-	-	-	N	-
3.1.13	**Phase 3**	Actuated valves	-	-	-	-	Future	30	-	-	-	1	4	-	-	-	-	N	-
											Subtotal (Phase 1)	**21.00**	**27.00**	**kW**		**27.45**	**kVa**		
											Subtotal (Phase 1 & 2)	**42.00**	**54.00**	**kW**		**54.90**	**kVa**		
3.2		**Blowers/air scour**																	
3.2.1	**Phase 1**	RGSF blower #1	Backwash Air	1.63	4235	m³/hr	Duty	1	50	kPa	75.00%	45.00	55.00	DOL	400 V	3 Phase	IP 68	N	-
3.2.2	**Phase 1**	*RGSF blower #2*	*Backwash Air*	*1.63*	*4235*	*m³/hr*	*Standby*	*1*	*50*	*kPa*	*75.00%*	*45.00*	*55.00*	*DOL*	*400 V*	*3 Phase*	*IP 68*	*N*	-
3.2.3	**Phase 2**	RGSF blower #3	Backwash Air	1.63	4235	m³/hr	Duty	1	50	kPa	75.00%	45.00	55.00	DOL	400 V	3 Phase	IP 68	N	-
3.2.4	**Phase 2**	*RGSF blower #4*	*Backwash Air*	*1.63*	*4235*	*m³/hr*	*Standby*	*1*	*50*	*kPa*	*75.00%*	*45.00*	*55.00*	*DOL*	*400 V*	*3 Phase*	*IP 68*	*N*	-
											Subtotal (Phase 1)	**45.00**	**55.00**	**kW**		**58.82**	**kVa**		
											Subtotal (Phase 1 & 2)	**90.00**	**110.00**	**kW**		**117.65**	**kVa**		
3.3		**Backwash**																	

Item no.	Phase	Equipment Item	Medium	Density (kg/m³)	Flow or Volume	Units	Operation	Qty.	Pressure Difference	Units (bar, m, kPa)	Efficiency	Absorbed Power (kW) Per Unit	Rated (kW) Per Unit	Starter Type	Voltage (V)	Phase (1 /3)	IP Rating	Standby Power (Y/N)	Power by GenSet (kW)
3.3.1	**Phase 1**	RGSF backwash pump #1-2	Filtered Water	1000	1440	m³/hr	Duty	2	80	kPa	65.00%	48.3	75	VSD	400 V	3 Phase	IP 68	N	-
3.3.2	**Phase 1**	*RGSF backwash pump #3*	*Filtered Water*	*1000*	*1440*	*m³/hr*	*Standby*	*1*	*80*	*kPa*	*65.00%*	*48.3*	*75*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
3.3.3	**Phase 2**	RGSF backwash pump #4-5	Filtered Water	1000	1440	m³/hr	Duty	2	80	kPa	65.00%	48.3	75	VSD	400 V	3 Phase	IP 68	N	-
3.3.4	**Phase 2**	*RGSF backwash pump #6*	*Filtered Water*	*1000*	*1440*	*m³/hr*	*Standby*	*1*	*80*	*kPa*	*65.00%*	*48.3*	*75*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
										Subtotal (Phase 1)		**96.60**	**150.00**	**kW**		**126.27**	**kVa**		
										Subtotal (Phase 1 & 2)		**193.20**	**300.00**	**kW**		**252.55**	**kVa**		
3.4		**Blowers and Backwash pump buildings**																	
3.4.1	**Phase 1**	Crawl beam #1-2	-	-	-	-	Duty	2	-	-	-	3.5	5.5	-	400 V	3 Phase	-	-	-
3.4.2	**Phase 1**	Small power & lighting	-	-	-	-	Duty	1	-	-	-	5	5	-	400 V	3 Phase	-	-	-
3.4.3	**Phase 1**	Forced ventilation for building	-	-	-	-	Duty	1	-	-	-	3	3	-	400 V	3 Phase	-	-	-
3.4.4	**Phase 1**	MCC Room HVAC	-	-	-	-	Duty	1	-	-	-	5	5	-	400 V	3 Phase	-	-	-
