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Reform of the Water Sector Programme Phase II in Zambia (RWS II)

Luapula Small Pipe Water Supply Schemes Package of Measures: Mulundu SPWS, Mwense

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ABBREVIATIONS

AA2	Action Area 2
Ah	Ampere hour
BoQ	Bill of Quantity
DC	Direct Current
DWASHE	District Water Sanitation and Hygiene Education
EPA	United States Environmental Protection Agency
EUR	Euro
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GPS	Geographical Positioning System
Hp	Horsepower
kW	Kilo Watt
LA	Local Authority
LpWSC	Luapula Water Supply and Sanitation Company
MCDM	Multi Criteria Decision Making
MLGH	Ministry of Local Government and Housing
MoU	Memorandum of Understanding
MWDS	Ministry of Water Development and Sanitation (formerly MWDSEP)
MWDSEP	Ministry of Water Development Sanitation and Environmental Protection
NGO	Non-Governmental Organisation
NWASCO	National Water Supply and Sanitation Council
O&M	Operation and Maintenance
PLGO	Luapula Province Provincial Local Government Office
PO	Priority Option
PVC	Polyvinyl Chloride
PWS	Pipe Water Supply Scheme
uPVC	Unplasticized Polyvinyl Chloride
RGC	Rural growth centre
RWSII	The Reform of the Water Sector Programme Phase II
SPWS	Small Pipe Water Supply Scheme
SUN	Scale Up Nutrition
UNICEF	United Nations Children Emergency Fund
USD	United State Dollar
UTM	Universal Transverse Mercator
V	Volt
W	Watt
WASH	Water, Sanitation and Hygiene
WASHE	Water Sanitation and Hygiene Education
WGS	World Geodetic System
WRM	Water Resources Management
WSS	Water Supply and Sanitation
ZESCO	Zambia Electricity Supply Corporation
ZSA	Zambia Statistics Agency

FOREWORD

Zambia aspires to be a middle-income country by 2030 and all development agenda in the water supply and sanitation sector are aimed at achieving clean and safe water supply and sanitation for all by 2030. The government in its 8NDP (2022-2026) has prioritised water and sanitation infrastructure development and maintenance as well as water quality monitoring and hygiene promotion. Investments are key for achievement of clean and safe water supply and sanitation for all.

These packages of measures, therefore, have been developed with the aim to improve the water supply service delivery to the beneficiaries of the Mulundu Small Pipe Water Supply Scheme. The packages of measures, in general, address all technical aspects of the Water Services from source of supply, abstraction and treatment through to transmission, distribution and supply; and are bankable proposals for attracting investments in small pipe water supply schemes.

Commissioned in the 1980s, Mulundu Small Pipe Water Supply Scheme source of water supply is the Luapula River. The scheme comprises a floating intake, the riser mains, distribution mains, distribution tank and a supply network of a close to 300 water supply outlets and/ or standpipes. Water is therefore pumped from the Luapula River to the distribution tank - a 50 m^3 capacity distribution tank - using an on-grid electricity powered centrifugal pump and distributed to the supply outlets (public standpipes and individual household connections).

Mulundu Small Pipe Water Supply Scheme being relatively old, has several challenges ranging from absence of primary treatment (chlorination) to the raw water to pressure losses and dead ends. This is in addition to the huge monthly electricity energy bills, whereby tying up the revenue which otherwise would be directed to operation and maintenance activities; thereby leading to inequitable access to the water supply to all scheme users. Furthermore, the absence of primary treatment (chlorination) of the raw water risks exposing users to waterborne diseases. Safe and clean water supply for all in Mulundu will never be achieved if these challenges are not addressed.

These packages of measures, therefore, outline, in detail, the interventions and the associated costs; and include: 1) Retrofitting the energy source from on-grind to off-grid solar solutions; 2) Repositioning and anchoring the floating intake to the deeper section of the Luapula River and installing the anti-clogging cage; 3); Constructing a pump house, primary water treatment facility, a clear water tank, and a new 350 m^3 capacity elevated galvanised steel pressed water reservoir tank; 4) Installing an inline chlorination dispenser, a solar energy powered centrifugal pump, solar modules and controls, and 101No. prepaid water metres; 5) Rehabilitating the pumping main, and the elevated steel water tank, and 6) Improving the water distribution network outlay constructing.

It is our hope that these measures are taken up and implemented by our various partners working to improve WASH services in Mwense District. Collectively, and with one vision, we can make a positive change in WASH in Mwense District.

Importantly, regular maintenance coupled with a suitable and appropriate O&M Model are at the core of longevity of the Water Services especially for small pipe water supply schemes. Thus, the effective implementation of the Hybrid O&M Model will prove valuable in contributing to the attainment of the clean and safe water supply for all.

Musonda S. Mumpa
Council Secretary
Mwense Town Council

ACKNOWLEDGEMENT

The Mulundu SPWS packages of measures were prepared by the GFA Consulting Group in teamwork with Mwense Town Council as part of the Reform of the Water Sector in Zambia Phase II Programme (RWSII) which was implemented by GIZ. Mwense Town Council is, therefore, grateful to the Germany Government for the continued financial and technical support in reforming the water sector in Zambia and particularly, the RWSII.

Mwense Town Council views this partnership as critical in the overall development of the WASH sector, and we are committed to directing our resources towards bridging the gap in the WASH sector.

EXECUTIVE SUMMARY

This report details the packages of measures and/ or investment packages for Mulundu Small Pipe Water Supply Scheme (SPWS).

Mulundu SPWS is in Mulundu Rural Growth Centre (RGC) of Mwense District. It is one of the four districts targeted for support by the Reform of the Water Sector Programme Phase II in Zambia (RWSII) implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). Such support involved developing packages of measures and/or investment measures that improve the infrastructure efficiencies of water supply and ensure its equitable access to the beneficiary communities.

The selection of packages of measures was based on a thorough assessment of operational set up of the Mulundu SPWS. Several on-site visits, interviews and follow up discussions with operators/ managers of this scheme as well as the users were carried out.

Mulundu SPWS is operated, maintained, and managed by a Water User Board but the overall supervisory functions are vested with Mwense Town Council. Commissioned in the 1980s, the pipe water supply scheme (PWS) comprises a network of transmission, distribution, and supply infrastructure. In addition, the pipe water supply system has an elevated steel reservoir and/ or distribution tank with storage capacity of approximately 50 m^3, and there are 101No. unmetered water supply outlets (standpipes).

The source of water is the Luapula River, which borders the west and southwest of Mulundu rural growth centre. The water is pumped from the floating intake into the pumping mains using a Zambia Electricity Supply Corporation (ZESCO) electricity energy powered centrifugal pump mounted on a ballast tank made from 10No. HDPE 210 litres narrow mouth tight head barrels (drums), stacked up together in two rows. However, the water supply infrastructure is very old and has developed frailties and leakages over the years, but it is still in a fair operating condition and functioning moderately well.

The results of the hydraulic analysis and pipe network modelling for Mulundu small pipe water supply scheme revealed the existence of low pressures as well as dead-ends. This study also provided insights into approaches for optimisation of the network including sizing of primary mains reinforcements as well as configuration of the extension and replacement pipes.

As a result, detailed packages of measures and/or investment packages which included the Bill of Quantities (BoQ), engineering designs and drawings were developed and consolidated for Mulundu small pipe water supply scheme. The identified packages of measures for Mulundu SPWS comprised, in general: retrofitting the energy source from on-grid to off-grid solar energy solutions; repositioning and anchoring the floating intake to the deeper section of the Luapula River; installing the anti-clogging cage; constructing a pump house; constructing primary water treatment facility; constructing a clear water tank; installing an inline chlorination dispenser; installing a solar energy powered centrifugal pump, solar modules and controls; rehabilitation of the pumping main and improving the water distribution network outlay; rehabilitation of the elevated steel water tank; constructing a new 350 m^3 capacity elevated galvanised steel pressed water reservoir tank., and installing 101No. prepaid water metres.

Leakages, dead-ends, loss of pressures and rationing of the water supply together with the frequent outages and load-shading of the ZESCO electricity energy were identified as some of the challenges contributing to the reliability of the water supply. Other challenges included the high cost of electricity. Thus, retrofitting the energy supply source from on-grid ZESCO power to off-grid solar energy solutions was recommended. In addition, improvement of the water distribution network outlay (i.e., rectifying the dead-ends, disconnecting customers connected directly to the transmission mains and connecting them to the nearest gravity line, etc.,) was also considered.

The overall cost for implementing the works at Mulundu small pipe water supply scheme was estimated at ***USD 727,107.82 (Euro 639,586.80)***. Nonetheless, it will cost ***USD 104,347.21 (EUR 91,787.06)*** to undertake the bare minimum meaningful interventions to guarantee increased infrastructure efficiencies and long-term operational sustainability for Mulundu small pipe water supply scheme. These minimum meaningful interventions entail partial implementation of interventions by downsizing and postponing interventions to be implemented, namely:

- Limiting the length of the distribution pipe network to rehabilitated to 650 m only.
- Limiting rehabilitation works on the old reservoir tank.
- Limiting the number of pre-paid water metres to be installed to 30No. only.
- Postpone installation of a new 350 m^3 capacity galvanised pressed steel water tank.
- Postpone construction of the water treatment plant.
- Postpone construction of a clear water well and/ or tank.
- Postpone construction of the pump house.

It is worth noting, therefore, that hydraulic analysis and modelling of the pipe network system are fundamental in developing investment packages because it pinpoints areas of low pressures in the pipe network, provides information on sizing the pipes and network design optimization.

Similarly important is a well thought out operator concept for the operation, maintenance, and management of this small pipe water supply scheme. A maintenance plan must be developed, implemented, and prioritised; as such, maintenance must never be ad hoc. Thus, a robust pipe O&M operator mechanism must be developed and implemented. Such a mechanism would provide for continuous attention to ensuring the longevity of assets. This, in turn, costs unavoidably less than their outright renewal after a period of neglect.

1 INTRODUCTION

The Reform of the Water Sector Programme Phase II (RWSII) is a follow up Programme to the GIZ RWS Phase I that was implemented between 2015 and 2019 in which the GIZ supported the Ministry of Water Development Sanitation and Environmental Protection (MWDSEP) in terms of institutional and organisational reforms in both sub-sectors of water supply and sanitation (WSS) services and water resources management (WRM). This Programme (RWSII), therefore, focuses on ***"improving the conditions for transparent planning and implementation processes for ensuring water and sanitation services (WSS), with a thematic focus on the rural settlement areas and growth centres of the Luapula Province in Northern Zambia''***.

Overall, the module objective of the Reform of the Water Sector Programme Phase II (RWSII) is: ***"Conditions for transparent planning and implementation processes for securing water and sanitation services as well as for skills development in the water sector are improved"***; to be achieved by implementing various activities clustered in the ***4No. action areas (AA)*** of the RWSII, namely:

1) Sector policy support
2) Rural WASH management
3) Urban WASH and industrial wastewater management including climate resilience
4) Jobs and skills development

Action area 2 (AA2), specifically, focuses on the development of ***planning procedures to improve water supply and sanitation in rural areas and rural growth centres***, as follows: ***'Planning procedures have been developed to implement measures to improve water supply and sanitation in rural areas and rural growth centres'***.

Two indicators had been foreseen for AA2 and these are:

1) Relevant actors (district administrations, Luapula Water and Sewerage Company, NGOs, development partners, women's groups) in 4 out of 11 districts have agreed on gender-sensitive district investment plans with priority water supply and sanitation packages, considering the principles of the Scale Up Nutrition (SUN) process, and
2) For 5 (out of an estimated 29) rural growth centres in Luapula Province, packages of measures (including design and implementation modalities for sustainable financing and operations) for drinking water and / or sanitation are agreed between the provincial water and sanitation companies and local government.

Output 2 was largely designed to strengthen the Department of Water Supply and Sanitation in Luapula Province as well as the Luapula Water Supply and Sanitation Company (LpWSC) and Local Authorities (LAs), i.e., 4 No.; selected LAs in the province.

Consequently, three (3) broad activities were envisioned under this output (Output 2), namely:

- Specialist and process consultancy for the district administrations and the multi-actor platforms (Water Sanitation and Hygiene Education (WASHE) committees) in SUN-oriented investment planning processes for drinking water supply and sanitation services;
- Developing operator concepts and packages for small drinking water supply systems in rural growth centres and strengthening the responsible actors for implementation, and

- Capacity Development for Luapula Water and Wastewater Company: gender-sensitive sanitation planning, human resources development, efficiency improvement, rural water supply, taking SUN principles into account.

The successful achievement of AA2 will contribute to the attainment of the overall RWSII module objective in that the developed DWASHE plans, Investment Packages as well as the pipe water schemes operator concepts, i.e., Management Models (and MoU) will, on one hand, provide the Ministry responsible for water supply and sanitation with frameworks and guidelines for planning and implementing the respective services; while on the other hand, the management models will expose new areas of focus for skills development and continuous professional development.

This report, therefore, details investment packages developed and consolidated for Mulundu small pipe water supply scheme of Mwense District. The investment focuses specifically on: retrofitting the energy source from on-grid to off-grid solar energy solutions; reposition and anchoring the floating intake to the deeper section of the Luapula River; installation of the anti-clogging cage; installation of an inline chlorination dispenser; installation of solar energy powered centrifugal pump, solar modules and controls; rehabilitation of the pumping main; rehabilitation of the elevated water tank, and installation of 101No. prepaid water metres. These interventions will respectfully free up the enormous financial resources tied to purchasing the electricity energy while at the same time guaranteeing increase in the volume of water reaching the users. In addition, the investments will increase the pressure in the pipe networks, and ultimately allow more users to access the water supply. Furthermore, these interventions will curb the wastage of the water by users through regulating water usage as well as triggering increase in the revenues for Mulundu small pipe water supply scheme.

1.1. Partner Districts and Rural Growth Centres

AA2 activities were to be implemented in four (4) partner districts and five (5) rural growth centres (RGC) located in the 4No. districts in Luapula Province. Thus, the selection of these 4No. partner districts and consequently the 5No. RGCs were key prerequisite activities.

The RWSII 4No. partner districts were selected by consensus. A multi-stakeholder meeting, comprising the implementing partner ministries (Ministry of Water Development and Sanitation (MWDS) formerly Ministry of Water Development Sanitation and Environmental Protection (MWDSEP), Ministry of Local Government and Housing (MLGH), Luapula Province Provincial Local Government Office (PLGO)), UNICEF and RWSII Team Members held on Friday, February 21st 2020 at the Hotel Neelkanth Sarovar Premiere in Lusaka, resolved to implement RWSII activities, particularly AA2 activities in the four (4) districts of Luapula Province, namely: Chipili District, Mansa District, Mwansabombwe District and Mwense District.

Consequently, the selection of the 5 rural growth points defined an important primary milestone in the overall implementation of AA2 of the RWSII Programme, particularly in reference to sub-object 2.2, namely: ***‘Developing operator concepts and packages for small drinking water supply systems in rural growth centres and strengthening the responsible actors for implementation’***. Four out of the targeted five rural growth centres (RGC) were recommended based on the ***presence of small pipe water scheme***. The remaining 1No. RGC was recommended ***based on the need for sanitation interventions***. Therefore, two interventions were foreseen in the RGC, namely activities focusing on ***rural water supply (particularly SPWS)*** as well as those activities focusing on ***sanitation*** interventions.

The district to ***anchor the fifth rural growth centre, whose focus will be sanitation interventions, was agreed to during the validation workshop held on February 26th, 2021, at Wetuna Gardens, Mansa, Luapula Province as Chipili District***.

A ***multi-criteria decision making (MCDM)*** approach was used in recommending the 4No. RGC where ***rural water supply (SPWS)*** activities had to be implemented. This approach comprised a set of linked criteria and/or norms that were evaluated in each proposed and/or identified RGC and scored either as 0 or 0.5 or 1. The scores were summed up and the RGC ranked according to the total sum of the scores, i.e., the RGC with the highest score ranked 1st and the RGC with the lowest scores, ranked last. Importantly, all potential RGC assessed were identified and/proposed by the respective ***beneficiary districts*** (Chipili, Mansa, Mwansabombwe and Mwense Districts). ***In principle, therefore, the selection process of the 5No. RGC was carried out by the respective beneficiary districts, i.e., from proposing and/or identifying the potential beneficiary RGC to their evaluation and scoring and final selection as beneficiary RGC***.

A total of 33 RGCs were identified and evaluated in the four partner districts in Luapula Province. These comprised 8No. RGCs in Chipili District; 18No. RGCs in Mwense District; 6No. RGCs in Mwansabombwe District and at least 20No. RGCs in Mansa Districts. Summary of the criteria used in evaluating rural growth centres is presented as Table 1 while Table 2 is the summary of the findings from Mulundu small pipe water supply scheme.

Mulundu RGC and Mulundu SPWS together with the other 3No. RGC (Mwenda, Fimpulu and Kazembe) as well as Chipili District, the district hosting the 5th RGC for the planned sanitation interventions were subsequently validated and approved by partners and stakeholders at a validation workshop held on Friday, February 26th, 2021, at Wetuna Gardens, Mansa (see ANNEX I: VALIDATION WORKSHOP REPORT, AGENDA AND ATTENDANCE LIST). Packages of measures and/or investments packages for the respective small pipe water supply schemes were also validated. Broadly, therefore, aspects approved during this validation workshop included: 1) sites for implementing respective interventions; 2) targeted rural WASH interventions (either water supply or sanitation); 3) components to the interventions, and 4) O&M operator concept.

Table 1: Selection criteria for 4No. RGC for rural water supply interventions

Criterion	Framing	Measure	Score		
			0	**0.5**	**1**
Criteria 1	Presence of the pipe water supply scheme (PWS)	Pipe water supply scheme (PWS)	Absence		Present
Criteria 2	Population/ communities served by pipe water supply scheme (PWS)	Number of households (hhs)	Low (250 hhs)	Medium (>250<999 hhs)	High (>999 hhs)
Criteria 3	Status of the pipe water scheme (PWS)	Functioning	Not working	Unavailable for use	Working
Criteria 4	Source water availability	Yield over time	Never available	Dependent on season	Always available
Criteria 5	Existing water treatment processes	Cost of water treatment	High	Moderate	Low
Criteria 6	Energy use affordability	Cost of energy as ratio of collected revenue	High	Medium	Low
Criteria 7	Water user fees are in place and guide access to service	Tariff structure in place (and access of water is through payment of user fees)	Low	Medium	High
Criteria 8	Community/ households pay water user fees regularly and on time	Regular and timely payment of user fees	Low	Medium	High

Table 2: Summary of findings from Mulundu small pipe water supply scheme

Beneficiary district	Name of the RGC	Name of the PWS	Pipe water supply schemes summary description
Mwense Town Council	Mulundu community	Mulundu pipe water scheme	• On-grid (hydroelectricity) driven system • Supply source is surface waterbody – Luapula River • The intake is a floating type, fitted with a 15 HP pump • Mixed distribution system comprising individual household connections and communal standpipes • System uses 1No. elevated storage/ distribution reservoir facilities ~ 60 m^3 • Post-paid flat rate tariff system • Supervisory function vested in Mwense Town Council • Areas of low water pressure common • Major leakages along the transmission main and distribution subnet works pipes • Dead-ends common on the distribution pipe network • Operated, maintained, and managed by local community (Water User Board) but supervisory functions vested in Mwense Town Council

1.2. Arrangement of the Report

The report is structured into five sections. Section 1 outlines the content of the report as well as the general context. Notably, the partner districts including the rural growth centres are also presented. Furthermore, the section presents the process adopted in selecting the partner districts and rural growth centres.

Section 2 introduces the packages of measures and/ or investment packages as well as the approaches used in coming up with these packages of measures for the small pipe water supply scheme broadly and Mulundu small pipe water supply, specifically. Importantly, specialist studies conducted on Mulundu small pipe water supply scheme including projected water demand for the next 10 years are detailed in this section as well.

Section 3, on the other hand, presents the detailed investment packages including the costs estimates for undertaking the various works at Mulundu small pipe water supply scheme.

The proposed implementation mechanisms for these packages of measures and/ or investment packages are detailed in Section 4. The prioritization philosophies are also presented under this Section.

Section 5 is the conclusion while annexes contain all the results of the hydraulic network analysis as well as the technical approach to specialist studies and pipe sizing. The BoQs including the engineering drawings and designs are also attached as annex.

2 IDENTIFIED PACKAGES OF MEASURES FOR MULUNDU SMALL PIPE WATER SUPPLY SCHEME

At the core of this activity was the development of ***'state-of-the-art (including solar solutions) investment packages (bankable projects)'***. As a principle, therefore, the introduction of off-grid energy solutions, preferable solar energy solutions, to power the water production processes at these small pipe water supply systems was evident. This intervention had capacity to free up the much-needed finances tied in purchasing of energy from ZESCO to other O&M activities.

Mulundu small pipe water supply scheme operates exclusively on ZESCO on-grid electricity power and reducing the amount of money spent on electricity energy bill presents a clear route for sustainable service provision and increase overall reliability in the supply of the water to the users. It is not uncommon to experience frequent outages and load-shading on the ZESCO electricity energy supply thereby affecting the reliability of the water supply from Mulundu small pipe water supply scheme.

A uniform flat-rate tariff system is applied to users at Mulundu small water supply scheme. This tariff system, however, tends to encourage wasteful and inefficient water use of the water supply by some users. As a result, therefore, fundamental to the developed, consolidated, and approved investment packages for Mulundu small pipe water supply scheme is reducing the dependency on ZESCO on-grid electricity energy supply and ultimately eliminate ZESCO electricity energy bills, curbing wasteful and inefficient water use of the water supply and, in the long run, improve water supply access and availability.

2.1 Packages of Measures

Packages of measures, in general, were designed to address the following aspects of the small pipe water supply schemes (SPWS), namely: ***water supply source; energy source***; ***transmission system***; ***distribution system***, and ***supply system***.

In general, therefore, the works foreseen in these small pipe water supply package of measures ranged from improvement in water sources to metering water supply outlets (see Fehler! Verweisquelle konnte nicht gefunden werden.).

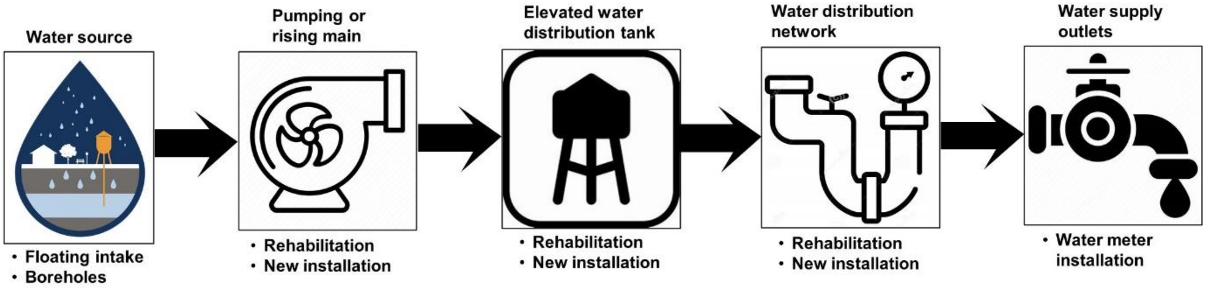

Figure 1: Range of interventions for small pipe water supply schemes package of measures

Water supply source was either groundwater sources and/ or surface water sources. Groundwater sources included hand-dug wells and/ or boreholes equipped with submersible pumps. Surface water sources, on the other hand, included rivers and/ or streams.

Two types of systems were generally distinguished based on the ***energy source*** for the water production process, and these were either ***on-grid systems*** and/ or ***gravity driven systems***. The on-grid systems depended wholly on electricity energy from the ZESCO national electricity grid supply.

It also became obvious that a large proportion of the revenue collected at all the pipe water supply schemes (PWS) was spent on on-grid electricity energy for the water supply processes. As such, for overall financial sustainability of the PWS, off-grid electricity energy solutions must be installed.

Therefore, an ***assessment guide*** to help understand further the status of the pipe water supply schemes (PWS) infrastructure with a view to providing interventions was developed. At the core of the ***assessment guide*** were the energy sources, namely: ***on-grid systems*** and/ or ***gravity driven systems*** (see Table 3).

Table 3: Assessment guide for the small pipe water supply schemes

On-grid driven processes		Gravity driven processes	
Id no.	**A.1: Component description**	**Id no.**	**A.2: Component description**
A1.1	Energy source for conveying water	**A2.1**	Water intake infrastructure
A1.2	On-site treatment, i.e., chlorination	**A2.2**	Primary treatment
A1.3	Metring at standpipes	**A2.3**	Secondary treatment, i.e., chlorination
A1.4	Pumping system	**A2.4**	Water transmission mains
A1.5	Water storage/ distribution reservoirs	**A2.5**	Water distribution network
A1.6	Water transmission mains	**A2.6**	Water storage/ distribution reservoirs
A1.7	Water distribution network	**A2.7**	Metring at standpipe
A1.8	Metring at individual household	**A2.8**	Metring at individual household
A1.9	Water abstraction source	**A2.9**	Water abstraction source

As a result, Mulundu SPWS was assessed using this developed ***assessment*** guide (cf. Table 3). This assessment preceded the mapping out of the ***investment measures*** as detailed hereunder (Section 2), and they cover the whole water supply chain infrastructure, i.e., from the floating intake to the water supply service outlets and/ or standpipes.

2.1.1 Outline of investment measures for Mulundu SPWS

Mulundu small pipe water supply scheme is in Mulundu rural growth centre in Mwense District; approximately 20 km southwest of Mwense Town Council offices from Mulundu small pipe water supply scheme Water User Board Office. The water intake (floating type) is further located some 1.2 km southwest of the Water User Board Office. The geographical location of Mulundu SPWS Water User Board Office is 681538.20 m E and 8835982.05 m S, 35S Universal Transverse Mercator (UTM) Zone, while the geographical location of the Mulundu small water supply scheme floating intake is 680912.00 m E and 8835395.00 m S, 35S Universal Transverse Mercator (UTM) Zone. Similarly, the geographical location of the Mwense Town Council offices is 686258.84 m E and 8850958.59 m S, 35S UTM.

Mulundu small pipe water scheme comprises a network of transmission, distribution and supply infrastructure that are very old but operational. The pipe water supply scheme (PWS) was commissioned in the 1980s. In addition, the pipe water supply system has an elevated steel reservoir and/ or distribution tank with storage capacity of approximately 50 m^3. There are 101No. unmetered water supply outlets (standpipes). The source of water is the Luapula River which borders the west and southwest of Mulundu rural growth centre. The water is pumped from the floating intake into the pumping mains using a ZESCO electricity energy powered centrifugal pump mounted on a ballast tank made from 10No. HDPE 210 litres narrow mouth tight head barrels (drums), stacked up together in two rows. Photo 1 presents selected key water supply infrastructure of Mulundu small pipe water supply scheme.

Photo 1: Selected key water supply infrastructure for Mulundu SPWS

Frequent electricity outage and load-shading not only render water supply to users unavailable but lead users to losing confidence in the small pipe water supply scheme, thereby reverting to traditional sources for the supply of water. In addition, the high cost of ZESCO electricity energy renders a large portion of the revenue to be taken up by electricity energy bill and this, together with the dwindling revenue base (i.e., less people paying for water supply service) makes effective O&M impossible. In addition, low pressure zones, dead-ends, and leaking water pipe network system, coupled with wasteful and inefficient water use of the water supply are at the core of the packages of measures for Mulundu small pipe water supply scheme (see Table 4).