3.4.5	**Phase 2**	Crawl beam #2-4	-	-	-	-	Duty	2	-	-	-	3.5	5.5	-	400 V	3 Phase	-	-	-
3.4.6	**Phase 2**	Small power & lighting	-	-	-	-	Duty	1	-	-	-	5	5	-	400 V	3 Phase	-	-	-
3.4.7	**Phase 2**	Forced ventilation for building	-	-	-	-	Duty	1	-	-	-	3	3	-	400 V	3 Phase	-	-	-
3.4.8	**Phase 2**	MCC Room HVAC	-	-	-	-	Duty	1	-	-	-	5	5	-	400 V	3 Phase	-	-	-
										Subtotal (Phase 1)		**20.00**	**24.00**	**kW**		**26.14**	**kVa**		
										Subtotal (Phase 1 & 2)		**40.00**	**48.00**	**kW**		**52.29**	**kVa**		
										RAPID GRAVITY SAND FILTERS LOAD TOTAL (Phase 1)		**183**	**256**	**kW**		**239**	**kVa**		
										RAPID GRAVITY SAND FILTERS LOAD TOTAL (Phase 1 & 2)		**365**	**512**	**kW**		**477**	**kVa**		
4		**CLEAR WATER**																	
4.1		**Clear water storage tank**																	
4.1.1	**Phase 1**	Clear water tank #1	Water	1000	10589	m³	Duty	1	-	-	-	-	-	-	-	-	-	-	-
4.1.2	**Phase 2**	Clear water tank #2	Water	1000	5295	m³	Duty	1	-	-	-	-	-	-	-	-	-	-	-
4.1.3	**Phase 3**	Clear water tank #3	Water	1000	5295	m³	Future	1	-	-	-	-	-	-	-	-	-	-	-
4.1.4	**Phase 1**	Instrumentation	-		-	-	Duty	1	-	-	-	1.5	1.5	-	400 V	3 Phase	-	N	-
4.1.5	**Phase 2**	Instrumentation	-		-	-	Duty	1	-	-	-	0.75	1.5	-	400 V	3 Phase	-	N	-
4.1.6	**Phase 3**	Instrumentation	-		-	-	Future	1	-	-	-	0.75	1.5	-	400 V	3 Phase	-	N	-
										Subtotal (Phase 1)		**1.50**	**1.50**	**kW**		**1.96**	**kVa**		
										Subtotal (Phase 1 & 2)		**2.25**	**3.00**	**kW**		**2.94**	**kVa**		
										CLEAR WATER LOAD TOTAL (Phase 1)		**2**	**2**	**kW**		**2**	**kVa**		
										CLEAR WATER LOAD TOTAL (Phase 1 & 2)		**2**	**3**	**kW**		**2**	**kVa**		
5		**CHEMICAL DOSING**																	
5.1		**Pre-chlorination**																	
5.1.1	**Phase 1**	Pre-chlorination booster dosing pumps #1	Water	1000	5	m³/hr	Duty	1	300	kPa	75.00%	0.6	0.75	VSD	400 V	3 Phase	IP 68	N	-
5.1.2	**Phase 1**	*Pre-chlorination booster dosing pumps #2*	*Water*	*1000*	*5*	*m³/hr*	*Standby*	*1*	*300*	*kPa*	*75.00%*	*0.6*	*0.75*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
5.1.3	**Phase 2**	Pre-chlorination booster dosing pumps #3	Water	1000	5	m³/hr	Duty	1	300	kPa	75.00%	0.6	0.75	VSD	400 V	3 Phase	IP 68	N	-
5.1.4	**Phase 2**	*Pre-chlorination booster dosing pumps #4*	*Water*	*1000*	*5*	*m³/hr*	*Standby*	*1*	*300*	*kPa*	*75.00%*	*0.6*	*0.75*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
5.1.5	**Phase 1**	Pre-chlorination chlorinator #1-2	Chlorine gas	3.21	20	kg/hr	Duty	2	-	-	-	-	-	-	-	-	-	-	-