Table 4: Outline of preliminary investment measures for Mulundu small pipe water supply scheme, Mwense District

Sn.	Component detailed description	Status	Investment required, i.e., A1.1, A1.2 ...A1.9
1	Energy source for conveying water	Working	A1.1; Change power source from on-grid (ZESCO) to solar energy
2	Submersible pump; ~10 hp; AC 300 V; On-grid hydroelectricity (ZESCO); pump discharge rate 5 l/s	Working	A1.4; 2 Hp solar powered submersible pump; 10 hp and 7.5 kW power rating; 60-120 m pump head; 6 m3/h max flow
3	Transmission mains; 75 mm diameter poly pipe; ~120 m long	Working	A1.6; N/A
4	Distribution mains; 2 km in total uPVC (600 m, 110 mm diameter; 1400 m, 75 mm diameter); communal taps 25 mm diameter	Working	A1.7; N/A
5	Solar panels: System works on hydropower (ZESCO)	N/A	A1.1; 7.5 kW solar panels, Distribution panel/ Control box and accessories
6	Metring at communal standpipe level	Communal standpipes are not metred	A1.3; Pre-paid metring at communal standpipe level
7	Metring at individual household level	Household connections are not metred	A1.8; Pre-paid metring at individual household connection level

Eliminating the electricity energy bill and ***assuring availability of the water supply*** along with ***curbing wasteful and inefficient water use*** are central to the packages of measures for Mulundu SPWS. Thus, retrofitting energy supply sources from on-grid ZESCO electricity power to off-grid solar energy solution will be key in cutting down the electricity energy bill while installing pre-paid metres will help change the attitude of water users and curb the wasteful and inefficient water use of the water supply. In addition, correcting dead-ends and low-pressure zones in the pipe network system will be primary to guaranteeing flows on all water supply outlets and/ or standpipes.

2.2 Hydraulic Analysis and Design

The first step in the identification of packages of measures is the detailed assessment of the pipe water supply scheme operations and process. This takes the form of mapping the water supply infrastructure, followed by pipe network hydraulic assessment and modelling (See Figure 2).

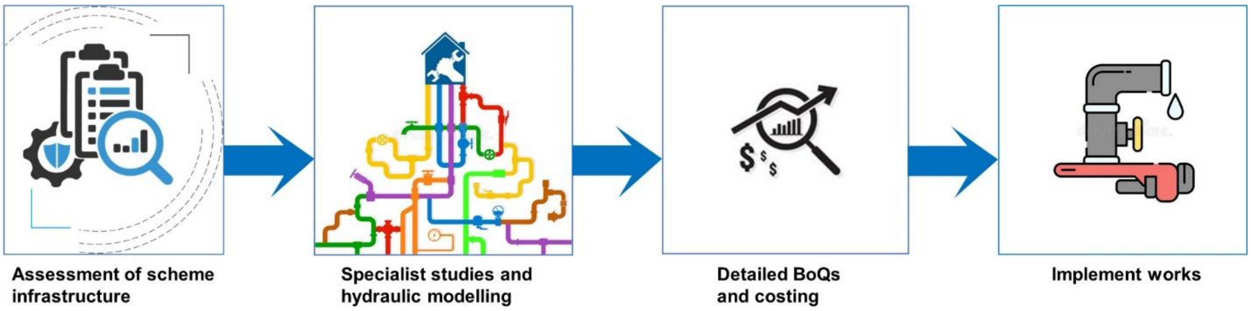

Figure 2: Design thought process for package of measures for small pipe water supply systems

A hydraulic network assessment and pipe network modelling was undertaken in view to establish the general pressure flow in the network as well as the likely areas of low pressure. The first step was the preliminary hydraulic networks assessment and mapping of the water supply networks system. This was then followed by the full hydraulic analysis and modelling the pipe network as well as producing detailed engineering designs of the networks and BoQs.

A handheld GPS, Garmin Montana 650®, was used to map the water supply network system.

All water supply outlets (standpipes) were mapped, and potential low-pressure zones identified. Arising out of the preliminary hydraulic network assessment of Mulundu SPWS, the following recommendations were made, thus:

i) To include pre-treatment and disinfection processes before supplying to the community at Mulundu small pipe water supply scheme; and the pre-treatment to either be in the form of a rapid gravity sand filter and disinfection in form of chlorination.

ii) Perform hydraulic analysis of Mulundu small pipe water supply scheme network and ascertain the causes of the low water pressures experienced in the area.

iii) Extend the intake further into the Luapula River of Mulundu small pipe water supply scheme.

iv) Undertake structural assessment of the Mulundu small pipe water supply scheme elevated water tank to ascertain the structural integrity of the tank.

v) De-sludge the Mulundu small pipe water supply scheme elevated water tank including unblocking the desludging pipe.

Based on the proposed preliminary investment interventions (cf. Table 4) and recommendations from the preliminary hydraulic network assessment and pipe network mapping as well as the assessment of existing water supply infrastructure at Mulundu small pipe water supply scheme; the full hydraulic analysis and engineering designs of the water supply network were subsequently carried out. Detailed approach and methodology for small pipe water supply scheme network design criteria is attached as Annex II (see ANNEX II: SMALL PIPE WATER SUPPLY SCHEME PIPE NETWORK DESIGN CRITERIA).

2.2.1 Mulundu small pipe water supply scheme hydraulic analysis

Full hydraulic analysis of Mulundu small pipe water supply scheme water network was performed to gain an understanding of the hydraulic capacity of the scheme and optimise the existing network, size primary mains reinforcements and to size and configure the extension and replacement pipes. The pipe flow hydraulics for Mulundu small pipe water supply scheme was modelled using EPANET *Ver 2.2* software, and the detailed hydraulic modelling analysis results are attached as Annex III (see ANNEX III: HYDRAULIC ANALYSIS FOR MULUNDU SMALL PIPE WATER SUPPLY SCHEME PIPE NETWORK).

Developed in 1983 by the United States Environmental Protection Agency's (EPA) Water Supply and Water Resources Division, EPANET is a public domain, water distribution system modelling software package; and it performs extended-period simulation of hydraulic and water-quality behaviour within pressurized pipe networks and is designed to be *"a research tool that improves our understanding of the movement and fate of drinking-water constituents within distribution systems"* (USEPA, 2022). This software, therefore, has all the functionalities required to undertake water network analysis and design.

The coordinate system used in these designs is the World Geodetic System 1984 (WGS84) Universal Transverse Mercator (UTM) Zone 35S.

The approach adopted in the hydraulic analysis and design was that of analysing the existing network to confirm the hydraulic problems reported by the Mulundu small pipe water supply scheme operation and maintenance (O&M) team. Thereafter, modifications were made to the network to achieve the required pressures and flows.

In general, therefore, the hydraulic model results for the existing Mulundu small pipe water supply scheme pipe network system confirmed the presence of low pressures in the pipe network. Hydraulic analysis of the modified improved Mulundu small water supply scheme pipe network, however, showed none of the junctions having any negative hydraulic pressure.

2.2.1.1 Hydraulic analysis of the existing Mulundu SPWS pipe network

The existing Mulundu small pipe water supply scheme pipe network was modelled using EPANET *Ver 2*.2, and the model results confirmed the occurrence of low pressures. The primary causes for the low pressures in the pipe network were established, namely: significant losses in pipes, and flawed design of the pipe network, i.e., the pipe network designed as a branched network with smaller diameter pipes. As a rule of thumb, no pipe less than 50 mm outer diameter should be part of the primary and secondary network. Small pipes that are used as mainline result in significant head losses. Figure 3 is the result of the EPANET *Ver 2.2* hydraulic model for the existing Mulundu small pipe water supply scheme pipe network while Figure 4 is the topographic map of the existing network with all the pipe diameters.

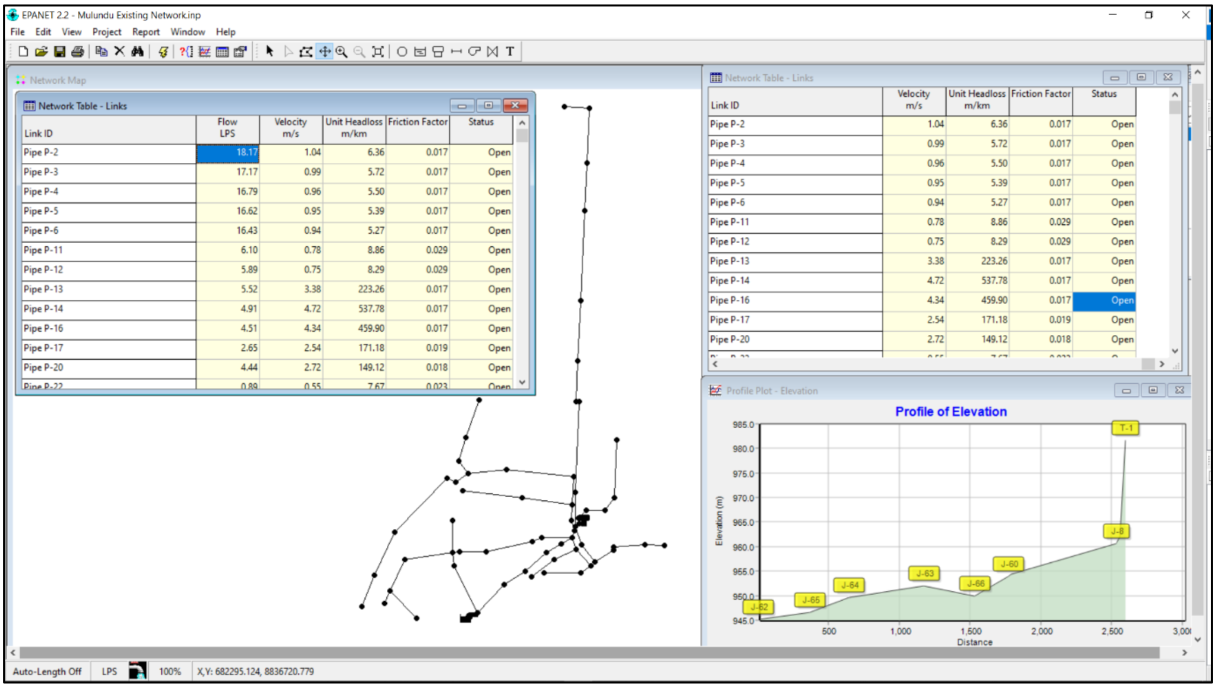

Figure 3: Hydraulic modelling results of the existing Mulundu small pipe water supply scheme pipe network

The model established that 24 out of 61 junctions had pressure less than 0 mH_2O, implying that 39 percent of the junctions in the network had negative pressures. In addition, 44.2 percent of the junctions had pressures less than the recommended 7 mH_2O. Therefore, the model revealed a significant failure rate of the network that is unacceptable in any water supply network (cf. ANNEX III: HYDRAULIC ANALYSIS FOR MULUNDU SMALL PIPE WATER SUPPLY SCHEME PIPE NETWORK).

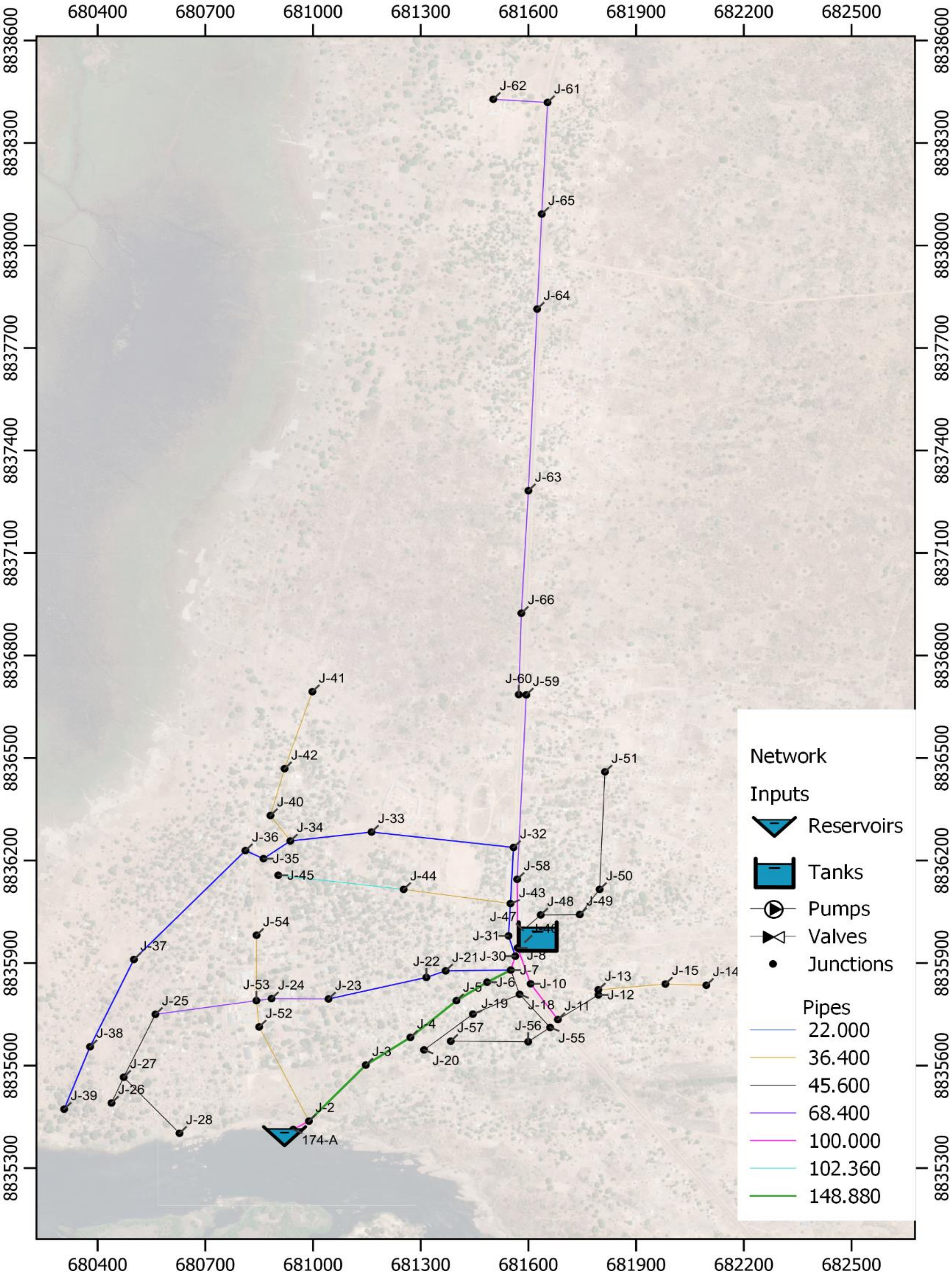

Figure 4: Mulundu small pipe water supply scheme existing pipe network topographic layout

2.2.1.2 Mulundu small pipe water supply scheme modified improved network

The existing water supply network was modified to improve the pressures as well as the flows. Figure 5 and Figure 6 are the results of the hydraulic model simulated to improve the pressures and flows as well as the pipe layout of the modified improved network.

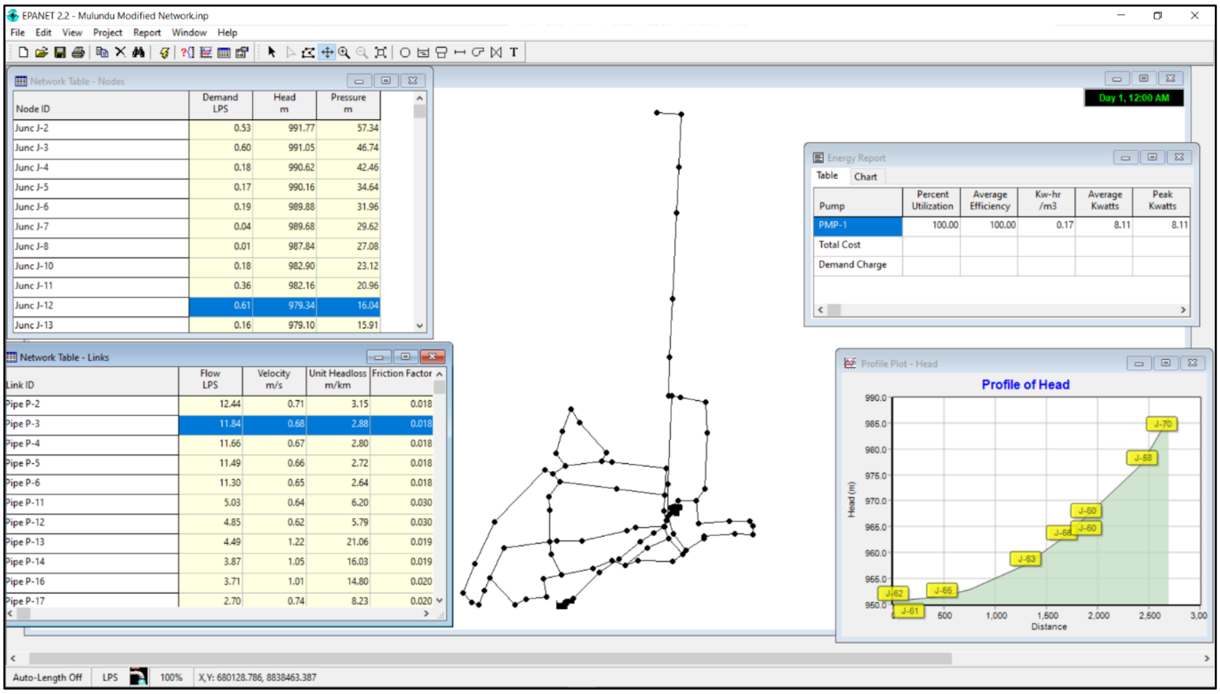

Figure 5: Mulundu small pipe water supply scheme modified improved pipe network hydraulic model

The results of the hydraulic model of the modified improved pipe network showed that there were no junctions in this modified improved network that had a negative hydraulic pressure. Nonetheless, only 8 junctions out of 84 junctions had pressures that were less than 7 mH_2O, representing less than 10 percent failure rate. The failure rate in the modified improved network was 9.5 percent, a while acceptable value in modelling of water supply networks (for detailed model analysis and results see ANNEX III: HYDRAULIC ANALYSIS FOR MULUNDU SMALL PIPE WATER SUPPLY SCHEME PIPE NETWORK).

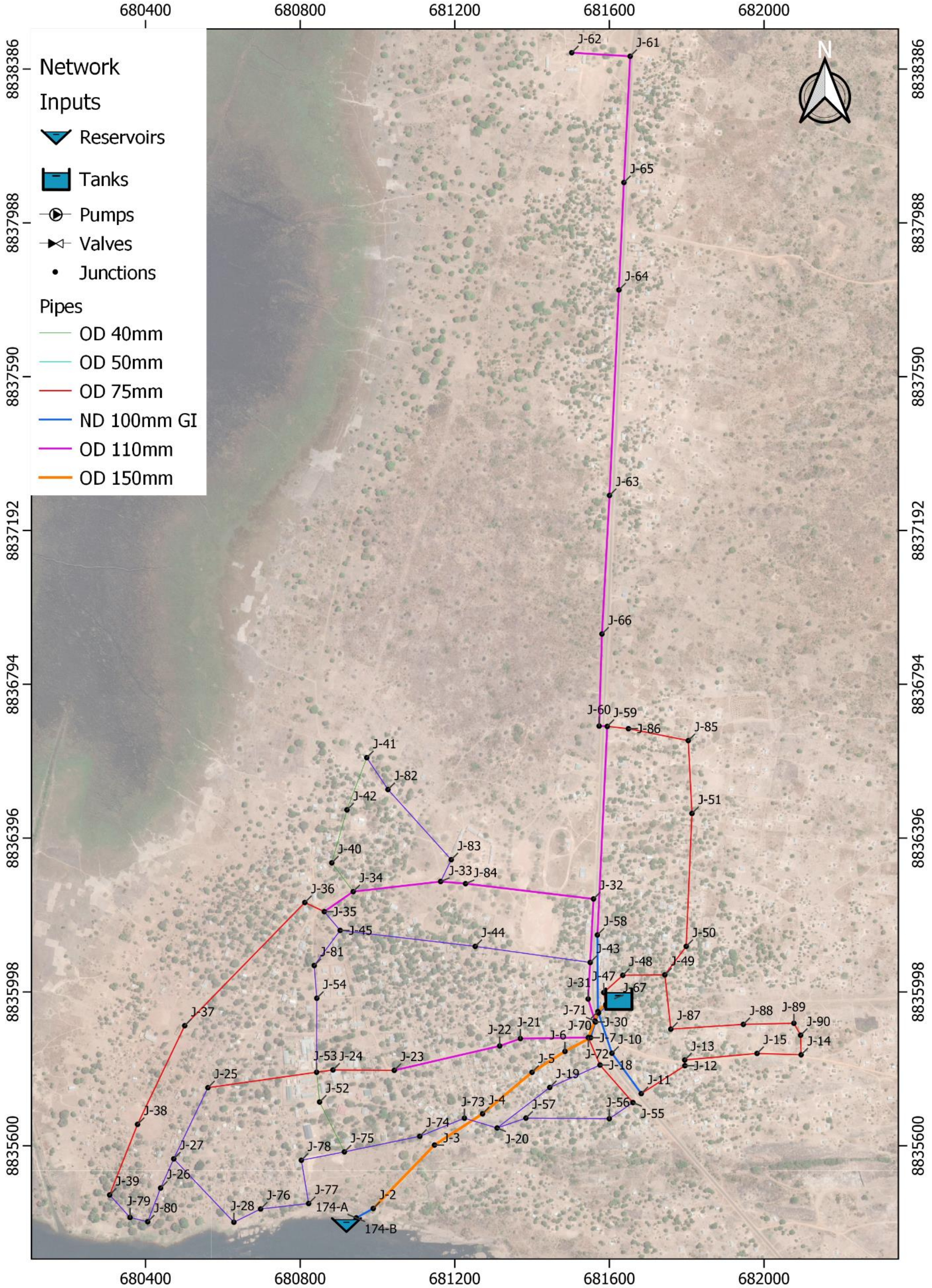

Figure 6: Mulundu small pipe water supply scheme modified improved pipe network model topographic layout

2.2.2 Hydraulic Model Results of Mulundu SPWS Transmission Main

The transmission main was analysed as part of the EPANET *Ver 2.2* hydraulic model and later checked for the effects of water hammer. Based on the model analysis and results, the total loss in head was 8.6 mH_2O. This loss in head of 8.6 mH_2O is very high. Water hammer calculation, on the other hand, showed the pressure surges and drops of more than the maximum allowable pressure for the current 160 mm class 6 uPVC pipe. Correct pipe size and class required for this pumping main is a 200 mm uPVC with a pressure class of 16 bars. Consequently, it was recommended that this line be upgraded to 200 mm uPVC with the pressure class of 16 bars. The water hammer calculations are attached as Annex IV (see ANNEX IV: WATER HAMMER CALCULATIONS FOR MULUNDU SMALL PIPE WATER SUPPLY SCHEME TRANSMISSION MAINS).

2.2.3 Summary of Mulundu small pipe water supply scheme pipe quantities and Diameters

Mulundu small pipe water supply scheme has a total water supply network of 10,963 m with the largest pipe diameter of 160 mm and the smallest of 40 mm. The modified Mulundu small pipe water supply scheme had the pipe network total length of 13,585 m, with the largest pipe diameter being 160 mm and the smallest being 40 mm pipe (cf. ANNEX III: HYDRAULIC ANALYSIS FOR MULUNDU SMALL PIPE WATER SUPPLY SCHEME PIPE NETWORK).

The summary of the pipe quantities and diameters of the Mulundu small pipe water supply scheme modified improved pipe network is presented as Table 5.

Table 5: A summary of the pipe quantities and diameters of the modified improved Mulundu small pipe water supply scheme pipe network

No	Nominal diameter (mm)	Internal diameter (mm)	Length (m)	Material	Pressures class
1	40	36.4	601	uPVC	9
2	50	45.6	3767	uPVC	9
3	75	68.4	3715	uPVC	9
4		100	653	GI	9
5	110	102.36	3996	uPVC	9
6	160	148.88	853	uPVC	9
Total			**13,585**		

Based on analysis of the results of the hydraulic simulation and design, some pipes in the water network will have to be upgraded, while others will need to be retained in their current state while at the same time some new lines are to be installed (see Table 6, Table 7 and Table 8 for the existing network to be retained, upgraded and that requiring new installations).

Table 6: Existing pipes to be retained in the water distribution network of Mulundu small pipe water supply scheme

Material	Class	Nominal diameter (mm)	Inside diameter (mm)	k (mm)	Length (m)
uPVC	9	160	148.88	0.01	723
GI	9	115	100	0.01	456
uPVC	9	110	102.4	0.01	1554
uPVC	9	75	68.4	0.01	1466
uPVC	9	50	45.6	0.01	971
uPVC	9	40	36.4	0.01	601

Table 7: Length and diameters of pipes to be upgraded in the water distribution network of Mulundu small pipe water supply scheme

Material	Class	Nominal diameter (mm)	Inside diameter (mm)	k (mm)	Length (m)
uPVC	9	110	102.4	0.01	2447
uPVC	9	75	68.4	0.01	1496
uPVC	9	50	45.6	0.01	846

Table 8: Length and diameters of new pipe to be installed in the water distribution network of Mulundu small pipe water supply scheme

Material	Class	Nominal diameter (mm)	Inside diameter (mm)	k (mm)	Length (m)
uPVC	9	160	148.88	0.01	135
uPVC	9	110	102.4	0.01	986
uPVC	9	75	68.4	0.01	949
uPVC	9	50	45.6	0.01	1954.6

Table 7 provides the length and diameters of the pipes to be upgraded while Table 8 detailed the length and diameters of the required new pipes for the water distribution network. In all, 4,790 m length of existing pipes must be upgraded while 3,039 m length of new pipes must be added to the water distribution network of Mulundu small pipe water supply scheme (cf. Table 7 and Table 8 for the respective length, diameter, pressure class and material of the pipes).

2.3 Pipe Materials

The following criteria was taken into consideration to identify the most suitable pipeline material.

- Installation.
- Operation.
- Maintenance of the distribution network.

2.3.1 Installation

In general, the laying of water distribution pipelines requires reliable, experienced labourers, special technical equipment, and knowledge of health precautions. Laying instructions as recommended by the manufacturer of the pipes must always be adhered to.

Different soil formations along the proposed lines should be analysed by trial excavations before pipe laying works commence. Measures, such as changing the backfill or reuse of the excavated materials, should be taken depending on the results of the soil investigations. In addition to the above measures, soil samples should be analysed for aggressivity, and suitable measures (coatings, alternative materials) should be taken to provide protection against corrosion. However, it should be noted that corrosion protection is not required for non-corrosive materials like uPVC which will be used in the distribution network. The location of existing lines, channels and cables must be determined and marked, especially that the works are in settled areas, to avoid damage during the excavation of new trenches.

Pressure testing, flushing and disinfection of the pipelines are to be done in compliance with norms after completion of pipe laying, while all lines to be laid with ascending (or descending) slope to ensure continuous ventilation, and lines crossing beneath the highways must be installed in protective pipes. Importantly, air valves to be placed at all high points and gate valves to be located to form loops.

2.3.2 Operation

Only materials that have no harmful effects on water and human health to be used for potable water facilities. It must be noted that in some cases, pressure increases, exceeding the usual values, can occur and the use of pipes with bigger diameters to avoid these pressure excesses, e.g., downstream of pump stations, are technically not acceptable. This only sets up alternating pressures which would affect the safety to the pipe if the materials do not have enough strength to resist these pressures.

2.3.3 Maintenance of the distribution network

The distribution network must be inspected periodically, i.e., once every 3 to 6 months by walking along all the lines. During these inspections, the movable parts of the valves such as slide valves, stop gates, fire hydrants and air relief equipment must be checked, and any defects noted must repaired immediately.

Particular attention must be taken to detect leaking sections. Suspected leakage must be investigated by exposing the section in question to the extent required to make a meaningful assessment. Any damage to the line must be repaired immediately. As such, appropriate tools, and equipment as well as spare parts must always be kept and be readily available when required.