5.1.6	**Phase 1**	*Pre-chlorination chlorinator #3*	*Chlorine gas*	*3.21*	*20*	*kg/hr*	*Standby*	*1*	-	-	-	-	-	-	-	-	-	-	-
5.1.7	**Phase 2**	Pre-chlorination chlorinator #4	Chlorine gas	3.21	20	kg/hr	Duty	1	-	-	-	-	-	-	-	-	-	-	-
5.1.8	**Phase 2**	*Pre-chlorination chlorinator #5*	*Chlorine gas*	*3.21*	*20*	*kg/hr*	*Standby*	*1*	-	-	-	-	-	-	-	-	-	-	-
5.1.9	**Phase 3**	Pre-chlorination chlorinator #6	Chlorine gas	3.21	20	kg/hr	Future	1	-	-	-	-	-	-	-	-	-	-	-
										Subtotal (Phase 1)		**0.60**	**0.75**	**kW**		**0.78**	**kVa**		
										Subtotal (Phase 1 & 2)		**1.20**	**1.50**	**kW**		**1.57**	**kVa**		
5.2		**Post-chlorination**																	
5.2.1	**Phase 1**	Post-chlorination dosing pumps #1	Water	1000	10	m³/hr	Duty	1	100	kPa	75.00%	0.4	0.55	VSD	400 V	3 Phase	IP 68	N	-
5.2.2	**Phase 1**	*Post-chlorination dosing pumps #2*	*Water*	*1000*	*10*	*m³/hr*	*Standby*	*1*	*100*	*kPa*	*75.00%*	*0.4*	*0.55*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
5.2.3	**Phase 2**	Post-chlorination dosing pumps #3	Water	1000	10	m³/hr	Duty	1	100	kPa	75.00%	0.4	0.55	VSD	400 V	3 Phase	IP 68	N	-
5.2.4	**Phase 2**	*Post-chlorination dosing pumps #4*	*Water*	*1000*	*10*	*m³/hr*	*Standby*	*1*	*100*	*kPa*	*75.00%*	*0.4*	*0.55*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
5.2.5	**Phase 1**	Post-chlorination chlorinator #1-3	Chlorine gas	3.21	20	kg/hr	Duty	3	-	-	-	-	-	-	-	-	-	-	-

Item no.	Phase	Equipment Item	Medium	Density (kg/m³)	Flow or Volume	Units	Operation	Qty.	Pressure Difference	Units (bar, m, kPa)	Efficiency	Absorbed Power (kW) Per Unit	Rated (kW) Per Unit	Starter Type	Voltage (V)	Phase (1 /3)	IP Rating	Standby Power (Y/N)	Power by GenSet (kW)
5.2.6	**Phase 1**	*Post-chlorination chlorinator #4*	*Chlorine gas*	*3.21*	*20*	*kg/hr*	*Standby*	*1*	-	-	-	-	-	-	-	-	-	-	-
5.2.7	**Phase 2**	Post-chlorination chlorinator #5-6	Chlorine gas	3.21	20	kg/hr	Duty	2	-	-	-	-	-	-	-	-	-	-	-
5.2.8	**Phase 2**	*Post-chlorination chlorinator #7*	*Chlorine gas*	*3.21*	*20*	*kg/hr*	*Standby*	*1*	-	-	-	-	-	-	-	-	-	-	-
5.2.9	**Phase 3**	Post-chlorination chlorinator #8	Chlorine gas	3.21	20	kg/hr	Future	1	-	-	-	-	-	-	-	-	-	-	-
										Subtotal (Phase 1)		**0.40**	**0.55**	**kW**		**0.52**	**kVa**		
										Subtotal (Phase 1 & 2)		**0.80**	**1.10**	**kW**		**1.05**	**kVa**		
5.3		**Chlorine scrubber + chlorine building**																	
5.3.1	**Phase 1**	Chlorine scrubber	-	-	5000	m³/hr	Duty	1	-	-	-	-	-	-	-	-	-	-	-
5.3.2	**Phase 1**	Pressure room extraction fan	-	-	5000	m³/hr	Duty	1	-	-	-	15	18.5	-	400 V	3 Phase	-	N	-
5.3.3	**Phase 1**	Pressure room ventilation fan	-	-	5000	m³/hr	Duty	1	-	-	-	15	18.5	-	400 V	3 Phase	-	N	-
5.3.4	**Phase 1**	Vacuum room extraction fan	-	-	-	-	Duty	1	-	-	-	0.25	0.37	-	400 V	3 Phase	-	N	-
5.3.5	**Phase 1**	Chlorine Storage Crawl Beam #1	-	-	-	-	Duty	1	-	-	-	3.5	5.5	-	400 V	3 Phase	-	N	-
5.3.6	**Phase 1**	Small power & lighting	-		-	-	Duty	1	-	-	-	5	5	-	400 V	3 Phase	-	N	-
5.3.7	**Phase 1**	Safety valves	-		-	-	Duty	30	-	-	-		0.37	-	400 V	3 Phase	-	N	-
5.3.8	**Phase 2**	Chlorine scrubber	-	-	5000	m³/hr	Duty	1	-	-	-	-	-	-	-	-	-	-	-
5.3.9	**Phase 2**	Pressure room extraction fan	-	-	5000	m³/hr	Duty	1	-	-	-	15	18.5	-	400 V	3 Phase	-	N	-
5.3.10	**Phase 2**	Pressure room ventilation fan	-	-	5000	m³/hr	Duty	1	-	-	-	15	18.5	-	400 V	3 Phase	-	N	-
5.3.11	**Phase 2**	Vacuum room extraction fan	-	-	-	-	Duty	1	-	-	-	0.25	0.37	-	400 V	3 Phase	-	N	-
5.3.12	**Phase 2**	Chlorine Storage Crawl Beam #2	-	-	-	-	Duty	1	-	-	-	3.5	5.5	-	400 V	3 Phase	-	N	-
5.3.13	**Phase 2**	Small power & lighting	-	-	-	-	Duty	1	-	-	-	5	5	-	400 V	3 Phase	-	N	-
5.3.14	**Phase 2**	Safety valves	-	-	-	-	Duty	30	-	-	-		0.37	-	400 V	3 Phase	-	N	-
										Subtotal (Phase 1)		**38.75**	**58.97**	**kW**		**50.65**	**kVa**		
										Subtotal (Phase 1 & 2)		**77.50**	**117.94**	**kW**		**101.31**	**kVa**		
5.4		**Stabilisation chemical dosing - Lime**																	
5.4.1	**Phase 1**	Lime silo #1	Lime	500	80	m³	Duty	1	-	-	-	-	-	-	-	-	-	-	-
5.4.2	**Phase 1**	*Lime silo #2*	*Lime*	*500*	*80*	*m³*	*Standby*	*1*	-	-	-	-	-	-	-	-	-	-	-
5.4.3	**Phase 3**	*Lime silo #3*	Lime	500	80	m³	Future	1	-	-	-	-	-	-	-	-	-	-	-
5.4.4	**Phase 1**	Lime silo filter fan #1	-	-	-	-	Duty	1	-	-	-	2.2	3	FSD	400 V	3 Phase	-	N	-
5.4.5	**Phase 1**	Lime silo filter fan #2	-	-	-	-	*Standby*	*1*	-	-	-	*2.2*	*3*	*FSD*	*400 V*	*3 Phase*	-	*N*	-
5.4.6	**Phase 3**	Lime silo filter fan #3	-	-	-	-	Future	1	-	-	-	2.2	3	FSD	400 V	3 Phase	-	N	-
5.4.7	**Phase 1**	Silo vibrating bin discharger #1	Lime	500	-	-	Duty	1	-	-	-	0.62	0.75	VSD	400 V	3 Phase	-	N	-
5.4.8	**Phase 1**	*Silo vibrating bin discharger #2-4*	*Lime*	*500*	-	-	*Standby*	*3*	-	-	-	*0.62*	*0.75*	*VSD*	*400 V*	*3 Phase*	-	*N*	-
5.4.9	**Phase 3**	Silo vibrating bin discharger #5-6	Lime	500	-	-	Future	2	-	-	-	0.62	0.75	VSD	400 V	3 Phase	-	N	-
5.4.10	**Phase 1**	Lime silo dosing screws #1	Lime	500	-	-	Duty	1	-	-	-	-	0.37	VSD	400 V	3 Phase	-	N	-
5.4.11	**Phase 1**	*Lime silo dosing screws #2-4*	*Lime*	*500*	-	-	*Standby*	*3*	-	-	-	-	*0.37*	*VSD*	*400 V*	*3 Phase*	-	*N*	-