Proposed measures to help prevent damage to the material and ultimately prevent leakages include using robust, durable materials for the pipes, and careful installation and compliance with safety rules.

2.4 Water Demand Calculations

The per capita water demand consumption was computed using the Zambian Standards ZS361 of 1997 and the projected population of inhabitants. An annual population growth rate for Luapula Province of 2.5 percent was used in projecting the population for 10-year design timeframe. This annual population growth rate was computed from the census of population and housing undertaken in 2010 by the Central Statistics Office (now the Zambia Statistics Agency (ZSA)). Table 9 presents the population projections for Mulund RGC, computed using the standard population growth rate exponential equation.

Table 9: Mulundu rural growth centre population projections

Area	Annual Growth rate (%)	Population		
		2021	2026	2031
Mulundu	2.5	11,222	11,362	11,503

The low-cost per capita consumption was assumed in projecting the water demand for Mulundu RGC (see Table 10, Table 11 and Table 12). The value of the low-cost per capita consumption is calculated as 100 l/cap/day.

Table 10: Current (2021) water demand for Mulundu small pipe water supply scheme

Description		Units	Mulundu
Per Capita Consumption	High Cost	l/c/d	280
	Medium Cost	l/c/d	150
	Low Cost	l/c/d	100
	Kiosk	l/c/d	40
Population	High Cost	No	
	Medium Cost	No	
	Low Cost	No	11222
	Kiosk	No	
Average daily demand		l/d	1,122,200
Physical Water Losses (%)		%	65
Physical Water Losses		l/d	729,430
Average Demand + Physical Losses		l/d	1,851,630
		m^3/d	1,851.63
Seasonal Fluctuation factor			1.2

Description	Units	Mulundu
Peak Seasonal Demand	m^3/d	2,221.96
	m^3/hr	92.58
Peak Hourly factor		2
Peak Demand	m^3/hr	185.16
	m^3/min	3.09
	m^3/s	0.05
	l/s	51.43

Table 11: 2026 Water demand for Mulundu small pipe water supply scheme

Description		Units	Mulundu
Per Capita Consumption	High Cost	l/c/d	280
	Medium Cost	l/c/d	150
	Low Cost	l/c/d	100
	Kiosk	l/c/d	40
Population	High Cost	No	
	Medium Cost	No	
	Low Cost	No	11362
	Kiosk	No	
Average daily demand		l/d	1,136,200
Physical Water Losses (%)		%	65
Physical Water Losses		l/d	738,530
Average Demand + Physical Losses		l/d	1,874,730
		m^3/d	1,874.73
Seasonal Fluctuation factor			1.2
Peak Seasonal Demand		m^3/d	2,249.68
		m^3/hr	93.74
Peak Hourly factor			2
Peak Demand		m^3/hr	187.47
		m^3/min	3.12
		m^3/s	0.05
		l/s	52.08

Table 12: 2031 Water demand for Mulundu small pipe water supply scheme

Description		Units	Mulundu
Per Capita Consumption	High Cost	l/c/d	280
	Medium Cost	l/c/d	150
	Low Cost	l/c/d	100
	Kiosk	l/c/d	40
Population	High Cost	No	
	Medium Cost	No	
	Low Cost	No	11503
	Kiosk	No	
Average daily consumption		l/d	1,150,300.00
Physical Water Losses (%)		%	65
Physical Water Losses		l/d	747,695
Average daily consumption + Physical Losses		l/d	1,897,995
		m³/d	1,898.00
Seasonal Fluctuation factor			1.2
Peak Seasonal Demand		m³/d	2,277.59
		m³/hr	94.90
Peak Hourly factor			2
Peak Demand		m³/hr	189.80
		m³/min	3.16
		m³/s	0.05
		l/s	52.72

The water networks were designed to handle current demand and the 2031 demand. A relatively small design timeframe of 10 years was used in forecasting the demand. These calculated demands will meet the current requirements (2021) and those in 2031 while guaranteeing improved service delivery within the available budget. Importantly, the required demand for firefighting has been excluded and not factored into these calculations. Inclusion of firefighting demand leads to increased volumetric flows requirements and ultimately requires large pipes in the distribution network which in turn increase the initial investment cost. This thought pattern is consistent with the American Water Works Association (1998) who noted that the governing body does not have a legal obligation to size the distribution network to cater for fire protection, and as such encouraged properties with activities conducive to rapidly burning fires to have such activities eliminated (American Water Works Association, 2008).

3 MULUNDU SPWS INVESTMENT PACKAGE

Constructed in the 1980s, Mulundu small pipe water supply scheme in Mulundu rural growth centre in Mwense District comprises a floating intake constructed on the Luapula River, a pump house, a transmission main, an elevated steel-forged storage tank, and a distribution main with branches and water supply outlets (standpipes).

The floating intake is equipped with on-grid ZESCO electricity energy powered centrifugal pump mounted on a ballast tank constructed from 10No. HDPE 210 litres narrow mouth tight head barrels (drums), stacked up together in two rows.

The water supply infrastructure for Mulundu small pipe water supply scheme is very old and has developed a lot of defects over the years, and these include leakages and low pressures along the water distribution pipe network system. This, coupled with the gross wasteful and inefficient water use of the water supply, is further exacerbated by the high ZESCO electricity energy bill incurred by Mulundu small pipe water supply scheme in the supply of water. Despite this, the pipe water supply scheme is still in a fair operating condition and functioning moderately well.

Noticeably absent from the water supply infrastructure at Mulundu is the primary raw water treatment facility. Surface waterbodies are extremely susceptible to pollution and contamination, and hence the requirement to treat the raw water prior to supplying to users. As such, investment interventions for Mulundu SPWS targets the energy source, the intake, raw water treatment, transmission and distribution mains and branches as well as water supply outlets. Specifically, therefore, the interventions are focused on the following:

- Repositioning and anchoring the floating intake instream the Luapula River
- Installing the anti-clogging cage to the intake pipe.
- Retrofitting the source of energy supply from on-grid ZESCO electricity energy to off-grid solar energy solutions.
- Installing a solar energy powered centrifugal pump and applicable solar controls and modules.
- Construct a pump house.
- Install an inline chlorination dispenser.
- Construct primary water treatment facility.
- Construct a clear water well and/ or tank.
- Rehabilitate and improve the water supply pipe network system and outlay.
- Rehabilitate the elevated steel water reservoirs tank.
- Construct a new 350 m^3 capacity elevated galvanised steel pressed water reservoir tank.
- Installing pre-paid metres on all 101No. water supply outlets and/ or water supply standpipes.

Summary of the estimated costs for the improvement of Mulundu small pipe water supply scheme are detailed in Table 11, while the detailed BoQs including the detailed engineering designs and drawings are attached as Annex V and VI, respectively. (see ANNEX V: MULUNDU SMALL PIPE WATER SUPPLY SCHEME DETAILED BILLS OF QUANTITIES and ANNEX VI: DETAILED ENGINEERING DRAWINGS AND DESIGNS OF THE MULUNDU SPWS).

Therefore, the investment package detailed for Mulundu small pipe water supply scheme is an elaboration of interventions identified as critical to improve service provision and guarantee operational sustainability of the water supplies for the users in Mulundu RGC of Mwense District. The approach to identifying the required investments ranged from observations of the operations, use and management of the water supply to mapping of water supply infrastructure as well as conducting specialist studies and assessments including holding several meetings with operators and users of the services provided by Mulundu SPWS. The specialist studies, specifically, focused on analysis of the pipe network hydraulics with a view to identifying points of low pressures. The assessment also helped in sizing correctly the water supply network pipes as well as in identifying the right pipe materials to use for the water supply pipe network, including optimizing the pipe network designs.

Importantly, the water demand was computed and projected for the population growth of 2031. This further helped in sizing the water supply infrastructure, particularly the water storage and/ or distribution reservoir tanks.

A total of ***USD 727,107.82 (Euro 639,586.80)*** is required to undertake all works identified for Mulundu small pipe water supply scheme as detailed in Table 13.

Table 13: Summary of overall cost estimates for identified intervention measures for Mulundu small pipe water supply scheme

Item	Description	Cost (USD)	Cost (Euro)
1	Preliminary & General Items	233,468.82	205,366.50
2	Distribution Network	399,032.80	351,001.70
3	Water Treatment Plant	55,164.20	48,524.15
4	Pump Installation	15,000.00	13,194.47
5	Pump House	15,621.64	13,741.28
6	Pre-paid Metres	24,442.00	21,499.95
Total		**727,107.82**	**639,586.80**

Euro 1 = USD 1.13684

USD 727,107.82 (Euro 639,586.80) will be required if overall infrastructure efficiencies are to be improved and long-term operational sustainability of Mulundu small pipe water supply scheme is to be guaranteed (cf. Table 13).

Considering the huge costs required to implement all the foreseen interventions for Mulundu small pipe water supply scheme, thus a delicate balance must always be made, at any one time, between the works to be implemented and the funds available.

Huge sums of money are required for Mulundu small pipe water supply scheme to guarantee the pipe water supplies that is safe, of adequate quantity, and satisfies the demands of all users. As a result, it is desirable to prioritize further the interventions to be worked on first; based not only on the available finance resources but the minimum interventions that guarantees improved efficiencies to the Mulundu small pipe water supply scheme, as well. In these cost estimates, therefore, components of the packages of measures were prioritised such that when collectively implemented, safe pipe water supply to potential users and long-term operational sustainability are guaranteed (see Table 14 for the detailed cost estimates for the prioritised components).

Table 14: Summary of cost estimates of prioritized interventions for Mulundu small pipe water supply scheme

Item	Description	Priority Option 1 (PO1)		Priority Option 2 (PO2)		Priority Option 3 (PO3)	
		Cost (USD)	Cost (Euro)	Cost (USD)	Cost (Euro)	Cost (USD)	Cost (Euro)
1	Preliminary & General Items	28,100.47	24,718.05	47,795.64	42,042.54	233,468.82	205,366.50
2	Distribution Network	46,035.34	40,494.12	170,019.11	149,554.12	399,032.80	351,001.70
3	Water Treatment Plant	0.00	0.00	0.00	0.00	55,164.20	48,524.15
4	Pump Installation	22,190.00	19,519.02	22,190.00	19,519.02	15,000.00	13,194.47
5	Pump House	0.00	0.00	0.00	0.00	15,621.64	13,741.28
6	Pre-paid Metres	8,021.40	7,055.87	16,042.80	14,111.75	24,442.00	21,499.95
Total		**104,347.21**	**91,787.06**	**256,047.55**	**225,227.43**	**682,912.10**	**727,107.82**

Euro 1 = USD 1.13684

As such, ***USD 104,347.21 (EUR 91,787.06)*** will be required at a very minimum to undertake some meaningful interventions at Mulundu small pipe water supply scheme (cf. Table 14) and guarantee the pipe water supplies that is safe, and of adequate quantity, and satisfy the demand of all users. Similarly, ***USD 256,047.55 (EUR 225,227.43)*** will be needed for intermediary interventions for the Mulundu SPWS. Both options, however, entail downsizing and/or postponing some components of the works to future timelines. The components of the works affected are the distribution network, the treatment plant, the pump house, and the water pre-paid metres (cf. **Fehler! Verweisquelle konnte nicht gefunden werden.**Table 14 as well as Annex V and VI for detailed BoQs for all options and engineering designs and drawings, respectively).

4 PROPOSED IMPLEMENTATION MECHANISMS OF INVESTMENT PACKAGES

In general, therefore, all packages of measures must be implemented if the desired impact is to be attained. Two approaches are envisioned in the implementation of the packages of measures, and these are: ***i) implementation of all identified intervention in one scope***, and ***ii) phased implementation of the identified interventions***. The availability of the financial resources, however, will ultimately determine the preferred approach to the implementation of the investment packages.

In the ***phased implementation approach***, the interventions must first be prioritized within the broader context of interventions foreseen for Mulundu small pipe water supply scheme. For example, improving the sources of raw water supply first when there are still leakages along the transmission, distributions and supply network pipes will have little or no impact on improved service delivery, i.e., making the supply available to users. Similarly, changing the source of energy from on-grid to off-grid solutions prior to attending to leakage in the transmission, distribution and supply network pipes will equally have zero impact on the availability of the supply and ultimately on the revenue collected.

As a result, a rational decision must be made on the component of the pipe water supply scheme infrastructure (energy and supply source, transmission, distribution, and supply) to be worked on first, and still have the desired positive impact and marked improvements in the overall supply of water to the users.

4.1 Prioritisation Philosophy

The guiding principle to follow when deciding on works to be undertaken first when using the phased implementation approach is that of ***"undertaking minimum necessary works to supply water of better quality and adequate quantity to the community on demand"***.

Overall, the approach to implement the works will depend entirely on the financial resources available. As such, the option of implementing such work in a phased and/ or in a progressive manner must always be explored. The benefit of such an approach is that it provides flexibility to progressively work on all planned interventions over time, given the available finances at any one time. In addition, such an approach offers a greater opportunity to raise additional finances to complete the works.

The phased approach is highly recommended and is suitable for implementing works foreseen under the ***Output 2*** of the RWSII, i.e., the ***small pipe water supply schemes package of measures.*** In general, therefore, the works foreseen for Mulundu small pipe water supply scheme affects all aspects of the water supply infrastructure chain from abstraction and energy source to installation of prepaid metres on all the 101 water supply service outlets, thus:

- Repositioning and anchoring the floating intake instream the Luapula River
- Installing the anti-clogging cage to the intake pipe.
- Retrofitting the source of energy supply from on-grid ZESCO electricity energy to off-grid solar energy solutions.
- Installing a solar energy powered centrifugal pump and applicable solar controls and modules.
- Construct a pump house.

- Install an inline chlorination dispenser.
- Construct primary water treatment facility.
- Construct a clear water well and/ or tank.
- Rehabilitate and improve the water supply pipe network system and outlay.
- Rehabilitate the elevated steel water reservoirs tank.
- Construct a new 350 m^3 capacity elevated galvanised steel pressed water reservoir tank.
- Installing pre-paid metres on all 101No. water supply outlets and/ or water supply standpipes.

Therefore, to guarantee safe and adequate quantities of pipe water supplies as well as the pipe water supplies that satisfy the water demand of the users, given the financial resources available and the minimum acceptable interventions, three ***'priority options'*** were considered, namely: Priority Option1 (PO1), Priority Option 2 (PO2) and Priority Option 3 (PO3), thus:

4.1.1 Priority Option 1 (PO1)

Priority Option 1 (PO1) constituted all works considered as the minimum acceptable interventions to guarantee pipe water supply that is safe, and of adequate quantity, and that satisfy the demand of all its users of the Mulundu small pipe water supply scheme. The total cost of this option is estimated at ***USD 104,347.21 (EUR 91,787.06)***, and the scope of works including key components downsized and/or postponed from the works under the Priority Option 1 (PO1) are:

i) Reposition and anchoring the floating intake at the deeper section of the Luapula River.

ii) Installation of the anti-clogging cage.

iii) Installation of an inline chlorination dispenser.

iv) Installation of a hybrid solar/hydroelectric powered system to power the pump and the pumping station area.

v) Rehabilitation of the pumping main.

vi) Installation of 2No. bulk metres.

vii) Limiting the length of the distribution pipe network to rehabilitated to 650 m only.

viii) Limiting rehabilitation works on the old reservoir tank.

ix) Limiting the number of pre-paid water metres to be installed to 30No. only.

x) Postpone the installation of a new 350 m^3 capacity galvanised pressed steel water tank.

xi) Postpone the construction of the water treatment plant.

xii) Postpone the construction of a clear water well and/ or tank.

xiii) Postpone the construction of the pump house.

4.1.2 Priority Option 2 (PO2)

The works considered under this PO2 included all works in PO1 and the provision of an additional elevated water distribution tank at Mulundu RGC, a new 350 m^3 capacity galvanised pressed steel water tank, as well as increase in the metred domestic connections from 30No. to 60No. The total cost of PO2 was ***USD 256,047.55 (EUR 225,227.43)***, and this include the full rehabilitation of the existing Mulundu elevated tank.

The key components of the Mulundu small pipe water supply scheme water supply infrastructure downsized and/or postponed from the works under the Priority Option 2 (PO2) include:

i) Limiting the length of the distribution pipe network to rehabilitated to 1,635 m only.

ii) Limiting the number of pre-paid water metres to be installed to 60No. only.

iii) Postponing the construction of the water treatment plant.

iv) Postponing the construction of a clear water well and/ or tank.

v) Postponing the construction of the pump house.

4.1.3 Priority Option 3 (PO3)

Priority Option 3 (PO3) interventions comprised all works constituting PO1 and PO2 and entail the reinstatement of the whole water distribution network of the Mulundu SPWS (approximately 7,829 m of total length) as well as the installation of pre-paid metres on all domestic water supply outlets (101 domestic water supply outlets). The total cost of PO3 works is estimated to be approximately ***USD 727,107.82 (Euro 639,586.80).*** Other works include:

i) Construction of the water treatment plant.

ii) Construction of a clear water well and/ or tank.

iii) Construction of the pump house.

Once implemented in full, PO3 interventions will lead to improved efficiencies in the operations and service delivery of the Mulundu small pipe water supply scheme since dead-ends as well as leakages in the water distribution network will be rectified and reduced, respectively; while at the same time, consumers supplied directly from the pumping main will be disconnected and reconnected through the nearest gravity lines. Importantly, retrofitting the energy supply source from on-grid ZESCO electricity power to off-grid solar energy solutions and installing pre-paid metres on all water supply outlets, therefore, comprised crucial actions fundamental to improving operation efficiencies and guarantee long term sustainability of Mulundu SPWS.

It must be noted, nevertheless, that the high costs associated with refurbishment of the Mulundu small pipe water supply scheme further illustrates the need for an effective preventive maintenance of the pipe water supply infrastructure. It is a well-known fact that asset renewal after periods of neglect inevitably costs far more than the implementation of programmes that give continuous attention to activities that ensure the longevity of pipelines, pumps, motors, and technical structures.

5 CONCLUSION

Investment packages and/or packages of measures were developed for the 4No. small pipe water supply schemes (SPWS) in the four (4) partner districts of Chipili, Mansa, Mwansabombwe and Mwense. These 4No. small pipe water schemes are Mwenda in Chipili District; Fimpulu in Mansa District; New Kazembe in Mwansabombwe District and Mulundu in Mwense District.

Detailed investment packages, based on identified needs and requirements of individual small pipe water supply scheme, were developed. The approach to developing these detailed investment packages, in general, included: holding several consultative meetings with local authorities (districts), operators, managers and users of the services of small pipe water supply schemes; onsite visits and preliminary assessments of small pipe water supply scheme infrastructure, and conducting specialist studies.

The specialist studies involved the hydraulic analysis and modelling of existing networks with a goal of identifying zones of low pressures as well as accurately sizing the water pipes as well as optimizing the pipe network designs. The EPANET *Ver 2.2* hydraulic modelling software was used in the analysis.

Mulundu small pipe water supply scheme is very old. Constructed in the 1980s, the water supply infrastructure has, over the years, developed a lot of defects, and these include leakages and low pressures along the water distribution pipe network system. This, coupled with wasteful and inefficient water use of the water supply are further exacerbated by the high ZESCO electricity energy bill incurred in the supply of water. Despite all this, the pipe water supply scheme is still in a fair operating condition and functioning moderately well.

The results of the hydraulic analysis and modelling of Mulundu small pipe water supply scheme pipe network system confirmed the existence of several zones of low pressure as well as dead-ends. This coupled with the faulty design of the network were identified as primary reasons for the low pressure in the distribution pipe network. The immediate intervention required to improve the pressure in the pipe water system and guarantee water supply availability to all users, therefore, comprise eliminating leakages and dead ends and improving the water distribution pipe network overall outlay.

In general, therefore, investment interventions for Mulundu SPWS targets the energy source, the intake, transmission and distribution mains and branches as well as water supply outlets. The high cost of on-grid ZESCO electricity energy coupled with the huge electricity bill incurred by Mulundu small pipe water supply scheme, on one hand, and the leakages and low pressure in the water supply pipe network, on the other hand, were central to the comprehensive packages of measures for Mulundu small pipe water supply scheme.

Therefore, the packages of measures proposed for Mulundu small pipe water supply scheme, in general, include the following components:

i) Repositioning and anchoring the floating intake instream the Luapula River
ii) Installing the anti-clogging cage to the intake pipe.
iii) Retrofitting the source of energy supply from on-grid ZESCO electricity energy to off-grid solar energy solutions.
iv) Installing a solar energy powered centrifugal pump and applicable solar controls and modules.

v) Construct a pump house.

vi) Install an inline chlorination dispenser.

vii) Construct primary water treatment facility.

viii) Construct a clear water well and/ or tank.

ix) Rehabilitate and improve the water supply pipe network system and outlay.

x) Rehabilitate the elevated steel water reservoirs tank.

xi) Construct a new 350 m^3 capacity elevated galvanised steel pressed water reservoir tank.

xii) Installing pre-paid metres on all 101No. water supply outlets and/ or water supply standpipes.

Detailed BoQs including engineering drawings and designs of works were developed for Mulundu small pipe water supply scheme.

Two options were proposed to guide the implementation of the investment measures; namely: (1) implementing all components in one goal, and/or, (2) progressive or phased implementation of the components. The phased approach was recommended as the most ideal approach when multiple interventions are planned but with limited budget to finance all identified components. This could entail either implementing works targeted at a singular component, i.e., energy supply source, floating intake, water supply outlets, etc., or works targeted at multiple components. Whatever the approach, notwithstanding, improvement in infrastructure efficiencies in the supply water must be achieved.

It will cost ***USD 104,347.21 (EUR 91,787.06)*** to undertake the very minimum meaningful interventions to guarantee improved infrastructure efficiencies and long-term operational sustainability for Mulundu small pipe water supply scheme. However, a total of ***USD 727,107.82 (Euro 639,586.80)*** will be needed for Mulundu small pipe water supply scheme to achieve outright improved infrastructure efficiencies and long-term operational sustainability.

The huge costs needed to improve infrastructure efficiencies and long-term operational sustainability of Mulundu small pipe water supply scheme reflects the absence and/ or ad-hoc nature maintenance of small pipe water supply schemes infrastructure continues to be prioritised. It is, therefore, obvious that asset renewal after periods of neglect inevitably costs far more than the implementation of programmes that give continuous attention to activities that ensure the longevity of pipelines, pumps, motors, and technical structures. As a result, a well thought out operation and maintenance (O&M) operator mechanism for the overall day to day operation, maintenance and management of these small pipe water supply schemes becomes imperative and needs to be developed and operationalized.

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ANNEX I: VALIDATION WORKSHOP REPORT, AGENDA AND ATTENDANCE LIST

Zambia

Reform of the Water Sector Programme Phase II (RWS II)

Validation O&M Models for Small Piped Water Supply Systems and Beneficiary Rural Growth Centres

26th February, 2021

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List of Acronyms and Abbreviations

APMs	Area Pump Menders
CapManex	Capital Maintenance expenditure
CBO	Community Based Organization
CU	Commercial Utility
D-WASH IP	District Water Sanitation and Hygiene Investment Plan
DDP	Deputy Director Planning
GIZ	Gesellschaft für Internationale Zusammenarbeit
GFA	GFA Consulting Group
HR	Human Resource
ISTE	International Short-Term Expert
KfW	Kreditanstalt für Wiederaufbau
LA	Local Authority
LpWSC	Luapula Water and Sanitation Company
MoU	Memorandum of Understanding
NGO	Non-Governmental Organizations
NWASCO	National Water and Sanitation Council
O and M	Operations and Maintenance
OPs	Operations
PPP	Public Private Partnership
PWS	Piped Water System
RGC	Rural Growth Centre
RWS II	Reform of the Water Sector Phase II
SOMAP	Sustainable Operations and Maintenance Program
SPWSS	Small Piped Water Supply System
SUN	Scaling Up Nutrition
WDC	Ward Development Committee
WSP	Water Supply Programs
WSS-SAG	Water Supply and Sanitation Skills Advisory Group

1. Background

The National framework for Rural Water Supply and Sanitation (WSS) mandates Commercial Utilities (CU) to progressively extend the water supply and sanitation services to rural areas. The framework specifically provides for, among others (NWASCO, 2018): CUs with licenses for WSS service provision in the entire districts and to be specifically responsible for WSS to cover urban areas, peri-urban areas, and growth centres with piped systems; LAs with specific responsibility for WSS services in rural settlements for WSS points; LAs to continue being responsible for piped systems not yet taken up by CUs and be supported by CUs through MoU. The need, therefore, to develop operation and maintenance system for piped water schemes became apparent. As a result, a study to develop O&M Models for piped water schemes was undertaken as part of the broader RWSII Output 2 workflows. Other workflows are in respect to WSS rural growth centres (RGC). A total of 5No. RGC are foreseen to directly benefit from the project. A selection criterion for the RGC was developed and 4No. RGC selected. The LAs spearheaded the selection of the 4No. RGC. The selection process and outcome of this process was shared and discussed during the workshop.

The Validation O&M Models for Small Piped Water Supply Systems and Beneficiary Rural Growth Centres (RGC's) Workshop was held on 26th February, 2021 at Wetuna Gardens in Mansa. This workshop combined both in-person as well as virtual participants with the virtual logging in on time. The workshop began at 09:05 hrs as opposed to the agreed 08:30hrs after the participants that attended the workshop in-person were registered, sanitized and seated accordingly observing the 1 meter distance.

2. Workshop Process

2.1. Overview of the Workshop Agenda

The workshop focused on revisiting the various O&M Models that were proposed following the review of O&M practices from the region, selected parts of Africa and Zambia as a whole. The aim of the workshop was to highlight the pros and cons of each of the proposed models and recommend a suitable model for small-piped water supply schemes in Luapula. The main objective of the workshop was to provide insights for future directions of the O&M situation in Luapula. With the aim of promoting creative thinking and receiving comprehensive feedback from the partners, the workshop emphasised informed and focused discussions by all participants through plenary sessions and group discussions. For a detailed Agenda see **Annex 1**

2.2. Specific Objectives of Workshop

This workshops aim was to validate the proposed O&M Models for the small-piped water supply schemes developed following the review of operation and maintenance practices from the region, selected parts of Africa and Zambia as a whole.

The objects were set out as follows:

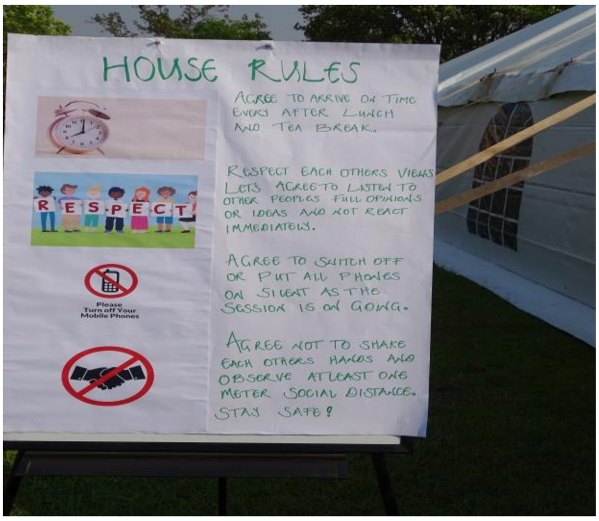
- Discuss the proposed O&M Models for SPWS systems
- Adopt the O&M Model for SPWS system
- Discuss the selection approach the 5No. Rural Growth Centres
- Discuss and adopt the selection of the 4No. RGC
- Discuss and select the 5th RGC

2.3. Workshop Attendance

The workshop comprised of a mixed model with both virtual and in-person participants. In-person participants being limited to 15 while virtual participants had no limit. Overall, representatives from partner institutions mainly constituted in-person participants.The list of workshop participants is attached in **Annex 2**

2.4. Covid 19 Measures

Strict adherence to the Covid-19 rules formed the central practice of the workshop. The sitting arrangements in all activities, i.e., the presentation space, group work as well as the restaurants, was informed by the observation of the at least 1 m distance between any two participants (i.e., maintaining the social distance). Thus, the workshop was held an open space in a marquee, and this allowed for sufficient air drifts through the meeting space. Importantly, upon arrival, the participants were sanitized with an alcohol-based sanitizer before being allowed to pick up the workshop package. Participants used the pens contained in their workshop packages for registration. Participant's body temperatures were also taken and recorded against participants details. It was only then that participants were allowed into the meeting room.