5.4.12	**Phase 3**	Lime silo dosing screws #5-6	Lime	500	-	-	Future	2	-	-	-	-	0.37	VSD	400 V	3 Phase	-	N	-
5.4.13	**Phase 1**	Lime silo mixing bowl #1	Lime slurry	1160	-	-	Duty	1	-	-	-	-	-	-	-	-	-	-	-
5.4.14	**Phase 1**	*Lime silo mixing bowl #2-4*	*Lime slurry*	*1160*	-	-	*Standby*	*3*	-	-	-	-	-	-	-	-	-	-	-
5.4.15	**Phase 3**	Lime silo mixing bowl #5-6	Lime slurry	1160	-	-	Future	2	-	-	-	-	-	-	-	-	-	-	-
5.4.16	**Phase 1**	Lime slurry pump #1	Lime slurry	1160	7	m³/hr	Duty	1	200	kPa	55.00%	0.8	1.1	VSD	400 V	3 Phase	IP 68	N	-
5.4.17	**Phase 1**	*Lime slurry pump #2*	*Lime slurry*	*1160*	*7*	*m³/hr*	*Standby*	*1*	*200*	*kPa*	*55.00%*	*0.8*	*1.1*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
5.4.18	**Phase 2**	Lime slurry pump #3	Lime slurry	1160	7	m³/hr	Duty	1	202	kPa	55.00%	0.8	1.1	VSD	400 V	3 Phase	IP 68	N	-
5.4.19	**Phase 2**	*Lime slurry pump #4*	*Lime slurry*	*1160*	*7*	*m³/hr*	*Standby*	*1*	*203*	*kPa*	*55.00%*	*0.8*	*1.1*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
5.4.20	**Phase 3**	Lime slurry pump #5	Lime slurry	1160	7	m³/hr	Future	1	203	kPa	55.00%	0.8	1.1	VSD	400 V	3 Phase	IP 68	N	-
5.4.21	**Phase 3**	Lime slurry pump #6	Lime slurry	1160	7	m³/hr	Future	1	203	kPa	55.00%	0.8	1.1	VSD	400 V	3 Phase	IP 68	N	-
5.4.22	**Phase 3**	Lime slurry pump #7	Lime slurry	1160	7	m³/hr	Future	1	203	kPa	55.00%	0.8	1.1	VSD	400 V	3 Phase	IP 68	N	-
										Subtotal (Phase 1)		**3.62**	**5.22**	**kW**		**4.73**	**kVa**		
										Subtotal (Phase 1 & 2)		**4.42**	**6.32**	**kW**		**5.78**	**kVa**		
5.5		**Coagulant - Ultrafloc U3500**																	
5.5.1	**Phase 1**	Coagulant storage tank #1	Ultrafloc U3500	1150	20000	L	Duty	4	-	-	-	-	-	-	-	-	-	-	-
5.5.2	**Phase 2**	Coagulant storage tank #2	Ultrafloc U3500	1150	20000	L	Duty	2	-	-	-	-	-	-	-	-	-	-	-

Item no.	Phase	Equipment Item	Medium	Density (kg/m³)	Flow or Volume	Units	Operation	Qty.	Pressure Difference	Units (bar, m, kPa)	Efficiency	Absorbed Power (kW) Per Unit	Rated (kW) Per Unit	Starter Type	Voltage (V)	Phase (1 /3)	IP Rating	Standby Power (Y/N)	Power by GenSet (kW)
5.5.3	**Phase 3**	Coagulant storage tank #3	Ultrafloc U3500	1150	20000	L	Future	2	-	-	-	-	-	-	-	-	-	-	-
5.5.4	**Phase 1**	Coagulant storage tank mixer #1	Ultrafloc U3500	1150	-	-	Duty	4	-	-	-	2.2	3	DOL	400 V	3 Phase	IP 68	N	-
5.5.5	**Phase 2**	Coagulant storage tank mixer #2	Ultrafloc U3500	1150	-	-	Duty	2	-	-	-	2.2	3	DOL	400 V	3 Phase	IP 68	N	-
5.5.6	**Phase 3**	Coagulant storage tank mixer #3	Ultrafloc U3500	1150	-	-	Future	2	-	-	-	2.2	3	DOL	400 V	3 Phase	IP 68	N	-
5.5.7	**Phase 1**	Coagulant batch tank #1	Ultrafloc U3500	1150	500	L	Duty	2	-	-	-	-	-	-	-	-	-	-	-
5.5.8	**Phase 2**	Coagulant batch tank #2	Ultrafloc U3500	1150	500	L	Duty	1	-	-	-	-	-	-	-	-	-	-	-
5.5.9	**Phase 3**	Coagulant batch tank #3	Ultrafloc U3500	1150	500	L	Future	1	-	-	-	-	-	-	-	-	-	-	-
5.5.10	**Phase 1**	Coagulant batch tank mixer #1	Ultrafloc U3500	1150	-	-	Duty	2	-	-	-	2.2	3	DOL	400 V	3 Phase	IP 68	N	-
5.5.11	**Phase 2**	Coagulant batch tank mixer #2	Ultrafloc U3500	1150	-	-	Duty	1	-	-	-	2.2	3	DOL	400 V	3 Phase	IP 68	N	-
5.5.12	**Phase 3**	Coagulant batch tank mixer #3	Ultrafloc U3500	1150	-	-	Future	1	-	-	-	2.2	3	DOL	400 V	3 Phase	IP 68	N	-
5.5.13	**Phase 1**	Coagulant dosing pump #1-4	Ultrafloc U3500	1150	77	L/hr	Duty	4	200	kPa	75.00%	0.1	0.37	VSD	400 V	3 Phase	IP 68	N	-
5.5.14	**Phase 1**	*Coagulant dosing pump #5-6*	*Ultrafloc U3500*	*1150*	*77*	*L/hr*	*Standby*	*2*	*200*	*kPa*	*75.00%*	*0.1*	*0.37*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
5.5.15	**Phase 2**	Coagulant dosing pump #7-8	Ultrafloc U3500	1150	77	L/hr	Duty	2	200	kPa	75.00%	0.1	0.37	VSD	400 V	3 Phase	IP 68	N	-
5.5.16	**Phase 2**	*Coagulant dosing pump #9*	*Ultrafloc U3500*	*1150*	*77*	*L/hr*	*Standby*	*1*	*200*	*kPa*	*75.00%*	*0.1*	*0.37*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
5.5.17	**Phase 3**	Coagulant dosing pump #10-11	Ultrafloc U3500	1150	77	L/hr	Future	2	200	kPa	75.00%	0.1	0.37	VSD	400 V	3 Phase	IP 68	N	-
5.5.18	**Phase 3**	Coagulant dosing pump #12	Ultrafloc U3500	1150	77	L/hr	Future	1	200	kPa	75.00%	0.1	0.37	VSD	400 V	3 Phase	IP 68	N	-
											Subtotal (Phase 1)	**13.60**	**19.48**	**kW**		**17.78**	**kVa**		
											Subtotal (Phase 1 & 2)	**20.40**	**29.22**	**kW**		**26.67**	**kVa**		
5.6		**Chemical dosing building**																	
5.6.1	**Phase 1**	Crawl beam #1-2	-	-	-	-	Duty	2	-	-	-	3.5	5.5	-	400 V	3 Phase	-	N	-
5.6.2	**Phase 1**	Small power & lighting	-	-	-	-	Duty	1	-	-	-	5	5	-	400 V	3 Phase	-	N	-
5.6.3	**Phase 1**	Forced ventilation for building	-	-	-	-	Duty	3	-	-	-	3	3	-	400 V	3 Phase	-	N	-
5.6.4	**Phase 1**	Safety valves	-	-	-	-	Duty	12	-	-	-	1.5	1.5	-	400 V	3 Phase	-	N	-
5.6.5	**Phase 1**	MCC Room HVAC	-	-	-	-	Duty	1	-	-	-	5	5	-	400 V	3 Phase	-	N	-
											Subtotal (Phase 1)	**44.00**	**48.00**	**kW**		**57.52**	**kVa**		
											Subtotal (Phase 1 & 2)	**44.00**	**48.00**	**kW**		**57.52**	**kVa**		