2.5. Expectations of the Workshop

During the workshop in person participants were asked to ouline their expectations of the workshop as they made their introductions which are highlighted as follows;

- To discuss and know the commencement of implementation of SPWSS
- To see Small Piped Water being implemented in Mansa
- Adoption of O & M for SPWSS
- To chose the best O&M model for SPWSS
- To know the time frame for rolling out the PWS in Mwansabombwe
- Learn and appreciate model for SPWSS
- To see the general improvement for water supply systems in Luapula a model to benefit the masses in the province
- To chose the best way of representation of the model and role of Luapula Water and Sanitation Company (LpWSC)

2.6. Workshop Official Opening Remarks and Assignment introduction

The workshop offical opening remarks were made by GIZ RWS II Project Manager who welcomed each and every participant both virtual and in person for making the time to attend the workshop. Acknowledgement was made on how the parcipants sat a meter apart observing the COVID 19 rules and thanked the GFA team for organising the workshop to discuss and validate the Small Piped Water Supply Systems and beneficiary Rural Growth Centre/s. The GFA RWS II Team Leader then gave a road map for the workshop by giving a background to the RWS II program and linking it to the present relevance of the workshop going back to the workshop and work done in the previous year by the GFA International Short Term Expert (ISTE) and the findings of the O&M models and the small Piped water Systems. Attention was brought to the ISTE to commence with the prepared presentation.

2.7. Workshop Sessions

2.7.1. Session 1: Presentation on Summary findings and Proposed O&M Models for Small Piped Water Supply Schemes

During the presentation, the following were highlighted on the proposed models to initiate discussions among the participants;

- *Proposed Models*

1. There is no single correct model!
2. No model will easily solve fundamental resource deficits and non-viable trading propositions
3. What operational resources and arrangements are required to sustain the functionality of the installed infrastructure?
    - Will the new schemes be ‘cash positive’ undertakings?
    - Are the ‘real’ operational resources available.
4. Available institutional resources:
    - Luapula Water and Sanitation Company (the Commercial Utility.
    - Community based organisations
    - Private Sector (including small scale contractors such as handpump mechanics and kiosk agents).
    - Various non-governmental organisations.

O&M Aspects	Option 1	Option 2	Option 3
Description	Full O&M responsibility taken by the CU. All staff employed by CU.	Community based management. All O&M matters dealt with at community level. Support from other agencies (NGOs, CU, and NGOs) on an ad-hoc / emergency	A hybrid of community based responsibility for day to day operations and technical support from either the CU or a willing and adequately resourced NGO
Day to day ops	CU	CBO	CBO
Minor repairs	CU	CBO	CBO
Major repairs	CU	Emergency support from LG, CO, or NGOs	CU / NGO
Billing and credit control	CU with Kiosk Agents	CBO	CBO
New connections	CU	CBO	CU
Spare part provision	CU	CBO	CU / NGO
Technical support *	CU	LG (minimal)	CU / NGO
Provision of fuel	CU	CBO	CBO
Payment for electricity	CU	CBO	CBO

Figure 1: Proposed O&M Models

- *Scenarios (for and against)*

1. Commercial Utility takes full responsibility.
   For: -*Aligned to longer term responsibilities and vision.*
   -Technical expertise available in house.
   Against: -*Raises day to day cost to the CU (esp. operators salary).*
   -Systems must be integrated (e.g., Billing).

2. Community takes full operational responsibility.
   For: -*Costs constrained through local arrangements (e.g., Salaries)*
   -Embedded rationing (energy costs).
   Against: -*Results in low level of service. (interruptions).*
   -Infrastructure is not maintained.
   -Lots of evidence that this has not worked elsewhere.

3. Community with CU support.
   For: -*Costs constrained through local arrangements (e.g., Salaries).*
   -Embedded rationing (energy costs).
   Against: -*staff may demand salaries aligned with CU permanent staff.*
   -Behaviour of local staff and customers not accountable to the CU.
   -CU may not have resources to provide support.

Plenary Session

Q1: Issue of expansion of schemes, what is the plan?

Ans: 2030 100% coverage (expansions for PWS) working with Luapula water. Where the scheme has capacity to extend further, to do just that.

An appreciation was made for the point on awareness creation. Involving women in this process.

Q2: What has the experience been so far with engaging women?

Ans: Mostly men show up than women although it is well known that women use up more water and so we need capacity building at every stage.

GIZ through FANSER is empowering women (water needs money). Managing of hand pumps. Capacity over user management. Water Aid/FSD are doing the same through savings, social cash transfer initiatives as well as toilet construction.

Q3: How can we cover for the loss or damage of water pipes or taps? Most schools are not a problem but institutions are.

2.7.2. Session 2: Break Away Groups

The participants then broke into 4 groups (the 4th group was that of the virtual participants) to discuss the three proposed models outlining the advantages and disadvantages of each model and then selecting the best model from which the groups were then to propose a road map. For each Group's findings/ discussions and roadmaps please refer to **Annex 3** and **Annex 4** respectively

The groups all agreed unimously that option 3 was the best model and option 3 being a hybrid of community based day to day operations and technical support from eith the CU or a willing and adequately resourced NGO.

2.7.3. Session 3: Presentation 2 on the 4 Rural Growth Centres (RGC) Selection Approach and Package of Measures

The GFA team gave a presentation on the milestones in which show cased the project area being Luapula Province, focus milestones such as gender sensitive DWASH IP; operator concepts and packages and LpWSC institutional capacity developed with these leading to investment packages for SPWS, validation O&M management models, MoUs between operators and LpWSC. The presentation also highlighted the status of activity implementation through which it was noted that the process of recommending beneficiary RGCs was coordinated, SPWS management systems in Luapula was assessed, investment packages were identified and estimated cost of the investment was made. Lastly, recommended RGCs and the investement plan were presented and the recommended RGCs namely being Mwenda in Chipili, Mulundu in Mwense, New Kazembe in Mwansabombwe and Fimpulu in Mansa. The investment packages included changing the energy source to off-grid (solar), installation of pre-paid meters, improvement of water supply sources and improvement to conveyance and distribution system.

Specifically, the package of measures related to the improvement to the water supply sytstems and development of the demonstartion model in Fimpulu, Mulundu, Mwenda and New Kazembe are summarised in the table below.

RGC name/ District	Beneficiary WASH infrastructure	Proposed measures to be supported
Fimpulu/ Mansa	Fimpulu small piped water supply scheme	1. Geophysical siting and drilling of a production borehole; 2. Construction of a pump house; 3. Installation of an inline chlorine dispenser; 4. Installation of a solar powered submersible pump; 5. Installation of a solar power control system, and 6. Construction and connection of the additional 55 m^3 elevated tank for the existing water distribution network.
Mulundu/ Mwense	Mulundu small piped water supply scheme	1. Reposition and anchoring the floating intake at the deeper section of the Luapula River; 2. Installation of the anti-clogging cage; 3. Installation of an inline chlorination dispenser;

RGC name/ District	Beneficiary WASH infrastructure	Proposed measures to be supported
		4. Installation of a hybrid solar/ hydroelectric powered system to power the pump and the pumping station area; 5. Rehabilitation of the pumping main; 6. Rehabilitation of the elevated water tank, and 7. Installation of 25 No. prepaid water meters.
Mwenda/ Chipili	Mwenda small piped water supply scheme	1. Geophysical siting and drilling of a production borehole; 2. Installation of solar powered submersible pump; 3. Construction of the pump house; 4. Installation an inline chlorine dispenser; 5. Installation of solar power control system and accessories; 6. Installation of the elevated water distribution tank (60 m^3); 7. Construction of the water distribution network; 8. Construction of at least 12 water standpipes, and 9. Installation of pre-paid water meters.
Kazembe/ Mwansabombwe	New Kazembe small piped water supply	1. Replacement of the hydroelectric submersible pump to a hybrid solar/ hydroelectric powered submersible pump; 2. Installation of a solar power control system and accessories to power the hybrid submersible motorised pump, and 3. Installation of 50 No. pre-paid water meters.

Plenary Session

Q1: Has GFA thought about storage in Mulundu?

Ans: We have and we shall look at the structural integrity of the storage tank. Nonetheless, as far as we have been told, no one knows the tanks full capacity and once the water is pumped, it is distributed.

Q2: When will the work in Fimpulu be done? And why are there no plans to put up new boreholes?

Ans: GIZ is focused on capacity development and rehabilitation, KfW deals with new infrastructure For the work in Fimpulu, the BOQs will be done next month, then the tenders. We intend to do the work this year.

Q3: Is there a soft skill training that will be done?

Ans: Yes, that is part of the package

Q4: How will the metering be done?

Ans: Let us first see look at the consumption. If there is a problem with the metering, then we will move from there.

Q5: What about storage?

Ans: We cannot go straight to storage; we need to know and curb the loss of water first before dealing with storage

2.7.4. Session 4: Presentation on context for the selection of the District for the 5th RGC and the Related Package of Intervention

This session was facilitated by the Provincial Water Supply and Sanitation Officer. The session was preceeded by a presentation from the Provincial Water and Sanitation Officer that highlighted the on-going WASH interventions in all the four RWS II partner districts, namely: Mansa; Mwense; Mwansabombwe, and Chipili. The presentation also highlighted the different partners funding the WASH intervention in the four districts, as well as the progresses made hitherto. It was became obvious from the presentation that Chipili District was the least supported district.

Arsing out of this, Chipili Town Council was proposed and adopted to host the 5th RGC whose interventions were sanitation related.

Plenary Session

Q1: How many people disagree to the selection of Chipili receiving the 5th RGC?

Ans: Silence (A sign that no one disagreed)

2.7.5. Session 5: Presentation on focus areas of intervention for the 5th RGC

The GFA team presented the focus areas of interventions for the 5th RGC. During this presentation it was proposed that the focus area of intervention for the 5th RGC was to be Sanitation. The Open Defecation Free (ODF) Zambia 2030 Strategy is the proposed approach that is to be used and guide the identification of specific activities to be implemented. **Figure 2** shows the areas of interest from the ODF Strategy key components and measures..

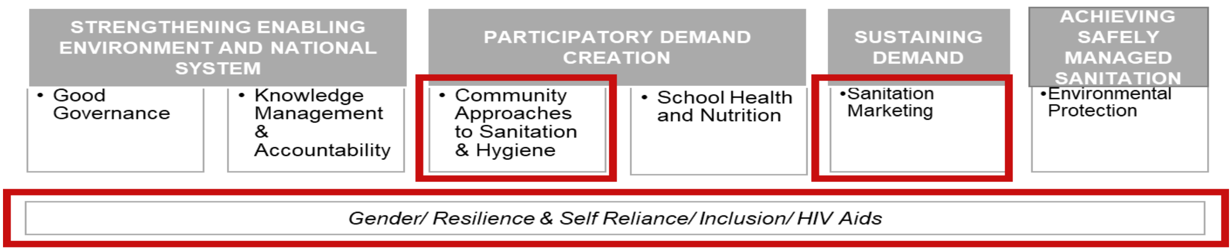


Figure 2: ODF Strategy key components and measures highlighting focus intervention areas

Plenary Session:

Q1: Where will finances for this come from?

Ans: Build Capacity to use available resources. No need for CLTS if we cannot manage.

2.7.6. Session 6: Presentation on context of workflows to support RWSS under Output 2 of RWS II

The GFA team presented the context of work flows. During this presentation, the participants were made to undersatnd how each activity being implemented by RWS II is interlinked and takes into account the components of the NRWSSP II. **Figure 3** and **Figure 4** shows how the RWS II takes into account the components of the NRWSSP II and linkages between RWS II activites respectively

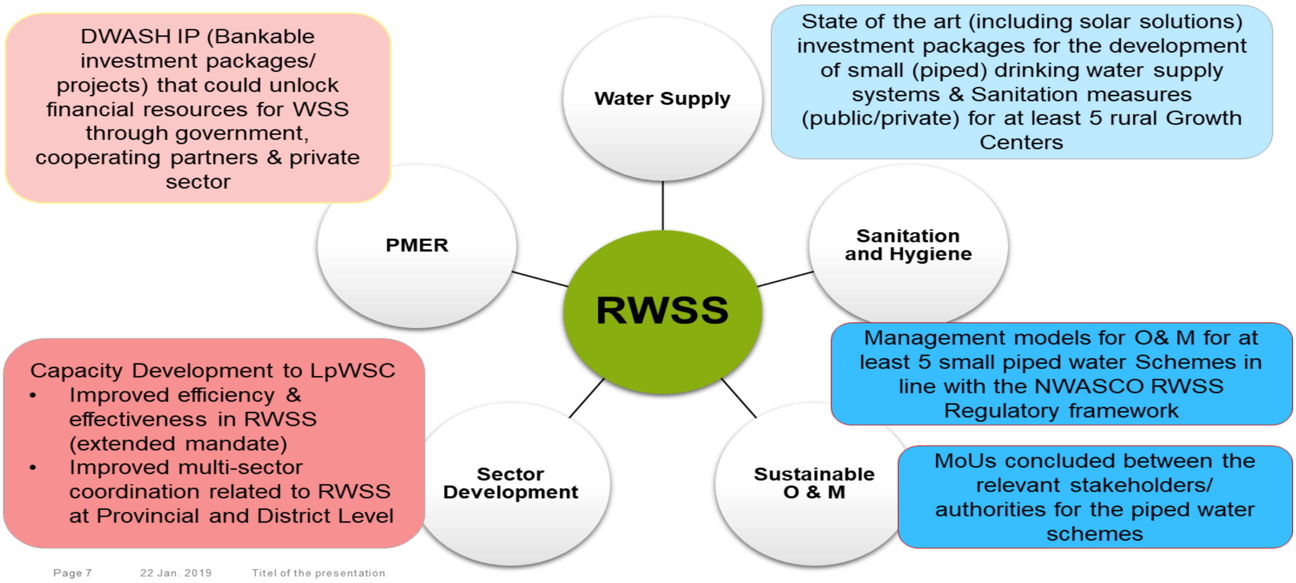


Figure 3: RWS II interventions taking into account key components of the NRWSSP II

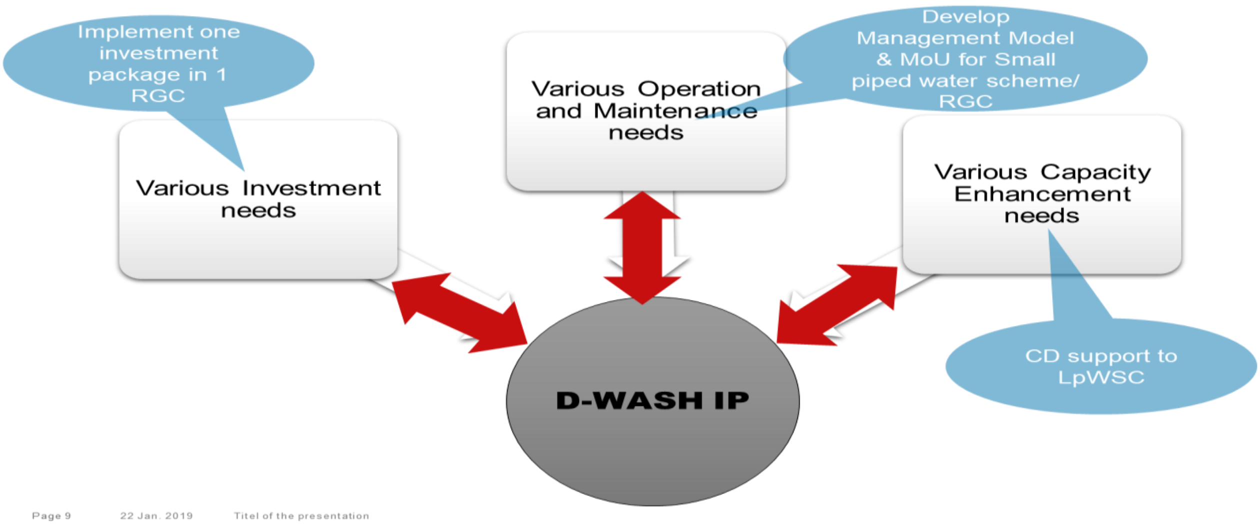
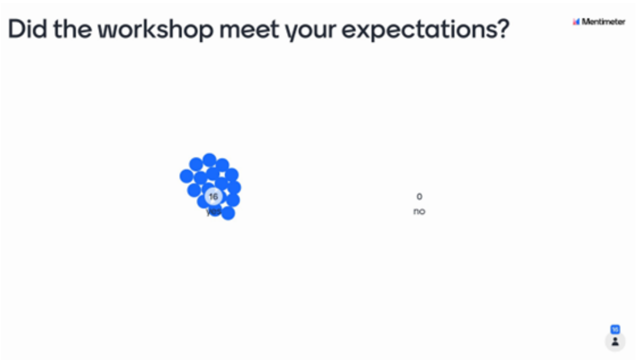
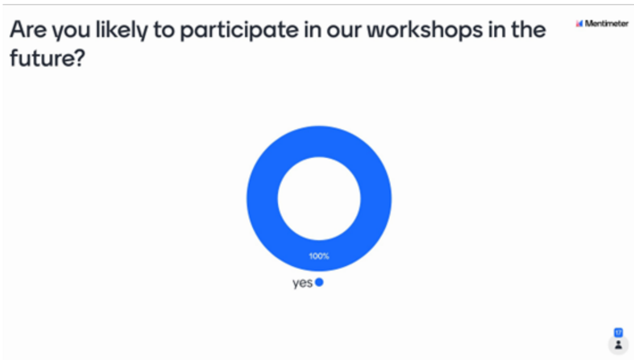


Figure 4: Linkages of all RWS II activities

3. Workshop Evaluation

To conclude the workshop, an evaluation was conducted inorder to get feedback from the participants on the workshop using a mentimeter. Mentimeter is an audience response management solution, which helps businesses of all sizes engage with the targeted audiences by providing tools to create interactive presentations. The platform enables professionals to collect data via live polls, quizzes, and questions in real-time and analyze data to gain insights into trends.





4. Workshop Closing Session

The workshop was officaially closed by the GFA team who run through the agreed propositions as set out in the agenda and everyone agreed to. Gratitude was extended to the particpants both virtual and in person for their partipation.

Annex

Annex 1: Workshop Agenda

Workshop: Validation O&M Models for Small Water Supply Systems in Rural Growth Centres of Luapula and the RGC

Luapula Province - Mansa

Friday, 26th February 2021

Time:	08:00 – 16:30 Hrs
Location and Venue:	Wetuna Gardens, Mansa
Participants:	Representatives from: Provincial Ministry of Water Development, Sanitation and Environmental Protection (MWDSEP) Provincial Ministry of Local Government Beneficiary District and Municipal Councils Luapula Water Supply and Sanitation Company, Cooperating Partners (CPs) Private Operator Companies
Facilitator:	GIZ/GFA-RWS II Support Team

Objective of the Workshop:

1. ***Discuss proposed O&M Models for Small Piped Water Supply System***
2. ***Adopt the O&M Model for Small Piped Water Supply System***
3. ***Discuss the selection approach the 5No. Rural Growth Centres***
4. ***Discuss and adopt the selection of the 4No. RGC***
5. ***Discuss and select the 5th RGC***

Reform of the Water Sector Phase II Programme Zambia
Validation O&M Models for Small Water Supply Systems in Rural Growth Centres of Luapula and Beneficiary Rural Growth Centres 26th February, 2021.

Implemented by:

Time	Activity	Facilitator
08:00 – 08:30	Arrival and Registration	All participants
08:30 – 08:35	National Anthem/ Prayer/ Welcome	Mwaba Kapema, *GFA WSS Junior Advisor*
08:35 – 08:45	Official Opening	Christian Rieck, *GIZ Project Manager*
08:45 – 08:55	Introductions of Participant/ Ground rules/ Agenda and Objectives for the Workshop	Sankwe Kambole, *GFA WSS Senior Advisor*
08:55 – 09:10	Assignment Introduction: O&M Model Study for SPWS and Link into RGC	Yulia Titova, *GFA Team Leader*
09:10 – 09:40	**Session 1: Presentation** • Summary of Study Findings and Proposed O&M Models for Small Piped Water Supply Schemes	Jim Gibson, *GFA Water Services Expert*
09:40 – 10:00	**Plenary Session 1: Questions/ Clarifications**	
10:00 – 10:30	**Tea Break**	
10:30 – 11:30	**Session 2: Break Away Groups** **3No. Groups to discuss:** • Proposed O&M Models, **highlighting** the **pros** and **cons** of each of the proposed models and **recommend** a suitable model for small-piped water supply schemes in Luapula Province	**BREAK AWAY GROUPS**
11:30 – 12:15	• Report Back on Group Discussions • Adopting the O&M Model	**PLENARY** • **10 Minutes** for Group Presentation & Question/ Answers • **15 Minutes** to Discuss and Adopt the O&M
12:15 – 12:45	**Session 3: Presentation 2** • RGC Selection Approach	Sankwe Kambole, *GFA WSS Senior Advisor*
12:45 – 13:00	**Plenary Session 2: Questions/ Clarifications**	
13:00 – 14:00	**Lunch**	
14:00 – 14:30	**Session 4: Presentation 3** • Context of Workflows to support RWSS under Output 2 of the RWSII	Mwaba Kapema, *GFA WSS Junior Advisor*
14:30 – 14:45	**Plenary Session 3: Questions/ Clarifications**	
14:45 – 15:15	**Session 5: Presentation 4** • Context on the District for the 5th RGC	*Eng. Alice Tembo, PWSSO*
15:15 – 15:30	**Plenary Session 4: Questions/ Clarification**	
15:30 – 16:00	**Session 6: Discussion** • Focus on areas of intervention for the 5th RGC	*Mwaba Kapema, GFA WSS Junior Advisor*
16:00 – 16:15	Workshop Evaluation and Feedback • **Mentimeter**	**ALL**
16:15 – 16:30	Wrap up and Closing Remarks	**GIZ/GFA**
Tea and Disperse / End of day		

Annex 2: Workshop Participants' list

Sn	NAME	POSITION	ORGANIZATION	EMAIL ADDRESS
A1	Geoffrey Bwalya	Health Inspector	Mwansabombwe Town Council	bwalyag@gmail.com
A2	David Luneta	Eng. Water	Ministry of Water Development Sanitation and Environmental Protection	mldluneta@gmail.com
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A4	Carmen Brubacher	Director	Access Water	carmen@water4.org
A5	Aim Kushikila	Deputy Director Works	Mwansabombwe Town Council	bamapalokush@gmail.com
A6	Alice Tembo	PWSO	Ministry of Water Development Sanitation and Environmental Protection	
A7	Mary Z. Banda	CO	Luapula Water Sewerage Company	m.zyambo@yahoo.com
A8	Francis Katanga	Provincial Local Government Officer	Ministry of Local Government	francischishibakatanga@gmail.com
A9	Benjamin Manda	Director of Works	Chipili Town Council	factbenjamin1@gmail.com
A10	Christopher Tembo	Health Inspector	Chipili Town Council	chrissytembojr@gmail.com
A14	Lawrence Chandwe	Rural Water Sanitation Service Coordinator	Mansa Municipal Council	chandwelawrence@gmail.com
A15	Manda Misheck	Water Sanitation Coordinator	Mwense Council	mandamisheck@yahoo.com
B1	Yulia Titova	Team Leader RWSSII	GFA Consulting Group	Yulia.titova@gfa-group.de
B2	Dijana Draganovic	Project Back stopper	GFA Consulting Group	Dijana.dragganovic@gfa-group.de
B3	Jim Gibson	ISTE	GFA Consulting Group	Jim.gibson@cluran.co.za
B4	Christian Rieck	Project Manager	GIZ	Christian.rieck@giz.de
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B7	Hebert Mwaanga	Deputy Team Leader	GFA	mwaanga.hebert@gfa-group.de
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B9	Kalusha Sakala		SAG-Water & Sanitation	
B10	Clemens Griesauer	Development Advisor	GIZ	clemens.griesauer@giz.de
C1	Sankwe Kambole	Senior Advisor	GFA	sankwe.kambole@gfa-group.de
C2	Mwaba Kapema	Junior Advisor	GFA	mwaba.kapema@gfa-group.de
C3	Lillian Kafunda	Office Manager	GFA	lilian.kafunda@gfa-group.de

Key	
A	Physical Implementing Partners
B	Virtual Participants
C	Physical GFA Facilitators

Annex 3: Groupwork Feedback

Group	Option 1		Option 2		Option 3 and preffered option	
	Pros	**Cons**	**Pros**	**Cons**	**Pros**	**Cons**
1	CU will have all responsibility for financing and other resources -CU have higher resource capacity (technical, capacity, plant, equipment) than CBO in general -Accountability in customer service Supply chain is more efficient	Operational costs are higher so they might have difficulties in financing -CU tariff rates can be higher than CBO managed system -More burdensome transport issues due to large geographical coverage	Operational costs are lower than CU -Tariffs are lower -Easy access because of a small target area -Higher community ownership – less likely to be vandalized	Lower tariff don't cover all expenses of the life cycle costing -Lower purchasing power for CapManEx -Accountability structure for management not well defined -Lower technical capacity	Operational costs are reduced -Sense of ownership by community so they safeguard the facility -Structure of accountability for water quality and service (NWASCO standards) -CU can provide technical capacity and support that the CBOs don't have -Improved customer sensitization for paying for water using CBOs -Hybrid allows for an inclusive strategy for NGOs, CBOs, CU, etc. to engage with customers – speak the same language	-There are certain precedence's set by NGOs/CBOs that need to be overcome in a financially sustainable hybrid management system -Long chain of command – needs very clear roles and responsibilities communicated at every level community
2	-CU has the HR capacity (manpower) -Communities agree on amount to be collected collection is done by committees	-CU cannot run these schemes financially viable -If community is not involved they become reluctant	-Operation is cheaper because community is contributing	CU and CBO not able to spend on repairs -Compromised quality of service -No assurance of sustainability	-Regular Trainings will be necessary, no technical know-how available, adds burden to the CU	-Billing could become challenge

Group	Option 1		Option 2		Option 3 and preffered option	
	Pros	**Cons**	**Pros**	**Cons**	**Pros**	**Cons**
		-Kiosk model is not feasible (cost of operator too high) -High tariffs would be required				
3	-Technical know-how in the management of piped water system. -There will be reduced illegal connections.	-Challenges in ensuring quick response in case of repair works due to CU not being near the Piped Water Scheme site -Community members lack the sense of ownership hence a high risk of vandalism. -Community members would be incapacitated as simple works shall be taken up by CU -Delay in payment for bills due to bureaucracy. -Likely hood of many communities drawing water from unprotected sources for lack of funds to buy water	-Sense of ownership -Hands on the running of the water system (proximity to the scheme)	-Major repairs and expansion may be taking longer -Mis management of funds -Open to external interference from political figures and traditional leadership -Acquiring of spare parts may take long to coordinate. -O and M due to low income	-Daily operations by technical and competent team is guaranteed -Major repairs and connection done promptly -Payment of electricity bill is prompt. -Sense of ownership by the community -There are shared responsibilities between the communities and the CU/NGO -Communities benefits in transfer of skills -High sense of ownership from community -There is proper coordinating in the running of the system.	-Likely hood of poor coordination between the community, technical or traditional leadership if roles are not well defined