											CHEMICAL DOSING LOAD TOTAL (Phase 1)	**101**	**133**	**kW**		**114**	**kVa**		
											CHEMICAL DOSING LOAD TOTAL (Phase 1 & 2)	**148**	**204**	**kW**		**167**	**kVa**		
6		**RESIDUAL HANDLING**																	
6.1		**Sludge Lagoon**																	
6.1.1	**Phase 1**	Sludge lagoon #1-2	Sludge	1500	42434	m³	-	2	-	-	-	-	-	-	-	-	-	-	-
6.1.2	**Phase 2**	Sludge lagoon #3	Sludge	1500	42434	m³	-	1	-	-	-	-	-	-	-	-	-	-	-
6.1.3	**Phase 3**	Sludge lagoon #4	Sludge	1500	42434	m³	-	1	-	-	-	-	-	-	-	-	-	-	-
6.1.4	**Phase 1**	Supernatant sump #1	Supernatant	1000	375	m³	-	1	-	-	-	-	-	-	-	-	-	-	-
6.1.5	**Phase 1**	Supernatant pump #1	Supernatant	1000	625	m³/hr	Duty	1	300	kPa	65.00%	78.6	110	VSD	400 V	3 Phase	IP 68	N	-
6.1.6	**Phase 1**	*Supernatant pump #2*	*Supernatant*	*1000*	*625*	*m³/hr*	*Standby*	*1*	*300*	*kPa*	*65.00%*	*78.6*	*110*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
6.1.7	**Phase 2**	Supernatant pump #4	Supernatant	1000	625	m³/hr	Duty	1	300	kPa	65.00%	78.6	110	VSD	400 V	3 Phase	IP 68	N	-
6.1.8	**Phase 2**	*Supernatant pump #5*	*Supernatant*	*1000*	*625*	*m³/hr*	*Standby*	*1*	*300*	*kPa*	*65.00%*	*78.6*	*110*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
6.1.9	**Phase 1**	Small power and lighting	-	-	-	-	Duty	1	-	-	-	5	5	-	400 V	3 Phase	-	N	-
6.1.10	**Phase 1**	MCC Room HVAC	-	-	-	-	Duty	1	-	-	-	5	5	-	400 V	3 Phase	-	N	-
											Subtotal (Phase 1)	**88.60**	**120.00**	**kW**		**115.82**	**kVa**		
											Subtotal (Phase 1 & 2)	**167.20**	**230.00**	**kW**		**218.56**	**kVa**		
											RESIDUAL HANDLING LOAD TOTAL (Phase 1)	**89**	**120**	**kW**		**116**	**kVa**		
											RESIDUAL HANDLING LOAD TOTAL (Phase 1 & 2)	**167**	**230**	**kW**		**219**	**kVa**		
7		**SERVICE WATER**																	
7.1		**Service water pumps (Chlorinated)**																	
7.1.1	**Phase 1**	Service water pump #1	Water	1000	2	m³/hr	Duty	1	600	kPa	75.00%	0.4	0.55	VSD	400 V	3 Phase	IP 68	N	-
7.1.2	**Phase 1**	*Service water pump #2*	*Water*	*1000*	*2*	*m³/hr*	*Standby*	*1*	*600*	*kPa*	*75.00%*	*0.4*	*0.55*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
											Subtotal (Phase 1)	**0.40**	**0.55**	**kW**		**0.52**	**kVa**		
7.2		**Service water pumps (Unchlorinated)**																	

Item no.	Phase	Equipment Item	Medium	Density (kg/m³)	Flow or Volume	Units	Operation	Qty.	Pressure Difference	Units (bar, m, kPa)	Efficiency	Absorbed Power (kW) Per Unit	Rated (kW) Per Unit	Starter Type	Voltage (V)	Phase (1 /3)	IP Rating	Standby Power (Y/N)	Power by GenSet (kW)