Group	Option 1		Option 2		Option 3 and preffered option	
	Pros	**Cons**	**Pros**	**Cons**	**Pros**	**Cons**
					-In Mwense district option 3 is working -Risk of vandalism is reduced because of the sense of ownership	
4					Increased revenue base Availability of spare parts	Increased operation cost of the utility

Annex 4: Proposed Roadmaps

	GROUP 1	**GROUP 2**	**GROUP 3**	**GROUP 4**
Proposed Roadmap	Clearly defined roles and responsibilities for: (1) implementation phase and (2) management phase of the following: -NGO or private partner to Council as focal point – link them to CU for the Province -CU should explain the hybrid strategy to the NGO and Community (WDC). Develop MoU for implementation and management phase that includes local authority and CBO management. Include accountability for service and water quality	-First step has to be awareness raising to achieve community ownership and buy-in -Active engagement of women is crucial to address everybody's needs -Training of Operators -Prepaid metering with units sold at kiosk could be an option – CU needs to be involve in the technical support and set up - Commission based payment for Kiosk operator -Tariffs for communal taps should be different depending on the location "clustered tariffs" (house hold connections could be same) – taps need to be metered Solar – CU does not have the capacity to manage solar schemes – skill development would be required -Chlorination/consumables has to be added to cost paid by the CBO -ZESCO needs to provide commercial tariff to save costs -New connections should be done by CBO after a training? Operators: rationing? Pump maintenance, billing, revenue collection -Policies need to be developed to guide the implementation -Local government needs to be involved to organize the communities	-Have a baseline data on the needs and the capacity of the communities in water system sustainability -Massive sensitization to the communities on the importance of sustainability of water scheme -Guarantee supply of clean and safe water -The tariffs be based on the income levels of the communities. -Clear roles and responsibilities spelt out and understood by everyone. -Need for Partnership and engagement of other well-wishers (PPP)	-Flexibility is important □ within prescript of the law □ Politics □ Transfers (money flows) □ Formally enter into service contracts where services to be provided are clearly stated and understood -Increased operation cost of the utility -Subsidies ?? Central Government?? Utility company?? -Lock-in finances at conceptual level where up to 80% is achieved; prudent asset management; installing equipment that are manageable at community level -Increased revenue base □ Efficient service delivery □ Strong and robust utility -Tariffs □ Need to be standardized and regulated by regulator □ Designed systems □ Subsidies -Build institutional capacity for managing the SPWS -Availability of spare parts □ Most frequent required spares □ Ringfence finances □Strengthen operation of SOMAP shops □ Effective stock management systems □ Improve accountability -Engagement of institutions □ Identify roles for key actors -There is no problem with NWASCO taking a role in ensuring this seeing as they regulate and interact with the CU

List of Meetings

Meeting name: **Results Dissemination Workshop – Small Piped Water Management Modalities**

Venue: **Wetuna Lodge - Mansa**

Date: **September 18th, 2020**

Meeting key outputs:

1. **Partners' feedback on study findings and study recommendations**
2. **Firmed-up recommendations on preferred SPWS O&M Operator Concept Model**
3. **Partners' buy-in on proposed SPWS O&M Operator Concept Model**

A: In-person participants

Sn	Name	Position	Organisation	Town	Email Address
1	Mr Sinkala Stephen	Provincial Water Development Officer (PWDO)	Ministry of Water Development, Sanitation and Environmental Protection (MWDSEP)	Mansa	sinkala@gmail.com
2	Mr Chris Mongo	Administrative Officer	Access Water 4 Zambia	Mansa	xkmongo@gmail.com
3	Eng. Kenneth Chense	Managing Director (MD)	Luapula Water Supply and Sanitation Company (LpWSC)	Mansa	kennethchense@yahoo.co.uk
4	Eng. Brighton Bwembya	Snr Manager Engineering	Luapula Water Supply and Sanitation Company (LpWSC)	Mansa	bwembyab@yahoo.com
5	Mr Kalima Richard	Snr Manager Finance & Commercial	Luapula Water Supply and Sanitation Company (LpWSC)	Mansa	ritchie0976901744@gmail.com
6	Mr Jeremy Colvin	Director	Choshen Farm (Z) Ltd	Mansa	choshenfarmzambia@gmail.com
7	Mr Chabu Njamu	Technician	Access Water 4 Zambia	Samfya	njamuchabu@gmail.com
9	Mr Martin Mulenga	District Planning Officer (DPO)	Chipili Town Council	Chipili	martinmulenga55@gmail.com
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12	Mr James Chikwanda	Water Development Officer	Mwense Town Council	Mwense	jchikwanda@ymail.com
13	Chishala Chipunka	SSO	Luapula Water Supply and Sanitation Company (LpWSC)	Mansa	chishalachipunka@gmail.com
14	Mr Khondwelani Tembo	WASH Coordinator	Mwansabombwe Town Council	Mwansabombwe	tembokhondwelani@gmail.com

Sn	Name	Position	Organisation	Town	Email Address
15	Ms Gift Mikandu	Director Development Planning	Mansa Municipal Council	Mansa	gmikandu@gmail.com
16	Mr Lawrence Chandwa	WASH Coordinator	Mansa Municipal Council	Mansa	chandwalawrence@gmail.com
17	Mr Jameson Lubingo	Project Officer	WaterAid	Mansa	JamesonLubingo@wateraid.org
18	Eng. Sankwe Kambole	National Advisor Water Supply and Sanitation	GFA Consulting Group	Mansa	sankwe.kambole@gfa-group.de
19	Ms Mwaba Kapema	Junior Expert Water Supply and Sanitation	GFA Consulting Group	Mansa	mwaba.kapema@gfa-group.de
20	Ms Lillian Kafunda	Office Manager	GFA Consulting Group	Mansa	Lillian.kafunda@gfa-group.de

B: Virtual participants

Sn	Name	Position	Organisation	Email Address
1	Ms Yulia Titova	Team Leader - RWSSII	GFA Consulting Group	yulia.titova@gfa-group.de
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3	Mr Jim Gibson	International Short-Term Expert (ISTE)	GFA Consulting Group	jim.gibson@cluran.co.za
4	Mr Christian Rieck	Project Manager RWSII	GIZ	christian.rieck@giz.de
5	Ms Iris Wilhelm	Snr Advisor/ AA2 Lead	GIZ	iris.wilhelm@giz.de
6	Ms Kalusha Sakala	Coordinator	SAG Secretariat/ NWASCO	-
7	Ms Chola Kasoma Mbilima	Snr Inspector – Financial and Commercial Management	NWASCO	cmbilima@nwasco.org.zm
8	Mr Mwape Bwalya	Junior Advisor	GIZ	mwape.bwalya@giz.de

Agenda of the Meeting

Workshop: <u>Operational and Maintenance Models for Small Water Supply Systems in Rural Growth Centres of Luapula</u>

Luapula Province - Mansa

Wednesday, 18th September 2020

Time: 08:00 – 16:00 Hrs

Location & Venue: Wetuna Gardens, Mansa

Participants: Representatives from:

Provincial Ministry of Water Development, Sanitation and Environmental Protection (MWDSEP)

Provincial Ministry of Local Government

Beneficiary District Councils

Luapula Water Supply and Sanitation Company, Cooperating Partners (CPs) Private Operator Companies

Facilitator: GIZ/GFA-RWS II Support Team

Objective of the Workshop:

1. ***Present findings from the assignment***
2. ***Identify options and risks associated with Operation & Maintenance of Water Supply (PWS) at Rural Growth Centers***
3. ***Stimulate discussion on strategies/models for the long-term Operation & Maintenance of Water Supply (PWS) at Rural Growth Centers***
4. ***Receive feedback from stakeholders on their perceptions of the options and risks***
5. ***Build institutional buy-in from key partners***

Time	Activity	Facilitator
08:00 – 08:30	Arrival and Registration	All participants
08:30 – 08:35	National Anthem / Prayer / Welcome	Mwaba Kapema, *GFA Junior Advisor*
08:35 – 08:45	Official Opening	Christian Rieck, *GIZ Project Manager*
08:45 – 08:55	Introduction to the Project	Yulia Titova, *GFA Team Leader*
08:55 – 09:10	Introductions and Expectations / Ground rules / Agenda and Objectives for the Workshop	Sankwe Kambole, *GFA Senior Advisor*
09:10 – 09:40	**Session 1: Presentation** • The Findings of Assignment	Jim Gibson, *GFA Water and Sanitation Expert*
09:40 – 10:00	**Plenary Session 1: Questions and Clarifications**	
10:00 – 10:30	**Tea Break**	
10:45–13:00	**Session 2: Break Away into Discussion groups** **Groups to discuss:**	**PLENARY**

Time	Activity	Facilitator
	1) The types of **business processes** required to **deliver acceptable services** with **available resources** 2) Discuss the **risks** and **opportunities** in achieving 1 above 3) What actions are identified from this workshop vis-à-vis the **required business processes** and **necessary resources**	
13:00 – 14:00	**Lunch**	
14:00–15:00	Report Back on Group Discussions	**PLENARY** Each Group will have 10 minutes to make a presentation and use 5 minutes for plenary session
15:00 – 15:30	Workshop Evaluation and Feedback	**ALL**
15:30 – 16:00	Wrap up and Closing Remarks	**GIZ/GFA**
Tea and Disperse / End of day		

Meeting name: **Validation Workshop – Small Pipe Water Supply Scheme O&M Operator Concept**

Venue: **Wetuna Lodge - Mansa**

Date: **February 26th, 2021**

Meeting key outputs:

1. **Approved O&M Operator Concept Model for SPWS in Luapula Province**
2. **Approved 4 RGC and Small Pipe Water Supply Schemes Investment Measures**
3. **Approved District Hosting 5th RGC**
4. **Approved RWSII AA2 Focus Area of Interventions for the 5th RGC**

Participants

A: In-person participants

Sn	Name	Position	Organization	Email Address
A: In-Person Participants				
A1	Geoffrey Bwalya	Health Inspector	Mwansabombwe Town Council	bwalyag@gmail.com
A2	David Luneta	Engineer - Water	Ministry of Water Development Sanitation and Environmental Protection	mldluneta@gmail.com
A3	Lombe B. Mwakanandi	Director of Development Planning	Mansa Municipal Council	lombemwakanandi@gmail.com
A4	Carmen Brubacher	Director	Access Water 4 Zambia	carmen@water4.org
A5	Aim Kushikila	Deputy Director Works	Mwansabombwe Town Council	bamapalokush@gmail.com
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A8	Francis Katanga	Provincial Local Government Officer	Ministry of Local Government	francischishibakatanga@gmail.com
A9	Benjamin Manda	Director of Works	Chipili Town Council	factbenjamin1@gmail.com
A10	Christopher Tembo	Health Inspector	Chipili Town Council	chrissytembojr@gmail.com
A14	Lawrence Chandwe	Rural Water Sanitation Service Coordinator	Mansa Municipal Council	chandwelawrence@gmail.com
A15	Manda Misheck	Water Sanitation Coordinator	Mwense Council	mandamisheck@yahoo.com

B: Virtual Participants				
B1	Yulia Titova	Team Leader RWSSII	GFA Consulting Group	Yulia.titova@gfa-group.de
B2	Dijana Draganovic	Project Back stopper	GFA Consulting Group	Dijana.dragganovic@gfa-group.de
B3	Jim Gibson	ISTE	GFA Consulting Group	Jim.gibson@cluran.co.za
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B9	Kalusha Sakala	Coordinator	SAG-Water & Sanitation	-
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C: Facilitators				
C1	Sankwe Kambole	Senior Advisor	GFA	sankwe.kambole@gfa-group.de
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C3	Lillian Kafunda	Office Manager	GFA	lilian.kafunda@gfa-group.de

Agenda of the Meeting

Workshop: <u>Validation O&M Models for Small Water Supply Systems in Rural Growth Centres of Luapula and the RGC</u>

Luapula Province - Mansa

Friday, 26th February 2021

Time: 08:00 – 16:30 Hrs

Location and Venue: Wetuna Gardens, Mansa

Participants: Representatives from:

Provincial Ministry of Water Development, Sanitation and Environmental Protection (MWDSEP)

Provincial Ministry of Local Government

Beneficiary District Councils

Luapula Water Supply and Sanitation Company, Cooperating Partners (CPs) Private Operator Companies

Facilitator: GIZ/GFA-RWS II Support Team

Objective of the Workshop:

1. ***Discuss proposed O&M Models for Small Piped Water Supply System***
2. ***Adopt the O&M Model for Small Piped Water Supply System***
3. ***Discuss the selection approach the 5No. Rural Growth Centres***
4. ***Discuss and adopt the selection of the 4No. RGC***
5. ***Discuss and select the 5th RGC***

Time	Activity	Facilitator
08:00 – 08:30	Arrival and Registration	All participants
08:30 – 08:35	National Anthem/ Prayer/ Welcome	Mwaba Kapema, *GFA WSS Junior Advisor*
08:35 – 08:45	Official Opening	Christian Rieck, *GIZ Project Manager*
08:45 – 08:55	Introductions of Participant/ Ground rules/ Agenda and Objectives for the Workshop	Sankwe Kambole, *GFA WSS Senior Advisor*
08:55 – 09:10	Assignment Introduction: O&M Model Study for SPWS and Link into RGC	Yulia Titova, *GFA Team Leader*
09:10 – 09:40	**Session 1: Presentation** • Summary of Study Findings and Proposed O&M Models for Small Piped Water Supply Schemes	Jim Gibson, *GFA Water Services Expert*
09:40 – 10:00	**Plenary Session 1: Questions/ Clarifications**	
10:00 – 10:30	**Tea Break**	

Time	Activity	Facilitator
10:30 – 11:30	**Session 2: Break Away Groups** **3No. Groups to discuss:** • Proposed O&M Models, **highlighting** the **pros** and **cons** of each of the proposed models and **recommend** a suitable model for small-piped water supply schemes in Luapula Province	**BREAK AWAY GROUPS**
11:30 – 12:15	• Report Back on Group Discussions • Adopting the O&M Model	**PLENARY** • **10 Minutes** for Group Presentation & Question/ Answers • **15 Minutes** to Discuss and Adopt the O&M
12:15 – 12:45	**Session 3: Presentation 2** • RGC Selection Approach	Sankwe Kambole, *GFA WSS Senior Advisor*
12:45 – 13:00	**Plenary Session 2: Questions/ Clarifications**	
13:00 – 14:00	**Lunch**	
14:00 – 14:20	**Session 4: Presentation 3** • Context of Workflows in RGCs	Mwaba Kapema, *GFA WSS Junior Advisor*
14:20 – 14:35	**Plenary Session 3: Questions/ Clarifications**	
14:35 – 15:15	**Session 5: Break Away Groups** **3No. Groups to discuss and propose:** The 5th RGC and the focus activities to be implemented	**BREAK AWAY GROUPS**
15:15 – 16:00	• Report Back on Group Discussions • Adopting the 5th RGC	**PLENARY** • **10 Minutes** for Group Presentation & Question/ Answers • **15 Minutes** to Discuss and Adopt the 5th RGC
16:00 – 16:15	Workshop Evaluation and Feedback • **Mentimeter**	**ALL**
16:15 – 16:30	Wrap up and Closing Remarks	**GIZ/GFA**
Tea and Disperse / End of day		

ANNEX II: SMALL PIPE WATER SUPPLY SCHEME PIPE NETWORK DESIGN CRITERIA

DESIGN CRITERIA

Overall, the ***water demand*** was projected using the ***population growth rate*** while the ***water reticulation systems*** were designed based on a ***ten-year population projection***, using a 2.5 % annual population growth rate. Consequently, the ***design flow*** was calculated using the peak average demand and factoring in the allowance for water losses, computed using a standard equation for the ***'design water demand'*** (equation 1 and 2).

$$Q = PADWD + SP + WL + FF \qquad (Eqn. 1)$$

Where:

Q	=	***Design Water Demand***
$PADWD$	=	***Peak Average Daily Water Demand***
SP	=	***Seasonal peak***
WL	=	***Water Losses***
FF	=	***Firefighting***

Whilst it is generally advised to provide for fire flow demand in majority of networks, however, for rural water supply networks, this practice is not recommended. This is because fire demand requirements result in large pipes in the distribution network making it expensive to implement. As a result, firefighting flows have not been included in the demand calculations (cf. equation 1).

$$PWD = ADWD + PF \qquad (Eqn. 2)$$

Where:

PWD	=	***Peak Water Demand***
$ADWD$	=	***Average Daily Water Demand***
PF	=	***Peak Factor***

Average daily water demand was computed based on population of the RGCs (and income class) while peak factors were calculated using the ***Harmon, Babbitt and Great Lakes Upper Mississippi River Board (GLUMB)*** equations and they compared very well with peak factors from projects in similar areas as well as those from literature. The peak factors used for the design of the water reticulation system in the 4No. RGCs are presented in Table 1-1.

Table 1-1: Peak factors

Description		Mulundu	Mwenda	Fimpulu	New Kazembe
	RGC population	11,222	4,000	3000	4,444
Peak Factor	Babbitt	3.08	3.79	4.01	3.71
	Harmon	2.90	3.33	3.44	3.29
	GLUMB	2.90	3.33	3.44	3.29
	Average Peak factor	**3.0**	**3.49**	**3.63**	**3.4**

HEAD LOSS METHOD

The ***Darcy Weisbach*** equation shall be used for the calculation of head losses along pipelines. shows the Darcy Weisbach equation.

$$H = \frac{F \times L \times V^2}{D2g} \qquad (Eqn. 3)$$

Where:

H	=	***Head loss (m)***
F	=	***Resistance coefficient (determined according to the Colebroke-White or the Swamee-Jain equation)***
L	=	***Length of pipe (m)***
D	=	***Diameter of pipe (m)***
V	=	***Velocity of flow (m/s)***
g	=	***Gravity of acceleration = 9.81 (m/s²)***

The roughness factor varies between 0.1 mm and 7 mm maximum. 1 mm is used for network distribution pipes, taking the junctions and fittings into account. The value of 0.4 mm is used for pipelines that have few fittings and 0.1 mm is used for the long-distance and nearly straight transmission pipelines and rising mains.

HYDRAULIC ANALYSIS OF RISING MAINS AND SELECTING PIPELINE DIAMETER

Hydraulic analyses were performed rising mains. The head losses along the pipeline were calculated using the Darcy-Weisbach equation (Eqn. 3). Allowance for the additional losses due to standard fittings was made by adding the equivalent lengths provided in standard tables.

The selection of the appropriate pipe sizes for the rising mains was based on the combination of investment costs and operation costs. The power consumption of the pumps and hence the operating costs were calculated based on the required flow and the pumping head that the pumps must overcome to deliver the required flow (considering the pump efficiency). But, since these are small networks and because the existing rising mains have been constructed from PVC pipes, the mains must be designed to be PVC-U.

The selected pipe sizes were further subjected to additional assessment to guarantee that the pipes remained capable of withstanding the highest operating pressure including ***water hammer*** effects. Water hammer occurs in any pressurized water pipeline and is set up by a sudden change in flow velocities which occurs when stopping or starting of pumps or closing or opening of valves, among others. The stopping of the pump and closing of the valve produces more severe water hammer effects. Thus, to account for the water hammer effects, surge pressure and surge wave velocities were calculated using eqn. 4 and 5, respectively.

$$\nabla h = \mp V \times \frac{C_p}{g} \qquad (Eqn. 4)$$

Where:

∇h	=	***Pressure surge***
V	=	***Average flow velocity before rapid closure or stoppage in m/s***
g	=	***Acceleration due to gravity (9.81 m/s²),***
C_p	=	***Surge wave velocity, which depends on several factors including physical characteristic of the main and the pumped medium, and is equal to***

$$C_p = \frac{C_w}{\left(1 + \left(\frac{E_w}{E_p}\right) * \left(\frac{d}{t}\right)\right)^{0.5}} \qquad (Eqn. 5)$$

Where:

C_w	=	***Celerity (speed) of the pressure wave in a column of water***
E_w	=	***Bulk modulus of water =2230 N/mm² at 30 °C***
E_p	=	***Modulus of elasticity of pipe wall material in N/mm² (170,000 for DI pipes),***
d	=	***Mean diameter of the pipe in metres,***
t	=	***Pipe wall thickness in metres***

PRESSURE LIMITS

To provide an acceptable level of service to consumers, water must be supplied at an adequate pressure. According to NWASCO Guidelines, the minimum pressure should be 7 metres (0.7 bars) at the consumer point, in this case, the standpipe. However, a pressure of 12 metres (1.2 bars) should be attained in the main supplying pipes. Therefore, the minimum pressure proposed for design was 12 metres (1.2 bars) in main lines and the absolute minimum pressure targeted was 7 metres (0.7 bars) at peak hour demand at all standpipes.

To provide this minimum pressure, it will be necessary to have higher pressures in the upstream parts of the system as well as low-lying areas. But it must be pointed out here that leakages and pipe bursts are most prevalent in areas where system pressures are high. Therefore, to minimise these leakages and bursts and to reduce noise and pressure shocks, the maximum pressure was to be limited to 60 mH_2O in the distribution pipes. As a result, the system pressure range for this project has been defined as follows: ***7m ≤ system pressure ≤ 60 m***.

VELOCITY LIMITS

Economic velocities are usually recommended by pipe manufacturers to ensure carrying efficiency. The velocities should be kept within certain limits to avoid deposition on the lower end and to limit forces on bends and water hammer effects, on the upper end. The economic velocities increase with the increase in the diameter of the pipe. Table 1-1 gives a general directive on economic velocities recommended in this project.

Table 1-2: Pipe velocity limits

Pipe size (mm)	Velocity (m/s)
50-100	0.6-1.0
150-250	1.0-1.5
300-500	1.2-2.0
>500	<3

ANNEX III: HYDRAULIC ANALYSIS FOR MULUNDU SMALL PIPE WATER SUPPLY SCHEME PIPE NETWORK

A: HYDRAULIC ANALYSIS FOR THE JUNCTIONS FOR MULUNDU SPWS

ID	Label	Elevation (m)	Zone	Demand Collection	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H_2O)
172	J-62	945.21	<None>	<Collection: 1 item>	2.98	761.55	-183
170	J-61	946.56	<None>	<Collection: 1 item>	5.15	763.05	-183
184	J-65	946.61	<None>	<Collection: 0 items>	0	783.79	-162
181	J-64	949.68	<None>	<Collection: 0 items>	0	801.44	-148
64	J-14	970	<None>	<Collection: 1 item>	2.65	828.45	-141
66	J-15	967.42	<None>	<Collection: 1 item>	1.87	847.98	-119
178	J-63	952	<None>	<Collection: 0 items>	0	835.2	-117
187	J-66	949.87	<None>	<Collection: 0 items>	0	857.99	-92
168	J-60	953.98	<None>	<Collection: 1 item>	2.18	873.1	-81
166	J-59	954.43	<None>	<Collection: 1 item>	3.45	875.16	-79
133	J-45	945.75	<None>	<Collection: 1 item>	0.61	894.01	-52
122	J-41	942.1	<None>	<Collection: 1 item>	1.22	909.49	-33
62	J-13	963.16	<None>	<Collection: 1 item>	0.4	934.39	-29
124	J-42	943.79	<None>	<Collection: 1 item>	1.19	919.16	-25
146	J-51	960.89	<None>	<Collection: 1 item>	1.68	938.51	-22
59	J-12	963.26	<None>	<Collection: 1 item>	0.61	942.37	-21
144	J-50	964.71	<None>	<Collection: 1 item>	1.59	946.95	-18
130	J-44	953.51	<None>	<Collection: 1 item>	1.33	940.86	-13
142	J-49	963.63	<None>	<Collection: 1 item>	0.46	954.7	-9
156	J-55	959.64	<None>	<Collection: 1 item>	1.13	951.4	-8
159	J-56	956.32	<None>	<Collection: 1 item>	1.62	948.27	-8
120	J-40	943.9	<None>	<Collection: 1 item>	0.54	939.65	-4
161	J-57	950.24	<None>	<Collection: 1 item>	0.63	947.4	-3
73	J-18	959.92	<None>	<Collection: 1 item>	0.17	963.02	3
140	J-48	962.85	<None>	<Collection: 1 item>	0.22	966.41	4
163	J-58	959.64	<None>	<Collection: 1 item>	0.34	965.94	6
76	J-19	954.95	<None>	<Collection: 1 item>	0.22	961.93	7
104	J-32	959.45	<None>	<Collection: 1 item>	1.51	966.95	7
127	J-43	959.38	<None>	<Collection: 1 item>	0.33	969.92	11
56	J-11	961.16	<None>	<Collection: 1 item>	0.36	972.28	11
106	J-33	948.98	<None>	<Collection: 1 item>	1.77	961.37	12
102	J-31	959.01	<None>	<Collection: 1 item>	0.23	972.28	13
138	J-47	961.06	<None>	<Collection: 1 item>	0.06	974.35	13
54	J-10	959.74	<None>	<Collection: 1 item>	0.22	973.35	14
99	J-30	960.24	<None>	<Collection: 1 item>	0.07	973.88	14
46	J-8	960.64	<None>	<Collection: 1 item>	0.03	974.33	14
44	J-7	960.01	<None>	<Collection: 1 item>	0.09	974.2	14
78	J-20	946.94	<None>	<Collection: 1 item>	0.67	961.15	14
108	J-34	944.68	<None>	<Collection: 1 item>	0.43	959.12	14
110	J-35	943.74	<None>	<Collection: 1 item>	0.14	958.76	15

ID	Label	Elevation (m)	Zone	Demand Collection	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H_2O)
112	J-36	943.09	<None>	<Collection: 1 item>	1.25	958.55	15
154	J-54	945.12	<None>	<Collection: 1 item>	1.13	961.14	16
135	J-46	961.97	<None>	<Collection: 1 item>	0.14	978.66	17
42	J-6	957.86	<None>	<Collection: 1 item>	0.19	974.6	17
80	J-21	956.19	<None>	<Collection: 1 item>	0.36	973.19	17
114	J-37	940.08	<None>	<Collection: 1 item>	2.24	957.56	17
82	J-22	954.79	<None>	<Collection: 1 item>	0.58	972.9	18
86	J-24	950.42	<None>	<Collection: 1 item>	0.31	968.61	18
150	J-53	949.44	<None>	<Collection: 1 item>	0.42	967.87	18
116	J-38	938.88	<None>	<Collection: 1 item>	1.15	957.43	19
148	J-52	948.87	<None>	<Collection: 1 item>	0.94	967.95	19
118	J-39	938.15	<None>	<Collection: 1 item>	0.46	957.42	19
40	J-5	955.45	<None>	<Collection: 1 item>	0.17	975.14	20
92	J-27	940.04	<None>	<Collection: 1 item>	0.5	960.56	20
90	J-26	939.43	<None>	<Collection: 1 item>	0.4	960.42	21
88	J-25	944.13	<None>	<Collection: 1 item>	0.95	965.63	21
84	J-23	949.6	<None>	<Collection: 1 item>	1.05	971.74	22
95	J-28	932.32	<None>	<Collection: 1 item>	0.79	959.19	27
38	J-4	948.08	<None>	<Collection: 1 item>	0.37	976.06	28
36	J-3	944.22	<None>	<Collection: 1 item>	1	976.91	33
34	J-2	934.32	<None>	<Collection: 1 item>	0.97	978.36	44

B: HYDRAULIC ANALYSIS FOR THE PIPES FOR MULUNDU SPWS

ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Has Check Valve?	Minor Loss Coefficient (Local)	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/m)
134	P-52	352	J-44	J-45	36.4	PVC	150	FALSE	0	0.61	1.62	0.133
63	P-14	15	J-12	J-13	36.4	PVC	150	FALSE	0	4.91	4.72	0.538
67	P-16	188	J-13	J-15	36.4	PVC	150	FALSE	0	4.51	4.34	0.46
68	P-17	114	J-15	J-14	36.4	PVC	150	FALSE	0	2.65	2.54	0.171
121	P-45	93	J-34	J-40	36.4	PVC	150	FALSE	0	2.95	2.84	0.21
125	P-47	143	J-40	J-42	36.4	PVC	150	FALSE	0	2.41	2.31	0.144
126	P-48	238	J-42	J-41	36.4	PVC	150	FALSE	0	1.22	1.17	0.041
131	P-51	300	J-43	J-44	36.4	PVC	150	FALSE	0	1.94	1.87	0.097
149	P-60	309	J-2	J-52	36.4	PVC	150	FALSE	0	1.1	1.06	0.034
153	P-63	77	J-52	J-53	36.4	PVC	150	FALSE	0	0.16	0.15	0.001
155	P-64	191	J-53	J-54	36.4	PVC	150	FALSE	0	1.13	1.08	0.035
93	P-30	204	J-25	J-27	45.6	PVC	150	FALSE	0	1.69	1.03	0.025
94	P-31	83	J-27	J-26	45.6	PVC	150	FALSE	0	0.4	0.25	0.002
60	P-13	134	J-11	J-12	45.6	PVC	150	FALSE	0	5.52	3.38	0.223
74	P-20	75	J-7	J-18	45.6	PVC	150	FALSE	0	4.44	2.72	0.149
77	P-22	142	J-18	J-19	45.6	PVC	150	FALSE	0	0.89	0.55	0.008
79	P-23	172	J-19	J-20	45.6	PVC	150	FALSE	0	0.67	0.41	0.005
96	P-32	226	J-27	J-28	45.6	PVC	150	FALSE	0	0.79	0.48	0.006
139	P-55	35	J-46	J-47	45.6	PVC	150	FALSE	0	4	2.45	0.123
141	P-56	66	J-47	J-48	45.6	PVC	150	FALSE	0	3.94	2.41	0.119
143	P-57	109	J-48	J-49	45.6	PVC	150	FALSE	0	3.72	2.28	0.108
145	P-58	92	J-49	J-50	45.6	PVC	150	FALSE	0	3.26	2	0.084
147	P-59	344	J-50	J-51	45.6	PVC	150	FALSE	0	1.68	1.03	0.025
157	P-65	129	J-18	J-55	45.6	PVC	150	FALSE	0	3.38	2.07	0.09
160	P-67	74	J-55	J-56	45.6	PVC	150	FALSE	0	2.25	1.38	0.042
162	P-68	216	J-56	J-57	45.6	PVC	150	FALSE	0	0.63	0.39	0.004
87	P-27	159	J-23	J-24	68.4	PVC	150	FALSE	0	4.33	1.18	0.02
151	P-61	43	J-24	J-53	68.4	PVC	150	FALSE	0	4.02	1.1	0.017
152	P-62	284	J-53	J-25	68.4	PVC	150	FALSE	0	2.64	0.72	0.008
167	P-70	540	J-58	J-59	68.4	PVC	150	FALSE	0	13.76	3.75	0.168
169	P-71	21	J-59	J-60	68.4	PVC	150	FALSE	0	10.32	2.81	0.098
173	P-73	151	J-61	J-62	68.4	PVC	150	FALSE	0	2.98	0.81	0.01
182	P-78	532	J-63	J-64	68.4	PVC	150	FALSE	0	8.13	2.21	0.063
185	P-80	278	J-64	J-65	68.4	PVC	150	FALSE	0	8.13	2.21	0.063

ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Has Check Valve?	Minor Loss Coefficient (Local)	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/m)
186	P-81	327	J-65	J-61	68.4	PVC	150	FALSE	0	8.13	2.21	0.063
188	P-82	238	J-60	J-66	68.4	PVC	150	FALSE	0	8.13	2.21	0.063
189	P-83	359	J-66	J-63	68.4	PVC	150	FALSE	0	8.13	2.21	0.063
55	P-11	111	J-8	J-10	100	Galvanized	120	FALSE	0	6.1	0.78	0.009
57	P-12	129	J-10	J-11	100	Galvanized	120	FALSE	0	5.89	0.75	0.008
100	P-34	42	J-7	J-30	100	Galvanized	120	FALSE	0	5.58	0.71	0.007
101	P-35	25	J-30	J-8	100	Galvanized	120	FALSE	0	-8.91	1.13	0.018
136	P-53	27	J-8	J-46	100	Galvanized	120	FALSE	0	-29.14	3.71	0.16
137	P-54	36	J-46	T-1	100	Galvanized	120	FALSE	0	-33.28	4.24	0.205
164	P-69	201	J-8	J-58	100	Galvanized	120	FALSE	0	14.11	1.8	0.042
175	P-74	32	R-1	PMP-1	100	Galvanized	120	FALSE	0	20.24	2.58	0.082
176	P-75	50	PMP-1	J-2	100	Galvanized	120	FALSE	0	20.24	2.58	0.082
81	P-24	182	J-7	J-21	102.4	PVC	150	FALSE	0	6.32	0.77	0.006
83	P-25	57	J-21	J-22	102.4	PVC	150	FALSE	0	5.96	0.72	0.005
85	P-26	280	J-22	J-23	102.4	PVC	150	FALSE	0	5.38	0.65	0.004
103	P-36	62	J-30	J-31	102.4	PVC	150	FALSE	0	14.41	1.75	0.026
107	P-38	398	J-32	J-33	102.4	PVC	150	FALSE	0	10.39	1.26	0.014
109	P-39	228	J-33	J-34	102.4	PVC	150	FALSE	0	8.62	1.05	0.01
111	P-40	91	J-34	J-35	102.4	PVC	150	FALSE	0	5.24	0.64	0.004
113	P-41	56	J-35	J-36	102.4	PVC	150	FALSE	0	5.1	0.62	0.004
115	P-42	445	J-36	J-37	102.4	PVC	150	FALSE	0	3.85	0.47	0.002
117	P-43	283	J-37	J-38	102.4	PVC	150	FALSE	0	1.61	0.2	0
119	P-44	196	J-38	J-39	102.4	PVC	150	FALSE	0	0.46	0.06	0
128	P-49	95	J-31	J-43	102.4	PVC	150	FALSE	0	14.19	1.72	0.025
129	P-50	165	J-43	J-32	102.4	PVC	150	FALSE	0	11.91	1.45	0.018
37	P-2	228	J-2	J-3	148.9	PVC	150	FALSE	0	18.17	1.04	0.006
39	P-3	148	J-3	J-4	148.9	PVC	150	FALSE	0	17.17	0.99	0.006
41	P-4	167	J-4	J-5	148.9	PVC	150	FALSE	0	16.79	0.96	0.005
43	P-5	101	J-5	J-6	148.9	PVC	150	FALSE	0	16.62	0.95	0.005
45	P-6	75	J-6	J-7	148.9	PVC	150	FALSE	0	16.43	0.94	0.005

ANNEX IV: WATER HAMMER CALCULATIONS FOR MULUNDU SMALL PIPE WATER SUPPLY SCHEME TRANSMISSION MAINS

Design Flows	Unit	2026	Comment
$Q_{p,dmax,d}$	[m³/d]	1874.73	
Pmp. Hours:	[h]	15	
$Q_{p,dmax,h}$	[m³/h]	124.98	
$Q_{p,dmax,h}$	[l/s]	34.72	
WATER PROPERTIES:		**2029**	**Comment**
Viscosity v:	[m²/s]	1.00E-06	H_2O at T = 20°C
Density ρ:	[kg/m³]	999.88	H_2O at T = 20°C
Gravity Acceleration g:	[m/s²]	9.81	
DELIVERY MAIN DESIGN:		**2029**	**Comment**
Roughness k:	[mm]	0.0015	assumed integral roughness
Length L:	[m]	1500	approximate value
Diameter D:	[mm]	219	
Delivery Velocity V:	[m/s]	0.92	$V_{max.}$ = 1,5 m/s; $V_{min.}$ = 0,5 m/s;
Material	[-]	uPVC	
Pressure Class PN	[-]	12	from Water Hammer Calculation
Reynolds No. Re:	[-]	201842	
Friction Coefficient λ:	[-]	0.0076	acc.: Swamme & Jain Eq.
Linear Headloss $\Delta H_{lin.del.}$:	[m]	2.26	
Sum of Minor Losses Coef. ∑ζ:	[-]	5.00	accounting for all bends, fittings,etc.
Total Minor Losses $\sum H_{min.del.}$:	[m]	0.22	
Total Losses $\sum H_{tot.del.}$:	[m]	2.47	
Comments:			
WATER HAMMER CALCULATION		**2029**	
Wave Propagation Velocity a:			
Pipe material:	[-]	uPVC	
Water modulus of elasticity ε:	[N / mm²]	2050	
Material modulus of elasticity E:	[N / mm²]	210000	
Water density ρ :	[kg/m³]	999.88	H_2O at T = 20°C
Diameter D:	[mm]	219	
Pipe Thickness e:	[mm]	6.5	
Wave Propagation Velocity a:	[m/s]	1242.10	
Selection of Formula:			
Input:			
effective closing time t:	[s]	0	assume: worst case
Gravity Acceleration g:	[m/s²]	9.81	
Length of Pipeline L:	[m]	1500	
Selection of Formula:	Formula:	ALLIEVI	Sudden Closure
Pressure surges and drops ∆H:			
Input:			
flow velocity before v_1:	[m/s]	0.92	

Design Flows	Unit	2026	Comment
flow velocity after v_2:	[m/s]	0	
Pressure surges and drops ΔH:	[m]	116.7	
Resistance Check against water hammer:			
Pipe Entities:			
Allowable Operating Pressure (PFA)	[bar]	16	
Allowable Maximum operating Pressure (PMA)	[bar]	20	
Allowable Test Pressure (PEA)	[bar]	25	
System Entities:			
Max service Pressure (DP):	[m H_2O]	60.0	system entity; approximate value
Pressure surges and drops ΔH:	[m H_2O]	116.7	
Max Design Pressure (MDP) :	[m H_2O]	177	
Inequalities to meet:			
Design Pressure (DP) < Allowable Operating Pressure (PFA)	Test	2.67	is Safe
Max. Design Pressure (MDP) < Allowable Max. operating pressure (PMA)	Test	1.13	is Safe

ANNEX V: MULUNDU SMALL PIPE WATER SUPPLY SCHEME DETAILED BILLS OF QUANTITIES

A: PRELIMINARIES AND GENERAL ITEMS

ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (USD)	AMOUNT USD
1-A	**GENERAL ITEM**				
1-A1	**CONTRACTUAL REQUIREMENTS**				
1-A1.1	ADVANCE PAYMENT BOND	SUM	1		
1-A1.2	PERFORMANCE BOND	SUM	1		
1-A1.3	INSURANCES OF WORKS	SUM	1		
1-A1.4	THIRD PARTY INSURANCE	SUM	1		
1-A1.5	ESTABLISHMENT & MAINTENANCE OF CONTRACTORS CAMP,				
1-A1.5.1	FIXED PORTION	SUM	1		
1-A1.5.2	TIME RELATED PORTION	MONTH	6		
SUB-TOTAL					
1-A2	**SPECIFIED REQUIREMENTS**				
1-A2.1	FACILITIES FOR THE ENGINEER'S AND EMPLOYER'S STAFF				
1-A2.1.1	ALLOW FOR THE PROVISION AND MAINTENANCE OF THE SITE OFFICES. RATE TO INCLUDE PROVISION AND MAINTENANCES OF INTERNET ACCESS, TELEPHONE SERVICES, STATIONERY, FURNITURE AND OFFICE CONSUMABLES. THE FURNITURE SHALL REMAIN A PROPERTY OF THE CONTRACTOR	MONTH	RATE ONLY		
1-A2.1.2	ESTABLISH, MAINTAIN & REMOVE LABORATORY. RATE TO INCLUDE THE PROVISION OF LABORATORY EQUIPMENT IN ACCORDANCE WITH TECHNICAL SPECIFICATION PART 2 CLAUSE 2.1	MONTH	RATE ONLY		
SUB-TOTAL					
1-A3	**SERVICES FOR THE ENGINEER'S AND EMPLOYER'S STAFF**				
1-A3.1	SIGNBOARDS				
1-A3.2	PROVIDE AND MAINTAIN PROJECT SIGNBOARDS AS PER ENGINEER'S INSTRUCTION	MONTH	6		
1-A4	**TESTING OF MATERIALS**				
1-A4.1	TESTING OF MATERIALS AS PER ENGINEER'S INSTRUCTION AND SPECIFICATION	SUM	1		
1-A5	**TEMPORARY WORKS**				
1-A5.1	TRAFFIC DIVERSIONS	SUM	RATE ONLY		
1-A5.2	TRAFFIC REGULATION	SUM	RATE ONLY		
1-A5.3	PREPARATION, MAINTENANCE OF TEMPORARY ACCESS ROAD IN REQUIRED WIDTH AND LENGTH INCL. REINSTATEMENT AFTER COMPLETION OF THE WORKS	SUM	RATE ONLY		
1-A6	**OTHER**				
1-A6.1	TEMPORARY REMOVAL OF AND REINSTALLATION OF SIGNBOARDS, STREET LIGHTING, ELECTRIC POLES, ETC.	SUM	1		
1-A7	**SUBMISSION OF DOCUMENTS AND OTHER PROJECT REQUIREMENTS**				
1-A7.1	PROVISION OF PROJECT PROGRESS REPORTS, PROJECT EXECUTION PLAN AND DRAWINGS, WORK PROGRAM (IN MS PROJECT ON A GANTT CHART FORMAT), METHOD STATEMENT AND PHOTO DOCUMENTATION AS DESCRIBED IN THE SPECIFICATIONS.	SUM	6		
1-A7.2	PREPARATION OF CONSTRUCTION / WORKING DRAWINGS IN ACCORDANCE TO THE ENGINEERS	SUM			

ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (USD)	AMOUNT USD
	AND EMPLOYERS INSTRUCTION AS-BUILT DRAWINGS (PROVIDED AS PRINTED FULL SIZE PAPER COPIES AND AS ELECTRONIC COPIES IN BOTH PDF AND AUTOCAD DWG. FORMATS)				
SUB-TOTAL					
1-A8	**PRIME COST ITEMS**				
1-A8.1	IDENTIFICATION, SECURING, PROTECTION, MAINTENANCE ETC. INCLUDING DEVIATION OF EXISTING PUBLIC UTILITIES. RATE TO INCLUDE PAYMENTS TO UTILITY COMPANIES FOR RELOCATION OF BURIED OR OVERHEAD SERVICES	SUM	1		
1-A8.2	PERCENTAGE ADJUSTMENT TO ITEM A511.1	%			
1-A9	**OTHER COST ITEMS**				
1-A9.1-EP	ENVIRONMENTAL AND SOCIAL SAFEGUARDS	MONTH	6		
1-A9.2-HS	HEALTH AND SAFETY SAFEGUARDS (AT LEAST 1 HSS OFFICER	MONTH	6		
1-A9.3-SG	SOCIAL AND GENDER INTEGRATION	MONTH	6		
1-A9.4-IEC	HIV / AIDS INFORMATION, EDUCATION AND COMMUNICATION CAMPAIGN (IEC)	MONTH	6		
1-A9.5-CD	CONDOM DISTRIBUTION TO ALL SITE STAFF AND LABOUR	MONTH	6		
SUB-TOTAL					
TOTAL					

B: MULUNDU SPWS BILL OF QUANTITIES

ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (USD)	AMOUNT USD
D	**DEMOLITION & SITE CLEARANCE**				
2-D1	**GENERAL CLEARANCE**				
2-D112	URBAN LAND LOCALLY DISPOSED. (PROVISIONAL)	HA	0.20		
2-D2	**REMOVAL OF TREES AND STUMPS**				
2-D212	TREES OF GIRTH: 500 MM - 1 M., LOCALLY DISPOSED. (PROVISIONAL)	NR	1.00		
2-D222	TREES OF GIRTH: 1 - 2 M., LOCALLY DISPOSED. (PROVISIONAL)	NR	1.00		
2-D232	TREES OF GIRTH: 2 - 3 M., LOCALLY DISPOSED. (PROVISIONAL)	NR	1.00		
2-D3	**DEMOLITION OF BUILDINGS**				
	REMOVED FROM SITE & DISPOSED AS DIRECTED				
2-D331	MASONRY CONSTRUCTION VOLUME: NOT EXC. 50 M^3. (PROVISIONAL)	NR	RATE ONLY		
2-D332	MASONRY CONSTRUCTION VOLUME: 50 - 100 M^3. (PROVISIONAL)	NR	RATE ONLY		
2-D5	**CLEARANCE OF PIPELINE**				
	WAYLEAVES, DISPOSAL LOCAL				
2-D511	NOMINAL BORE: N.E. 100 MM., PIPELINE ONLY	M	RATE ONLY		
2-D521	NOMINAL BORE: 100 - 300 MM., PIPELINE ONLY	M	1,635.00		
2-D6	**REMOVAL OF ANT AND TERMITE**				
	HILLS AND NESTS				
2-D622	ALONG PIPELINE ROUTES, EXCESS MATERIAL LOCALLY DISPOSED. (PROVISIONAL)	M^3	2.00		
	REMOVAL OF MAN PLACED OR NATURALLY DEPOSITED MATERIAL				
2D744.P	REMOVAL OF EXISTING PIPES AND DISPOSED OF AS DIRECTED BY THE CLIENT OR CLIENTS REPRESENTATIVE	M	500.00		
E	**EARTHWORKS**				
E87	LANDSCAPING, PLANT TREES - REPLANT INDIGENOUS PLANTS ***(PROVISIONAL)***	NR	2.00		

ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (USD)	AMOUNT USD
SUB-TOTAL					
I	**PIPE - FITTINGS - SUPPLY**				
	NOTE: PIPES AND FITTING REQUIREMENTS, SIZES, QUANTITIES, ETC. TO BE DETERMINED IN LIAISON WITH THE ENGINEER AND WATER SERVICE PROVIDER PRIOR TO ORDERING				
2-I1	**SUPPLY OF UPVC PIPES**				
	PVC-U S & S TO SSRN 300 - MINIMUM PN 10				
2-I162.4F	50 MM DIAMETER	M	RATE ONLY		
2-I162.4H	75 MM DIAMETER	M	RATE ONLY		
2-I162.4J	110 MM DIAMETER	M	RATE ONLY		
2-I162.4K	160 MM DIAMETER	M	1,635.00		
2-I5	**FITTINGS IN UPVC TO UPVC PIPES**				
	BENDS DOUBLE SOCKETED NP 9/10				
	90˚ LONG RADIUS BENDS				
2-I524.3F	50 MM DIAMETER	NR	RATE ONLY		
2-I524.3H	75 MM DIAMETER	NR	RATE ONLY		
2-I524.3I	90 MM DIAMETER	NR	RATE ONLY		
	135˚ SHORT RADIUS BENDS				
2-I524.4F	50 MM DIAMETER	NR	RATE ONLY		
2-I524.4H	75 MM DIAMETER	NR	RATE ONLY		
2-I524.4I	90 MM DIAMETER	NR	RATE ONLY		
2-I524.4J	110 MM DIAMETER	NR	RATE ONLY		
2-I524.4K	160 MM DIAMETER	NR	3.00		
	TEES, EQUAL BRANCH AS MAIN				
2-I541.4F	50/50 MM DIAMETER	NR	RATE ONLY		
2-I541.4H	75/75 MM DIAMETER	NR	RATE ONLY		
	TEES BRANCH DOWN 1 DIAMETER.				
2-I542.4F	50/40 MM DIAMETER	NR	RATE ONLY		
2-I542.4H	75/50 MM DIAMETER	NR	RATE ONLY		
2-I542.4I	90/75 MM DIAMETER	NR	RATE ONLY		
2-I542.4K	160/110 MM DIAMETER	NR	RATE ONLY		
	TEES BRANCH DOWN 2 DIAMETER.				
2-I543.4J	110/75 MM DIAMETER	NR	RATE ONLY		
2-I543.4K	160/90 MM DIAMETER	NR	RATE ONLY		
	TEES BRANCH DOWN 3 DIAMETER.				
2-I544.4J	110/50 MM DIAMETER	NR	RATE ONLY		
2-I542.4K	160/75 MM DIAMETER	NR	RATE ONLY		
	TEES BRANCH DOWN 4 DIAMETER.				
2-I544.4J	110/40 MM DIAMETER	NR	RATE ONLY		
2-I542.4K	160/50 MM DIAMETER	NR	RATE ONLY		
SUB-TOTAL					
	CROSS OR WYE				
2-I549.4F	50/50 MM DIAMETER	NR	RATE ONLY		

ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (USD)	AMOUNT USD
2-I549.4H	110/50 MM DIAMETER	NR	RATE ONLY		
2-I549.4H	75/75 MM DIAMETER	NR	RATE ONLY		
2-I549.4J	110/50 MM DIAMETER	NR	RATE ONLY		
2-I549.4J	110/75 MM DIAMETER	NR	RATE ONLY		
2-I549.4K	160/75 MM DIAMETER	NR	RATE ONLY		
2-I549.4K	160/110 MM DIAMETER	NR	RATE ONLY		
	ADAPTORS, DETACHABLE COLLARS, COUPLINGS AND SADDLES				
	COMPLETE WITH BOLTS, NUTS AND GASKETS.				
	FLANGE ADAPTOR, FLEXIBLE				
2-I585.4F	50 MM DIAMETER	NR	RATE ONLY		
2-I585.4H	75 MM DIAMETER	NR	RATE ONLY		
2-I585.4I	90 MM DIAMETER	NR	RATE ONLY		
2-I585.4J	110 MM DIAMETER	NR	RATE ONLY		
2-I585.4K	160 MM DIAMETER	NR	3.00		
	ADAPTORS, DETACHABLE COLLARS COUPLINGS & SADDLES				
	ADAPTOR, STEPPED (REDUCERS)				
2-I589.4H	75/50 MM DIAMETER	NR	RATE ONLY		
2-I589.4I	90/50 MM DIAMETER	NR	RATE ONLY		
2-I589.4I	110/40 MM DIAMETER	NR	RATE ONLY		
2-I589.4J	110/50 MM DIAMETER	NR	RATE ONLY		
2-I589.4J	110/75 MM DIAMETER	NR	RATE ONLY		
2-I589.4K	160/75 MM DIAMETER	NR	RATE ONLY		
2-I589.4K	160/110 MM DIAMETER	NR	3.00		
	STANDARD COUPLERS, SOCKET & END PIECES				
	END CAPS				
2-I598.6F	50 MM DIAMETER	NR	RATE ONLY		
2-I598.6H	75 MM DIAMETER	NR	RATE ONLY		
2-I598.6I	90 MM DIAMETER	NR	RATE ONLY		
2-I598.6J	110 MM DIAMETER	NR	RATE ONLY		
	GATE VALVES TO SSRN 226 C/W T- KEYS				
	RESILIENT SEAL SERIES 14				
2-I911.4F	50 MM DIAMETER	NR	RATE ONLY		
2-I911.4H	75 MM DIAMETER	NR	RATE ONLY		
2-I911.4I	90 MM DIAMETER	NR	RATE ONLY		
2-I911.4J	110 MM DIAMETER	NR	RATE ONLY		
2-I911.4K	160 MM DIAMETER	NR	RATE ONLY		
	AIR VALVES, TRIPPLE FUNCTION VENTOMAT OR EQUIVALENT				
	WITH SEPARATE ISOLATING VALVE				
2-I957.42-D	160 MM TRIPLE ACTION, ANTI-SURGE, ANTI-SHOCK AIR VALVE	NR	2.00		
	C/W SEPARATE ISOLATING INTEGRAL VALVE. PN 10.				
SUB-TOTAL					
	ZONAL BULK METERS. FLANGED WOLTMAN TYPE COMPLETE WITH ALL THE FITTINGS				
2-991.3J	110 MM DIAMETER	NR			

ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (USD)	AMOUNT USD
I991.3K	160 MM DIAMETER	NR	1		
	DOMESTIC METERS				
	SINGLE JET, INFERENTIAL WITH DRY DIAL, DOMESTIC TYPE - NP 9/10 COMPLETE WITH A SADDLE, A 9 M 25 MM DIAMETER HDPE PIPE AND ALL THE FITTING ACCORDING TO DRAWING GFA-GIZ-SPWS-SD-001 AND GFA-GIZ-SPWS-SD-004				
2-I994.4B	15 MM DIAMETER	NR	RATE ONLY		
2-I994.4C	20 MM DIAMETER	NR	RATE ONLY		
2-I994.4D	25 MM DIAMETER	NR	25.00		
J	**PIPEWORK**				
	PIPES SEWERS & FITTINGS - INSTALL				
2-J1	**METHOD OF MEASUREMENT**				
	TYPE A IN METERS:				
	UPVC PIPES AND FITTINGS				
2-J161.2	PIPE N.B: N.E. 100 MM TRENCHES DEPTH: N.E 1 M	M	RATE ONLY		
2-J162.2	PIPE N.B: EXC. 100 BUT NOT EXC 200 MM TRENCHES DEPTH: N.E 1 M	M	1,635.00		
2-J2	**TESTING**				
2-J23	TEST PRESSURE EXC.6 BAR BUT NOT EXC. 12 BAR,				
2-J231	PIPE N.B.: N.E. 100 MM	M	RATE ONLY		
2-J232	PIPE N.B.: 100 - 200 MM.	M	1,635.00		
2-J3	**STERILISATION AND FLUSHING**				
2-J31	PIPE N.B.: N.E. 100 MM	M	RATE ONLY		
2-J32	PIPE N.B.: 100 - 200 MM.	M	1,635.00		
2-J4	**METHOD OF MEASUREMENT**				
	TYPE B BY NUMBER:				
	PIPE AND FITTINGS INSTALL				
	BENDS				
	SOCKETED				
	90°, 135° LONG RADIUS BENDS				
2-J421.12	NB: N.E. 100 MM IN TRENCHES, DEPTH: N.E. 1 M	NR	RATE ONLY		
2-J421.22	NB: EXC. 100 MM BUT NE. 200 MM IN TRENCHES, DEPTH: N.E. 1 M	NR	3.00		
	JUNCTIONS & BRANCHES				
	SOCKETED				
2-J422.12	NB: NE. 100 MM IN TRENCHES, N.E 1M	NR	RATE ONLY		
2-J422.22	NB: EXC. 100 BUT NOT EXC. 200 MM IN TRENCHES, N.E 1 M	NR	RATE ONLY		
	PIPE PIECES AND BELL MOUTHS				
	SINGLE FLANGED PIPE PIECES, LENGTH N.E 1.0 M				
2-J424.12	NB: NE. 100 MM IN TRENCHES, N.E 1 M	NR	RATE ONLY		
2-J424.22	NB: EXC. 100 BUT NOT EXC. 200 MM IN TRENCHES, N.E 1 M	NR	RATE ONLY		
SUB-TOTAL					
	STANDARD COUPLERS AND END PIECES				
	END CAPS				
2-J425.12	NB: NE. 100 MM IN TRENCHES, N.E 1 M	NR	RATE ONLY		
2-J425.23	NB: EXC.100 BUT NE. 200 MM IN TRENCHES, N.E 1 M	NR	RATE ONLY		

ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (USD)	AMOUNT USD
	ADAPTORS, DETACHABLE COLLARS COUPLINGS & SADDLES				
	ADAPTOR, STEPPED (REDUCERS)				
2-J425.12	NB: NE. 100 MM IN TRENCHES, N.E 1 M	NR	RATE ONLY		
2-J425.22	NB: EXC. 100 BUT NOT EXC. 200 MM IN TRENCHES, N.E 1 M	NR	RATE ONLY		
2-J425.43	NB: EXC. 300 BUT NOT EXC. 400 MM IN TRENCHES, DEPTH: 1 - 1.5 M	NR	RATE ONLY		
	VALVES, PENSTOCKS, HYDRANTS, METERS				
	GATE & BUTTERFLY VALVES C/W PROTECTION TUBE AND SPINDLE CAP				
2-J426.13	NB: NE. 100 MM IN TRENCHES, N.E 1 M	NR	RATE ONLY		
2-J426.23	NB: EXC.100 BUT NE. 200 MM IN TRENCHES, N.E 1 M	NR	RATE ONLY		
	AIR VALVES, CATT TYPE COMPLETE WITH ISOLATING VALVE				
2-J427.19	NB: NE. 100 MM DOUBLE ACTING AIR, SURGE SUPPRESSING AIR VALVE C/W ISOLATING INTEGRAL VALVE. PN 10. IN CHAMBERS	NR	2.00		
	ZONAL BULK METERS				
	DOUBLE FLANGED COMPLETE WITH ALL THE FITTINGS				
2-J428.29	NB: EXC.100 BUT NE. 200 MM IN CHAMBERS	NR	1.00		
	DOMESTIC METERS				
	COMPLETE WITH A SADDLE, A 8 M 25 MM DIAMETER HDPE PIPE AND ALL THE FITTING ACCORDING TO DRAWING GFA-GIZ-SPWS-SD-001 AND GFA-GIZ-SPWS-SD-004				
2-J428.19	NB: NOT EXC.100 MM IN TRENCHES	NR	101		
K	**PIPEWORK**				
	MANHOLE & PIPEWORK ANCILLARIES				
2-K1	**MANHOLES AND OTHER CHAMBERS**				
	IN ACCORDANCE WITH STANDARD				
	DRAWINGS				
2-K131.11	IN SITU CONCRETE GATE VALVE CHAMBER PIPE NOM. BORE N.E. 100 DEPTH NOT N.E. 1.5 M.	NR	RATE ONLY		
2-K131.21	IN SITU CONCRETE GATE VALVE CHAMBER PIPE NOM. BORE EXC. 100 BUT NOT EXC. 200 MM DEPTH NOT N.E. 1.5 M.	NR	RATE ONLY		
2-K132.21	IN SITU CONCRETE SINGLE AIR VALVE (SMALL ORIFICE) CHAMBER PIPE NOM. BORE EXC. 100 BUT NOT EXC. 200 MM DEPTH N.E. 1.5 M	NR	2.00		
2-K134.21	IN SITU CONCRETE BULK METER & STRAINER CHAMBER PIPE NOM. BORE EXC. 100 BUT NOT EXC. 200 MM DEPTH N.E. 1.5 M.	NR	1.00		
	SUB-TOTAL				
2-K2	**MANHOLE COVERS**				
2-K253	PRECAST CONCRETE: AREA: 1 M^2 – 2 M^2	NR	1.00		
2-K6	**CROSSINGS**				
2-K641.3	HEDGE CROSSING, PIPE NOM. BORE N.E. 250 MM (PROVISIONAL)	NR	4.00		
2-K661.3	FENCE CROSSING PIPE NOM. BORE N.E. 250 MM (PROVISIONAL)	NR	1.00		
2-K662.3	FENCE CROSSING PIPE NOM. BORE 250 - 500 MM (PROVISIONAL)	NR	RATE ONLY		
	PIPES UNDERCROSSING TRACK/ROAD				

Item	Description	Unit	Quantity	Rate (USD)	Amount USD
	Precast concrete load spreader beams as detailed and instructed on site.				
2-K681.3	Pipe nom bore n.e. 250 mm (provisional)	m	40.00		
2-K7	**REINSTATEMENT**				
K711	Breaking up, temporary and permanent reinstatement of Surfaced roads, pipe nom. bore n.e. 250 mm ***(provisional)***	m	15.00		
2-K741	Breaking up, temporary and permanent reinstatement of dirt roads, pipe nom. bore n.e. 250 mm ***(provisional)***	m	25.00		
2-K751	Breaking up, temporary and permanent reinstatement of grassland & lawns, pipe nom. bore n.e. 250 mm ***(provisional)***	m	1.00		
2-K761	Breaking up, temporary and permanent reinstatement of cultivated lands incl. gardens, pipe nom. bore n.e. 250 mm ***(provisional)***	m	Rate only		
K8	**OTHER PIPEWORK ANCILLARIES**				
2-K821.2	Marker Posts for Sluice Valves in accordance with standard drawings.	nr	Rate only		
2-K825.2	Marker Posts for Water Mains in accordance with standard drawings.	nr	3.00		
2-K826.2	Marker Posts for Master Meters in accordance with standard drawings.	nr	1.00		
	TOTAL CARRIED FORWARD TO BILL COLLECTION SHEET				
5B-L	**PIPEWORK-SUPPORTS & PROTECTION**				
	ANCILLARIES TO LAYING & EXCAVATION				
2-L1	**EXTRAS TO EXCAVATION AND BACKFILLING**				
2-L111	In pipe trenches excavation of rock class I material. (provisional)	M^3	15.70		
2-L112	In pipe trenches excavation of rock class II material. (provisional)	M^3	4.71		
2-L117	In pipe trenches backfilling with class S2 material. (provisional)	M^3	20.40		
2-L121	In manholes and chambers excavation of rock class I material (provisional).	M^3	5.00		
2-L122	In manholes and chambers excavation of rock class II material (provisional).	M^3	2.00		
2-L5	**EMBEDMENT/SURROUNDING**				
	BACKFILING				
	Bedding Material				
2-L321	In pipe trenches lower bedding with blended imported and screened class S3 material. Pipe n.b. n.e. 100 mm (provisional)	M^3	Rate only		
2-L322	In pipe trenches lower bedding with blended imported and screened class S3 material. Pipe n.b. 100 - 200 mm (provisional)	M^3	163.50		
	Surround Material				
2-L521	In pipe trenches pipe material surround incl. upper bedding, side filling and initial backfill with blended imported and screened class S3 material. Pipe n.b. n.e. 100 mm (provisional)	M^3	Rate only		
2-L522	In pipe trenches pipe material surround incl. upper bedding, side filling and initial backfill with blended imported and screened class S3 material. Pipe n.b. 100 - 200 mm (provisional)	M^3	204.38		
2-L7	**CONCRETE STOOLS AND THRUST**				
	BLOCKS CONCRETE CLASS 20				
	To horizontal bends				

ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (USD)	AMOUNT USD
2-L711.1	VOLUME: NOT EXC. 0.1 M^3, NOM. BORE: N.E. 100 MM.	NR	RATE ONLY		
2-L711.2	VOLUME: NOT EXC. 0.1 M^3, NOM. BORE: 100 - 200 MM.	NR	3.00		
	TO JUNCTIONS				
2-L751.1	VOLUME: NOT EXC. 0.1 M^3, NOM. BORE: N.E. 100 MM.	NR	RATE ONLY		
2-L751.2	VOLUME: NOT EXC. 0.1 M^3, NOM. BORE: 100 - 200 MM.	NR	RATE ONLY		
SUB-TOTAL					
	TO END CAPS				
2-L771.1	VOLUME: NOT EXC. 0.1 M^3, NOM. BORE: N.E. 100 MM.	NR	RATE ONLY		
2-L772.2	VOLUME 0.1 -0.2 M^3, BORE: 100 - 200 MM.	NR	RATE ONLY		
	MASS CONCRETE GRADE C20				
	20 MM AGGREGATES:				
	VALVE STOOLS				
2-L771.1	VOLUME NOT EXCEEDING 0.1M^3, FOR VALVE N.B. N.E. 100 MM.	NR	RATE ONLY		
2-L772.2	VOLUME 0.1 -0.2 M^3, FOR VALVE N.B. 100 - 200 MM	NR	RATE ONLY		
2-N	**MISCELLANEOUS METALWORK**				
2-N131	SUPPLY AND INSTALL STAINLESS STEEL LADDERS ACCORDING TO THE DRAWINGS	SET			
	ADDITIONAL ELEVATED WATER TANK				
	SUPPLY AND ERECT TANK COMPLETE WITH A 20 M HIGH STEEL TANK, ALL THE FITTINGS AND BULK FLOW METER				
2-N774	RUST RESISTANT STEEL TANK, VOLUME 365 M^3	NR	RATE ONLY		
2-N783	SUPPLY AND INSTALL ROOF VENT ASSEMBLY ACCORDING TO THE DRAWINGS, DIAM: 100 MM	NR	RATE ONLY		
2-X	**MISCELLANEOUS**				
2-X9	**OTHER**				
2-X9.1	METALLIC TAPE/STRIP FOR PIPELINE LOCATION PIGMENTED LOW DENSITY POLYETHYLENE AND ALUMINIUM FOIL IN A BRIGHT COLOUR CONTINUOUSLY LABELLED "DANGER PLASTIC PIPE" 8 IN ENGLISH	M	1,000.00		
2-X9.2	TEE KEYS FOR VALVE OPERATION PROVIDE TEE KEYS FOR THE OPERATION OF SLUICE VALVES. LENGTH = 800 MM C/W TAPERED HANDLE TIP FOR SURFACE BOX OPENING. KEYS TO SUIT EXTENDED SPINDLE TOP PROVIDED.				
	REHABILITATION OF EXISTING ELEVATED WATER TANK				
2-X9.3	ALLOW FOR THE REFURBISHMENT OF THE EXISTING ELEVATED 80 M^3 WATER TANK. THE REHABILITATION WORKS INCLUDE THE FOLLOWING: • STRUCTURAL ASSESSMENT OF THE TANK STRUCTURE AND STAND • DE-SLUDGING OF THE EXISTING TANK IN AN ENVIRONMENTALLY FRIENDLY WAY • REPLACEMENTS OF WORN-OUT VALVES • REPLACEMENT AND SECURING OF EXISTING PIPE WORKS AS REQUIRED • REPAIR OF THE OF THE EXISTING TANK STRUCTURE, TANK STAND AND TANK ROOF STRUCTURE	PS	1.00		
SUB-TOTAL					
	FLOATING INTAKE REHABILITATION				

ITEM	DESCRIPTION	UNIT	QUANTITY	RATE (USD)	AMOUNT USD
2-x9.6	ALLOW FOR THE FOLLOWING REHABILITATION WORKS ON THE FLOATING INTAKE: • REFURBISHMENT, REPOSITIONING THE INTAKE AT ABOUT 35M FROM THE LUAPULA RIVERBANKS AND ANCHORING THE PUMP PLATFORM • FABRICATION AND INSTALLATION OF A PROTECTIVE STEEL CAGE TO WORK AS SCREENS TO SUSPENDED SUBSTANCES TRANSPORTED BY THE RIVER	SUM	1.00		
2-x9.7	PROVIDE AND INSTALL A CENTRIFUGAL PUMP WITH A DISCHARGE OF 94.90 M^3/H AND HEAD OF 90 M	SUM	1.00		
2-x9.8	DESIGN, SUPPLY AND INSTALL A SOLAR POWER SYSTEM COMPLETE WITH SOLAR PANELS, STORAGE BATTERIES, INVERTER, AC CHARGER AND ALL THE NECESSARY FITTINGS FOR POWERING THE PUMP AND EXTERNAL LIGHTING FOR THE INTAKE AREA	SUM	1.00		
SUB-TOTAL					
TOTAL					

C: MULUNDU SPWS PUMP HOUSE BILL OF QUANTITY

Item	Description	Unit	Quantity	Rate (USD)	Amount USD
D	**DEMOLITION & SITE CLEARANCE**				
4-D1	**GENERAL CLEARANCE**				
4-D112	Urban land Locally disposed. (Provisional)	ha	0.010		
4-D142	Rough grassland	ha	0.005		
4-D152	Open bush and thicket	ha			
4-E	**EARTHWORKS**				
4-E3	***Excavation for foundations***				
4-E311.1	Excavation for foundations topsoil maximum depth: not exceeding 0.25 m.	m^3	5.58		
4-E324.1	Excavation for foundations maximum depth: 1–2 m, in class III materials for Reuse	m^3	12.79		
4-E324.2	Excavation for foundations maximum depth: 1–2 m, in class III materials, for disposal	m^3	6.89		
3-E5	***Excavation ancillaries***				
4-E512.1	Trimming of excavated surfaces in class II material	m2	49.20		
4-E552	Preparation of excavated surfaces	m2	49.20		
4-E7	***Backfilling and Compaction***				
	The following items for filling shall include compaction to 98% MOD AASHTO in layers of not more than 150mm, and additional filling necessitated by settlement or penetration into underlying material as applicable.				

Item	Description	Unit	Quantity	Rate (USD)	Amount USD
	Backfilling of foundation trenches				
4-E611.4	backfilling to structures using suitable excavated selected class III material	m^3	12.79		
	Backfilling for the hardcore				
4-E612.5	backfilling to structures using imported class II material from Contactor's own source	m^3	8.83		
4-W	**WATERPROOFING**				
4-W1	***Damp proofing (membranes***				
4-W131	Damp proofing, waterproof sheeting to upper surfaces inclined at an angle not exceeding 30 degrees to the horizontal; 500 Gauge Heavy Duty polythene to BS 3012 laid under surface beds, with minimum 200 mm side and end laps including dressing to sinkings, across tops of walls etc (measured nett no allowance made for laps) in one layer	m^2	24.53		
4-X9	**Anti-termite treatment**				
4-X941	Chemical anti-termite treatment executed by an approved specialist under a ten-year guarantee to surfaces hardcore, etc.	m^2	24.53		
	IN-SITU CONCRETE WORKS FOR SUBSTRUCTURE				
4-F3	***Designed mix for ordinary structural concrete for class C exposure using ordinary portland cement***				
	The rate for provision for concrete shall also include the provision of cement and all the necessary aggregates				
	Provision of concrete for blinding				
4-F226	Provide mass concrete grade 15 with maximum aggregate size of 20mm to be used for blinding	m^3	0.95		
TOTAL CARRIED FORWARD TO BILL COLLECTION SHEET					
	Provision of concrete for foundation Footing				
4-F236	Provide mass concrete grade 20 with maximum aggregate size of 20mm to be used for foundation footing	m^3	3.25		
	Provision of concrete ground floor slab				
4-F246	Provide mass concrete grade 25 with maximum aggregate size of 20mm to be used for ground floor slab	m^3	3.68		
4-F71	***Placing of mass concrete***				
4-F712	As blinding				
	thickness: not exceeding 50mm	m^3	0.95		
4-F724	In foundation footing				
	thickness: 150mm - 300 mm	m^3	3.25		

Item	Description	Unit	Quantity	Rate (USD)	Amount USD
4-F81	***Placing of Reinforced Concrete***				
4-F823	In ground floor slab				
	thickness: 100-150	m^3	3.68		
	CONCRETE ANCILLARIES FOR SUBSTRUCTURE				
4-G2	***Formwork: Fair finish***				
	Formwork for Slab				
4-G222	Plane vertical, width: 0.1 - 0.2m	m^2	6.89		
	Reinforcement				
4-G524	High yield bars to BS 4449, diameter 12mm	t	0.11		
4-G572	Steel mesh fabric reinforcement to BS 4483	m^2	24.53		
	Layer of mesh fabric reinforcement laid in slab or bed with 150mm side and end laps (measured net - no allowance made for laps) – con-force 86 weighing 0.086 kg per square				
4-U5	**BLOCKWORK SUBSTRUCTUE**				
	Dense blockwork. hollow block to BS 6073, filled solid with C10 concrete, stretcher bond, mortar ratio 1:3				
4-U521	150mm dense blockwork laid in stretcher bond jointed in (1:3) cement mortar for vertical walls	m^2	25.7		
4-U591.1	Joint reinforcement using 26 Gauge mild steel "Brick force" reinforcement laid horizontally every second course in mortar joint in 150mm thick vertical walls.	m	60		
TOTAL CARRIED FORWARD TO BILL COLLECTION SHEET					
	INSITU CONCRETE FOR SUPERSTRUCTURE				
	Provision of concrete for the ring beam				
4-F246	Provide mass concrete grade 25 with maximum aggregate size of 20mm to be used in the ring beam	m^3	0.81		
	Placing of Reinforced Concrete				
4-F86	In beams				
4-F862	X-sectional area: 0.03 - 0.01 m^2	m^3	0.81		
	CONCRETE ANCILLARIES FOR SUPERSTRUCTURE				
	Formwork: Fair finish				
	Formwork for ring beam				
4-G215	Plane horizontal, width: 0.1 - 0.2 m	m^2	3.15		
4-G243	Plane vertical, width:0.2 - 0.4	m^2	6.89		

Item	Description	Unit	Quantity	Rate (USD)	Amount USD
4-A632a	Testing of materials: concrete test cubes as specified and required by the engineer	nr	20.00		
4-A632b	Testing of materials: allow for carrying out slump tests when directed by the engineer or site manager	nr	20.00		
	BLOCKWORK SUPERSTRUCTUE				
	Lightweight blockwork. hollow block to BS 6073, stretcher bond, mortar (1:4).				
4-U421	Vertical 150 mm nominal thickness straight wall	m^2	73.32		
4-U492	Damp proof courses: width 150 mm to BS 743	m	25.00		
4-U591.2	Joint reinforcement using 26 Gauge mild steel "Brick-force" reinforcement laid horizontally every second course in mortar joint in 150mm thick vertical walls.	m	150.00		
	ROOF STRUCTURE				
	-				
4-W321	IBR widespan roof sheets or other approved profiled roof sheeting to BS 4868 with 0.5mm thickness in one layer upper surfaced inclined at an angle not exceeding 30° to the horizontal.	m^2	33.27		
4-O313	Structural softwood timber components, cross-sectional area 0.01 - 0.1 m^3, Length: 3-5 m to be used as purlins, rafters and wall plate treated with wood preservative.				
	i) 100 x 50 mm for rafters AND wall plate	m	61		
	ii) 50 x 50 mm for purlins	m	47.50		
	-				
	SURFACE FINISHES, LININGS AND PARTITIONS				
	In situ finishes, beds and backlings				
4-Z411	Sand and cement floor screed 40mm thick, floated of mix 1:4	m^2	24.53		
	Walls				
4-Z413.1	Render: Cement and sand backing (1:4), 13mm thick wood floated; externally	m^2	73.32		
4-Z413.2	Render: Cement and sand backing (1:4), 19mm thick steel floated; internally	m^2	73.32		
TOTAL CARRIED FORWARD TO BILL COLLECTION SHEET					
	PAINTING AND DECORATIONS				
	Emulsion paint				
	Prepare, touch up primer, one universal undercoat and two coats PVA washable				

Item	Description	Unit	Quantity	Rate (USD)	Amount USD
4-V563.1	Smooth concrete surfaces inclined at an angle exceeding 60º to the horizontal, to rendered walls externally	m^2	73.32		
4-V563.2	Smooth concrete surfaces inclined at an angle exceeding 60º to the horizontal, to rendered walls internally	m^2	73.32		
	CARPENTRY AND IRONMONGERY				
	Doors				
4-X711	Standard Wooden flush door for internal use with single leaf, size 700 x2000 mm	nr	2.00		
4-X713.1	Standard Wood, panel door for external use with double leaf, size 900 x 2000 mm	nr	1.00		
4-X713.2	Standard Wood, panel door for external use with double leaf, size 800 x 2000 mm	nr	1.00		
	Ironmongery				
	Should be supplied and fixed with matching screws				
4-Z343	Two lever mortice locksets as specified	nr	4.00		
	METALWORK				
	Door Frames				
	14 Gauge pressed steel door frames complete with fixing lugs, temporary supports and 3 No. 100mm long steel butt hinges per door leaf, fixed to jambs				
	-				
4-O361.1	Frame of 2 M profile, single rebate for flush panel hollow core door (doors measured separately) overall size 700 x 2000mm	nr	2		
4-O361.2	Frame of 2 M profile, single rebate for solid panel door (doors measured separately) overall size 800 x 2000 mm	nr	1		
4-O361.3	Frame of 2 M profile, single rebate for solid panel door (doors measured separately) overall size 900 x 2000 mm	nr	1.00		
	Windows				
4 - X65	Supply and install powder coated Aluminium window frames complete with 6mm thick clear glass, fixing lugs, temporary supports as supplied by manufacturer				
4 - X651.1	600 x 400 mm	nr	2.00		
4 - X651.2	600 x 600 mm	nr	2.00		
4 - X651.3	1200 x 600 mm	nr	1.00		
4 - X653	1800 x 1400 mm	nr	1.00		
	ELECTRICAL INSTALLATION				

Item	Description	Unit	Quantity	Rate (USD)	Amount USD
4-X942	Allow for the design of the solar powered electrical installation capable of powering the pump as well as the lighting of the area.	sum	1.00		
4-X943	Allow for the installation of a solar powered electrical system capable of powering the pump as well as the tank premises	sum	1.00		
TOTAL CARRIED FORWARD TO BILL COLLECTION SHEET					

ANNEX VI: DETAILED ENGINEERING DRAWINGS AND DESIGNS OF THE MULUNDU SPWS

Reform of the Water Sector Programme Phase II in Zambia (RWS II)

SMALL PIPE WATER SUPPLY SCHEMES HYDRAULIC DESIGN REPORT VOLUME II

LOT 2 DRAWINGS-MULUNDU SPWS)

NOVEMBER 2021

german cooperation
DEUTSCHE ZUSAMMENARBEIT

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

GFA CONSULTING GROUP

WATER CONNECTIONS DRAWINGS COVER PAGE

NOTES

SCALE ON A1: NTS

INDEX	NOTES:	DATE	SIGNED

REVISION AND ISSUES

CLIENT:

CONSULTANT: GFA Consulting Group GmbH

CONTRACT:

Reform of the Water Sector Programme Phase II in Zambia (RWS II)

TITLE:

Water Connection Drawings Cover Page

REFERENCE DRAWINGS:

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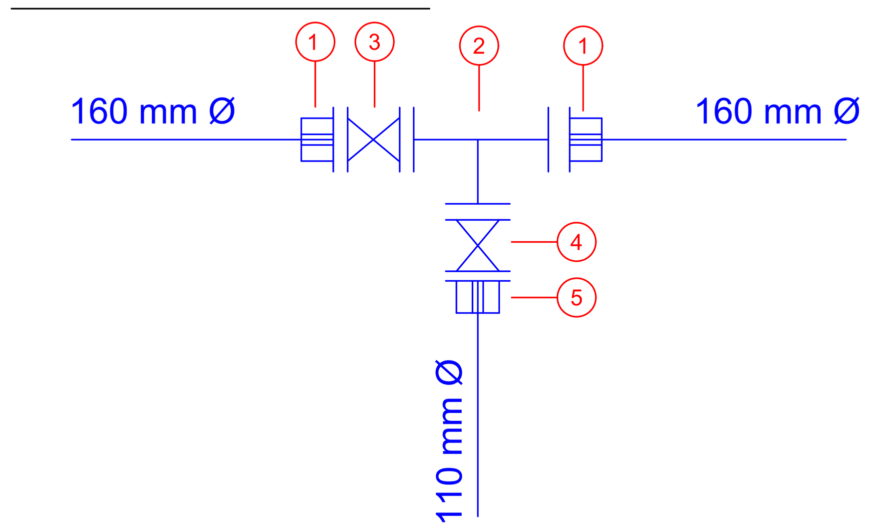
APPROVED:	KAM	NOV 2021	

PROJECTION: UTM 35 South / WGS 84 / metric

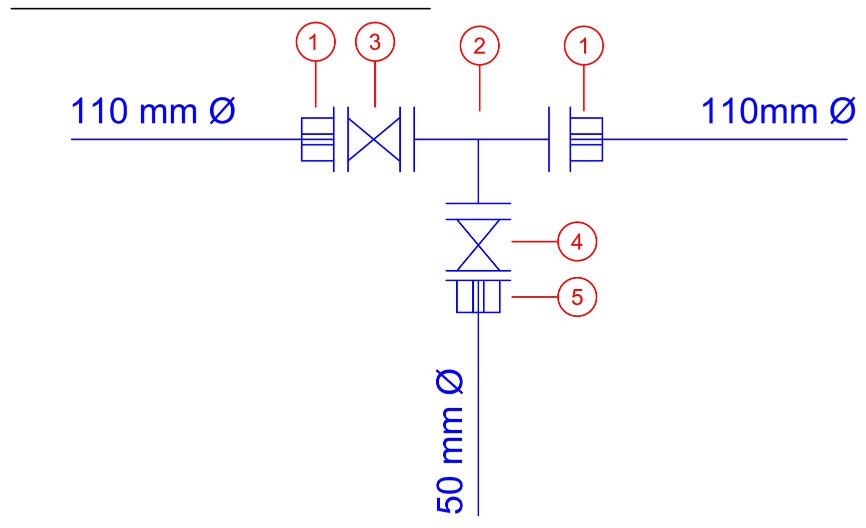
DRWG.No.: GFA-GIZ-SPWS-WCD-000

DETAIL TYPE 01



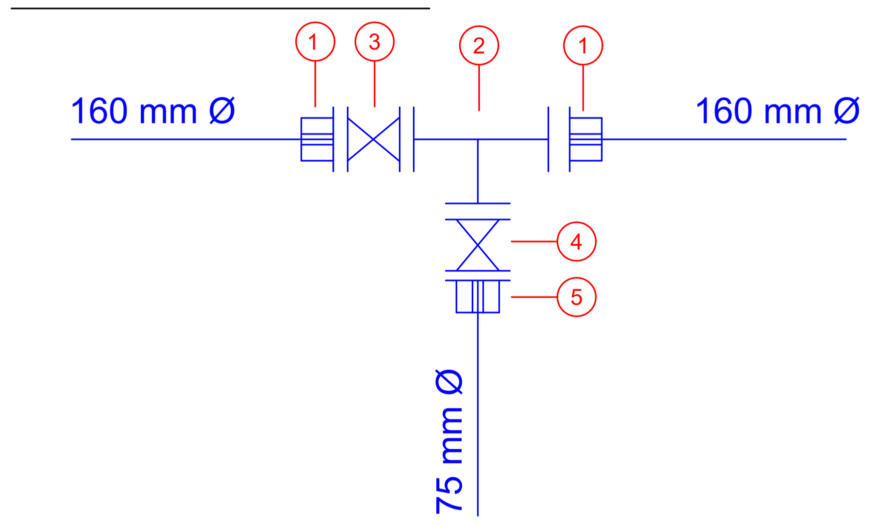
	ITEM DESCRIPTION	QTY.
1	160 mm Ø FLANGE ADAPTOR	2
2	160/110 mm Ø ALL FLANGED TEE	1
3	160 mm Ø SLUICE VALVE	1
4	110 mm Ø SLUICE VALVE	1
5	110 mm Ø FLANGE ADAPTOR	1

DETAIL TYPE 04



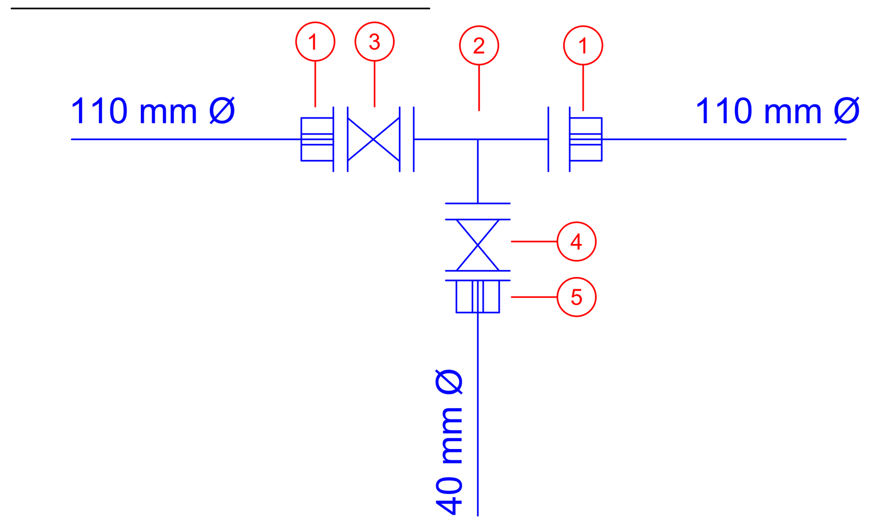
	ITEM DESCRIPTION	QTY.
1	110 mm Ø FLANGE ADAPTOR	2
2	110/50 mm Ø ALL FLANGED TEE	1
3	110 mm Ø SLUICE VALVE	1
4	50 mm Ø SLUICE VALVE	1
5	50 mm Ø FLANGE ADAPTOR	1