7.2.1	**Phase 1**	Service water pump #3	Water	1000	25	m³/hr	Duty	1	300	kPa	75.00%	2.8	4	VSD	400 V	3 Phase	IP 68	N	-
7.2.2	**Phase 1**	*Service water pump #4*	*Water*	*1000*	*25*	*m³/hr*	*Standby*	*1*	*300*	*kPa*	*75.00%*	*2.8*	*4*	*VSD*	*400 V*	*3 Phase*	*IP 68*	*N*	-
7.2.3	**Phase 2**	Service water pump #5	Water	1000	25	m³/hr	Duty	1	300	kPa	75.00%	2.8	4	VSD	400 V	3 Phase	IP 68	N	-
7.2.4	**Phase 2**	*Service water pump #6*	*Water*	*1000*	*25*	*m³/hr*	*Standby*	*1*	*300*	*kPa*	*75.00%*	*2.8*	*4*	*VSD*	*400 V*	*3 Phase*	*IP 69*	*N*	-
											Subtotal (Phase 1)	**2.80**	**4.00**	**kW**		**3.7**	**kVa**		
											Subtotal (Phase 1 & 2)	**5.60**	**8.00**	**kW**		**7.3**	**kVa**		
											SERVICE WATER LOAD TOTAL (Phase 1)	**3**	**5**	**kW**		**4**	**kVa**		
											SERVICE WATER LOAD TOTAL (Phase 1 & 2)	**6**	**9**	**kW**		**8**	**kVa**		
8		**SERVICE BUILDINGS**																	
8.1		**Power for additional buildings**																	
8.1.1	**Phase 1**	Small power & lighting	-	-	-	-	Duty	6	-	-	-	5	5	-	400 V	3 Phase	-	N	-
8.1.2	**Phase 1**	Admin building: Forced ventilation	-	-	-	-	Duty	1	-	-	-	10	10	-	401 V	4 Phase	-	N	-
8.1.3	**Phase 1**	Workshop: Forced ventilation	-	-	-	-	Duty	1	-	-	-	10	10	-	400 V	3 Phase	-	N	-
											Subtotal (Phase 1)	**25**	**25**	**kW**		**32.68**	**kVa**		
											SERVICE BUILDINGSLOAD TOTAL (Phase 1)	**25**	**25**	**kW**		**33**	**kVa**		
											SERVICE BUILDINGSLOAD TOTAL (Phase 1 & 2)	**25**	**25**	**kW**		**33**	**kVa**		

SITE SUMMARY

			Phase 1			Phase 2			Phase 1 & 2		
			Absorbed Power (kW)	Rated Power (kW)	Absorbed Power (kVa)	Absorbed Power (kW)	Rated Power (kW)	Absorbed Power (kVa)	Absorbed Power (kW)	Rated Power (kW)	Absorbed Power (kVa)
1		**INLET WORKS**	**24**	**32**	**31**	**0**	**0**	**0**	**24**	**32**	**31**
2		**FLOCCULATION AND CLARIFICATION**	**72**	**92**	**94**	**36**	**46**	**47**	**108**	**138**	**141**
3		**RAPID GRAVITY SAND FILTERS**	**183**	**256**	**239**	**183**	**256**	**239**	**365**	**512**	**477**
4		**CLEAR WATER**	**2**	**2**	**2**	**1**	**2**	**0**	**2**	**3**	**2**
5		**CHEMICAL DOSING**	**101**	**133**	**114**	**47**	**71**	**53**	**148**	**204**	**167**
6		**RESIDUAL HANDLING**	**89**	**120**	**116**	**79**	**110**	**103**	**167**	**230**	**219**
7		**SERVICE WATER**	**3**	**5**	**4**	**3**	**4**	**4**	**6**	**9**	**8**
8		**SERVICE BUILDINGS**	**25**	**25**	**33**	**0**	**0**	**0**	**25**	**25**	**33**
		PLANT TOTAL	**501**	**664**	**637**	**351**	**489**	**449**	**852**	**1152**	**1086**