DETAIL TYPE 02



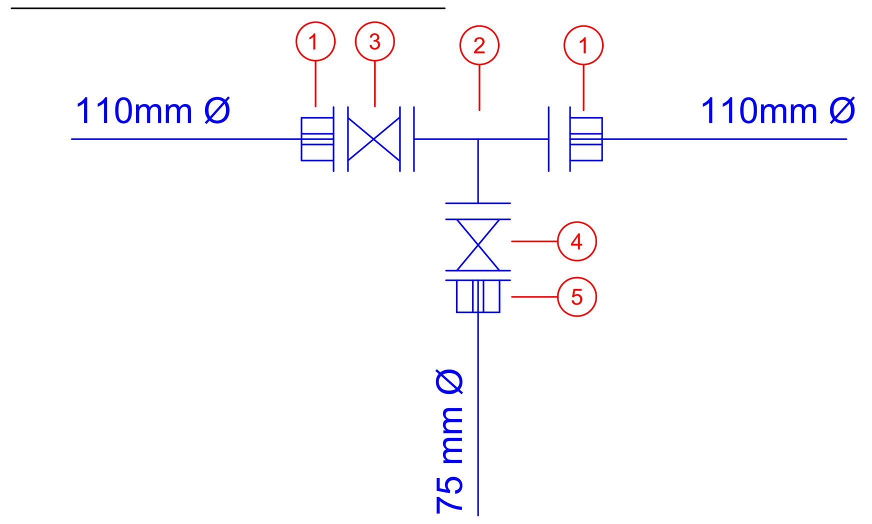
	ITEM DESCRIPTION	QTY.
1	160 mm Ø FLANGE ADAPTOR	2
2	160/75 mm Ø ALL FLANGED TEE	1
3	160 mm Ø SLUICE VALVE	1
4	75 mm Ø SLUICE VALVE	1
5	75 mm Ø FLANGE ADAPTOR	1

DETAIL TYPE 05



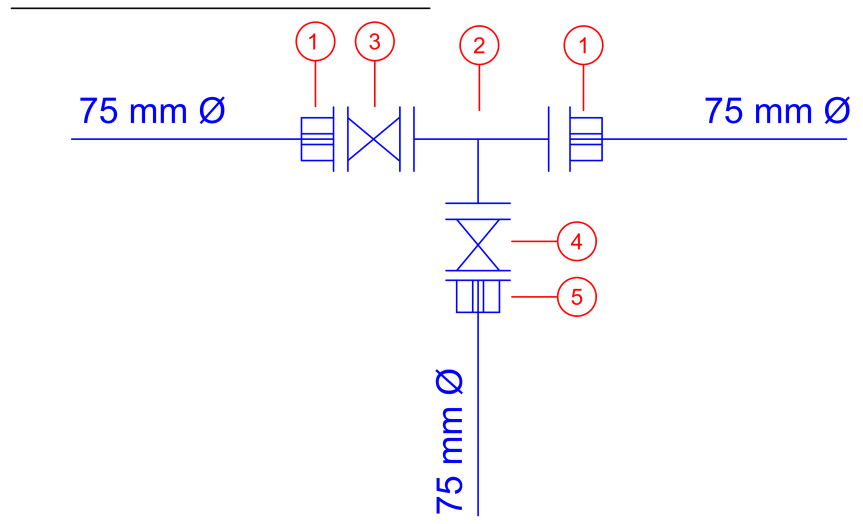
	ITEM DESCRIPTION	QTY.
1	110 mm Ø FLANGE ADAPTOR	2
2	110/40 mm Ø ALL FLANGED TEE	1
3	110 mm Ø SLUICE VALVE	1
4	40 mm Ø SLUICE VALVE	1
5	40 mm Ø FLANGE ADAPTOR	1

DETAIL TYPE 03



	ITEM DESCRIPTION	QTY.
1	110 mm Ø FLANGE ADAPTOR	2
2	110/75 mm Ø ALL FLANGED TEE	1
3	110 mm Ø SLUICE VALVE	1
4	75 mm Ø SLUICE VALVE	1
5	75 mm Ø FLANGE ADAPTOR	1

DETAIL TYPE 06



	ITEM DESCRIPTION	QTY.
1	75 mm Ø FLANGE ADAPTOR	2
2	75/75 mm Ø ALL FLANGED TEE	1
3	75 mm Ø SLUICE VALVE	1
4	75 mm Ø SLUICE VALVE	1
5	75 mm Ø FLANGE ADAPTOR	1

NOTES

SCALE ON A1: NTS

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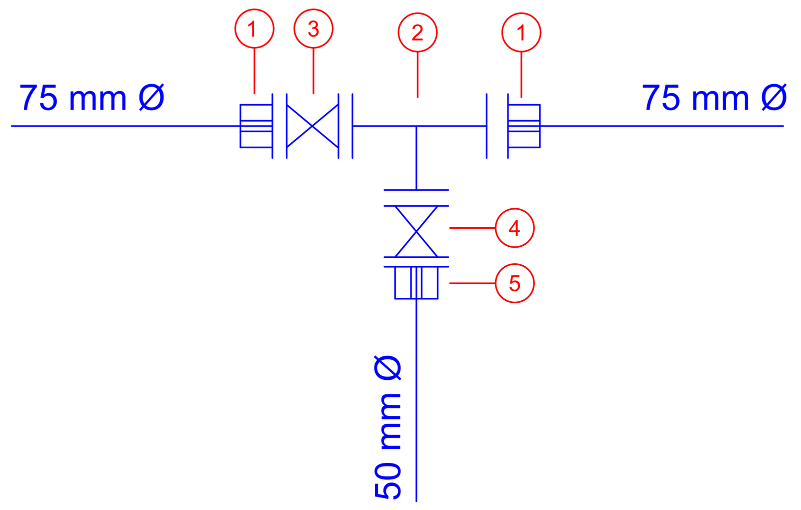
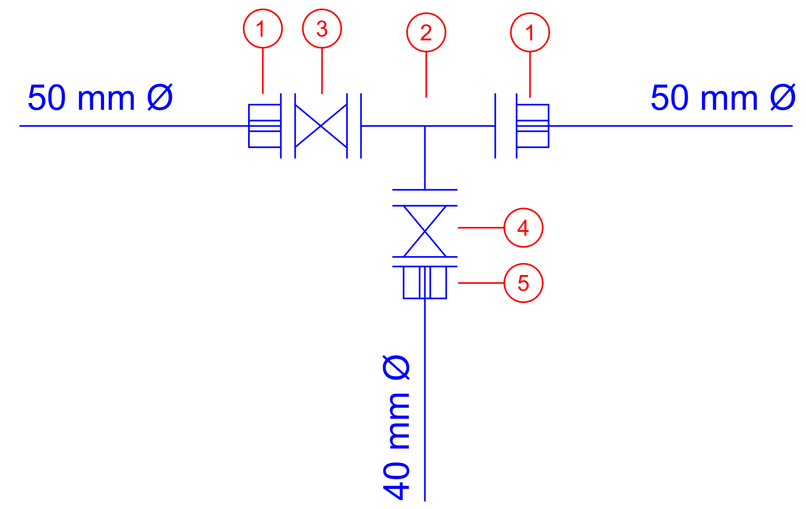
NOTES

DETAIL TYPE 07



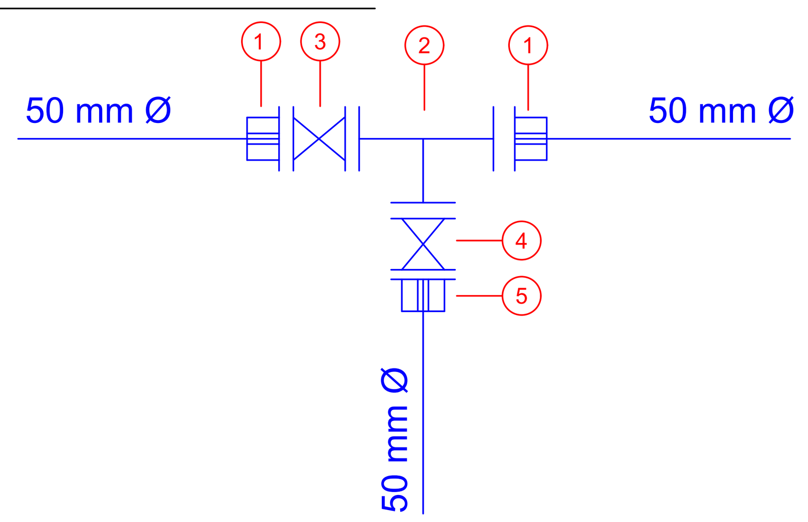
	ITEM DESCRIPTION	QTY.
1	75 mm Ø FLANGE ADAPTOR	2
2	75/50 mm Ø ALL FLANGED TEE	1
3	50 mm Ø SLUICE VALVE	1
4	50 mm Ø SLUICE VALVE	1
5	50 mm Ø FLANGE ADAPTOR	1

DETAIL TYPE 09



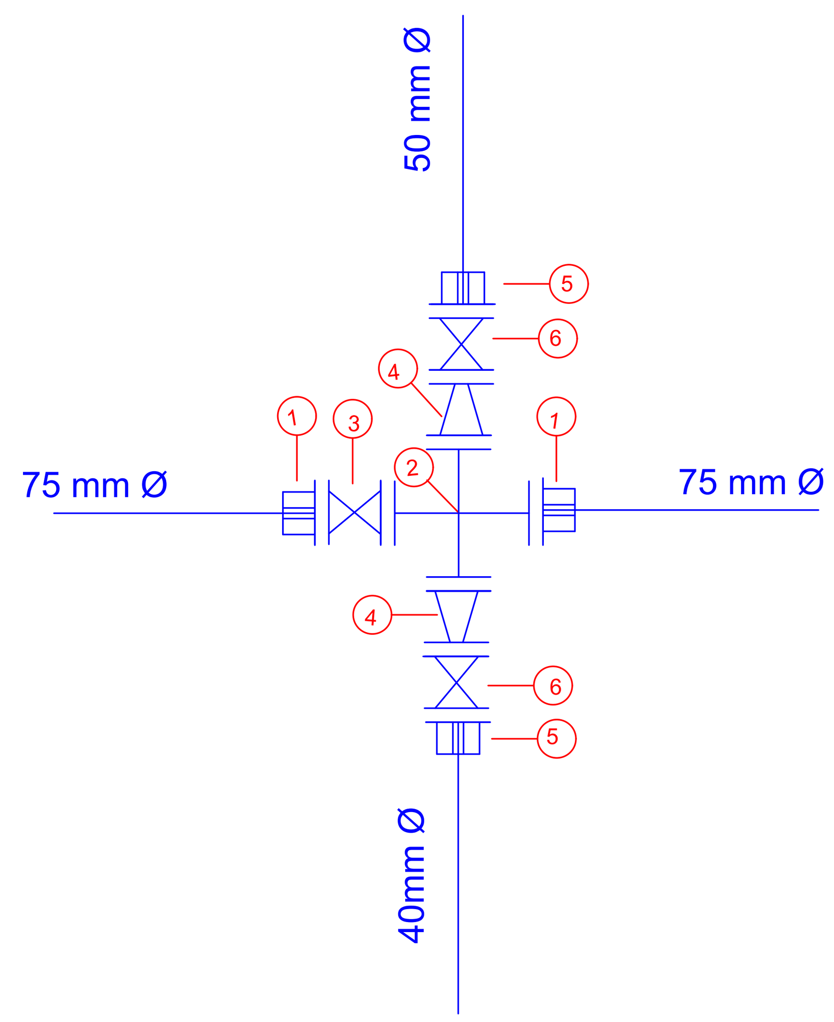
	ITEM DESCRIPTION	QTY.
1	50 mm Ø FLANGE ADAPTOR	2
2	50/40 mm Ø ALL FLANGED TEE	1
3	40 mm Ø SLUICE VALVE	1
4	40 mm Ø SLUICE VALVE	1
5	40 mm Ø FLANGE ADAPTOR	1

DETAIL TYPE 08



	ITEM DESCRIPTION	QTY.
1	50 mm Ø FLANGE ADAPTOR	2
2	50/50 mm Ø ALL FLANGED TEE	1
3	50 mm Ø SLUICE VALVE	1
4	50 mm Ø SLUICE VALVE	1
5	50 mm Ø FLANGE ADAPTOR	1

DETAIL TYPE 10



	ITEM DESCRIPTION	QTY.
1	75mm Ø FLANGE ADAPTOR	2
2	75 mm Ø ALL FLANGED CROSS	1
3	75 mm Ø SLUICE VALVE	1
4	75/40 mm Ø FLANGED REDUCER	2
5	50 mm Ø FLANGE ADAPTOR	2
6	40 mm Ø SLUICE VALVE	2

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INDEX:	NOTES:	DATE	SIGNED

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CONSULTANT: GFA Consulting Group GmbH

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STANDARD DRAWINGS COVER PAGE

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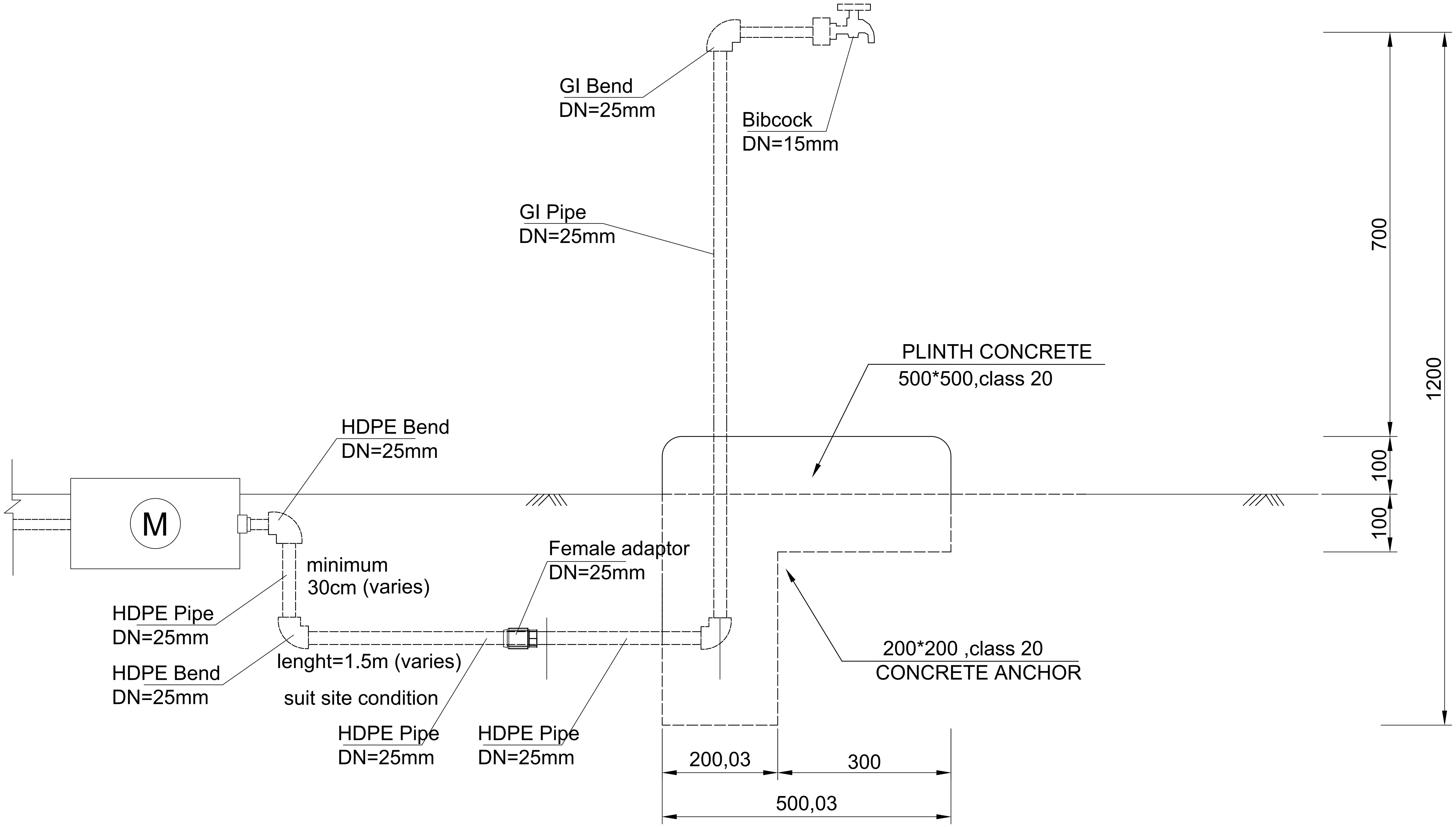

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Water Stand Pipe and Meter Connection Detail

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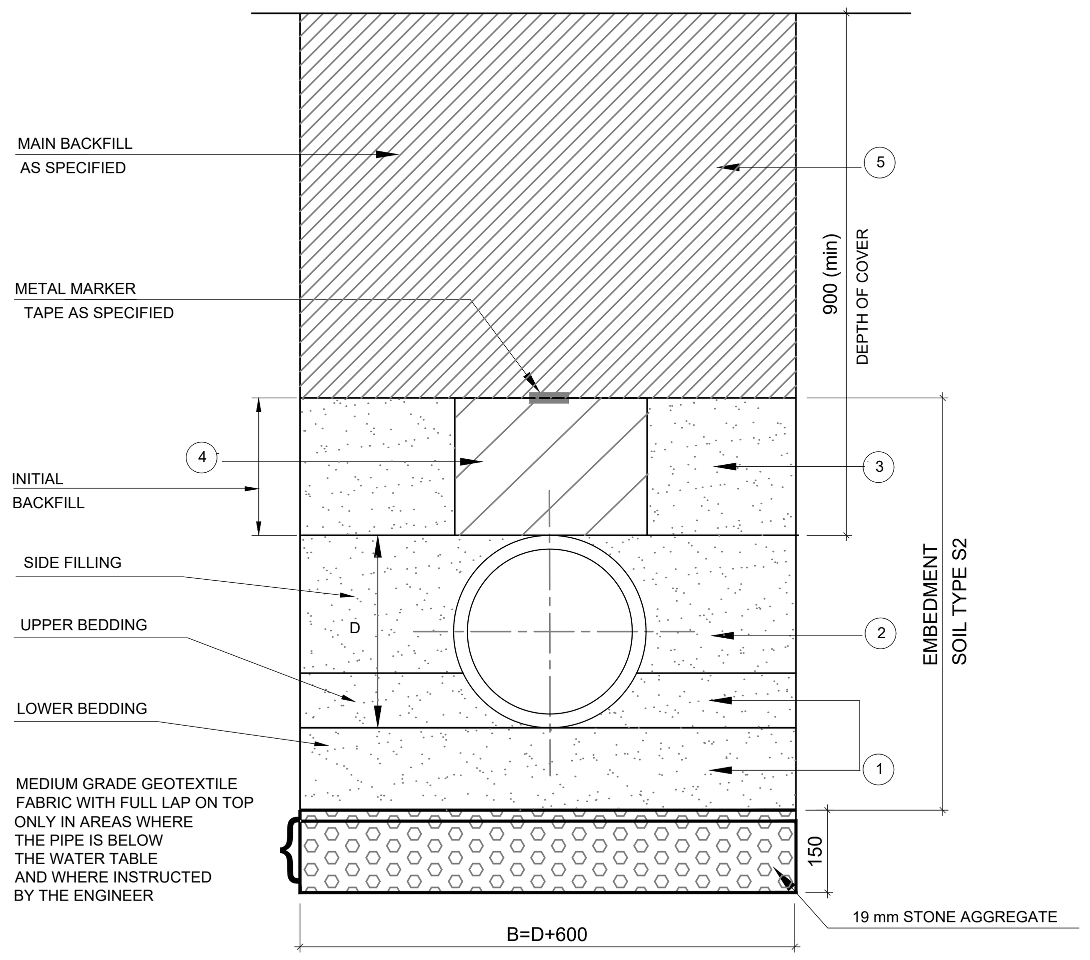
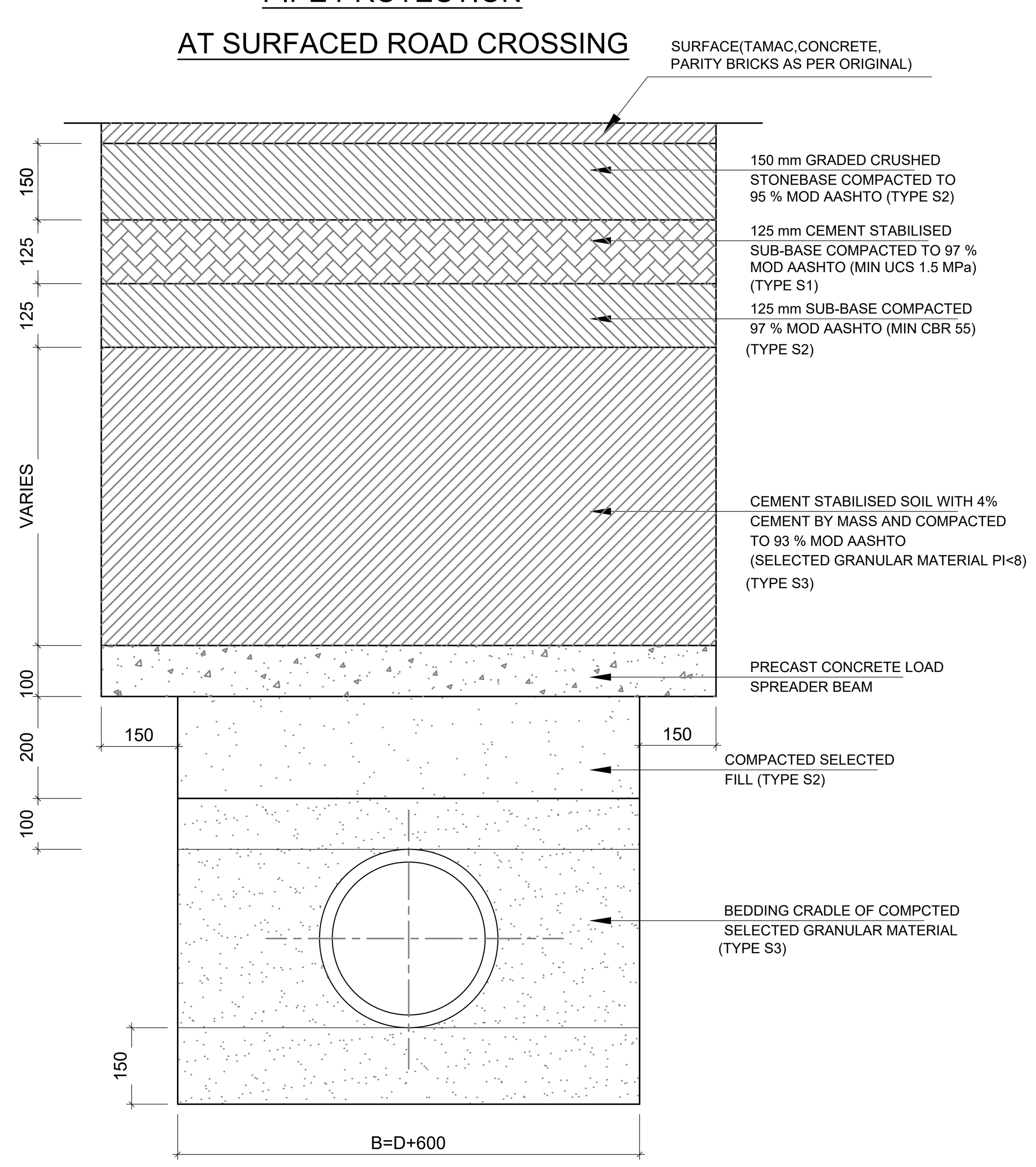
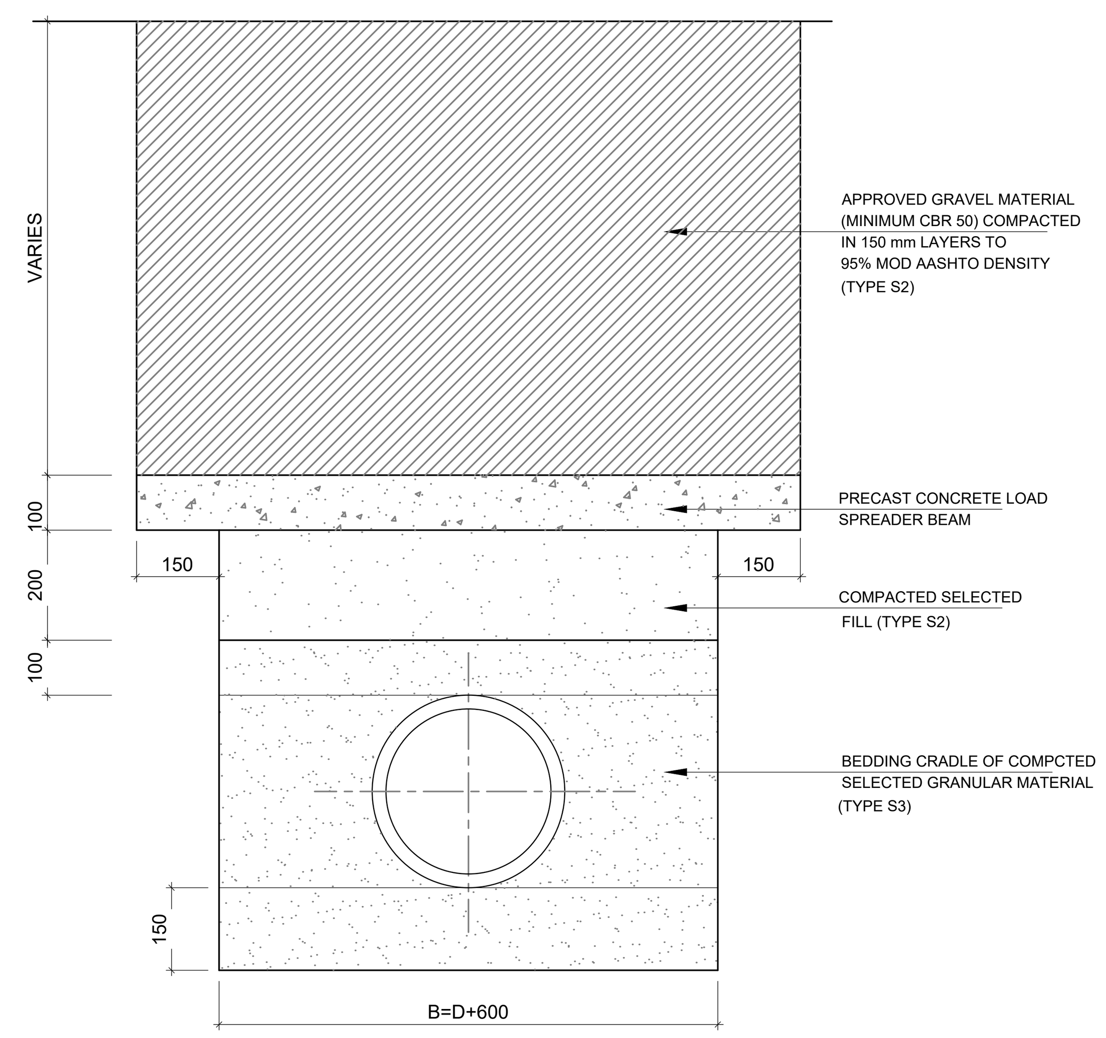
TYPICAL TRENCH EXCAVATION AND BACKFILLING FOR PE/ uPVC PIPES



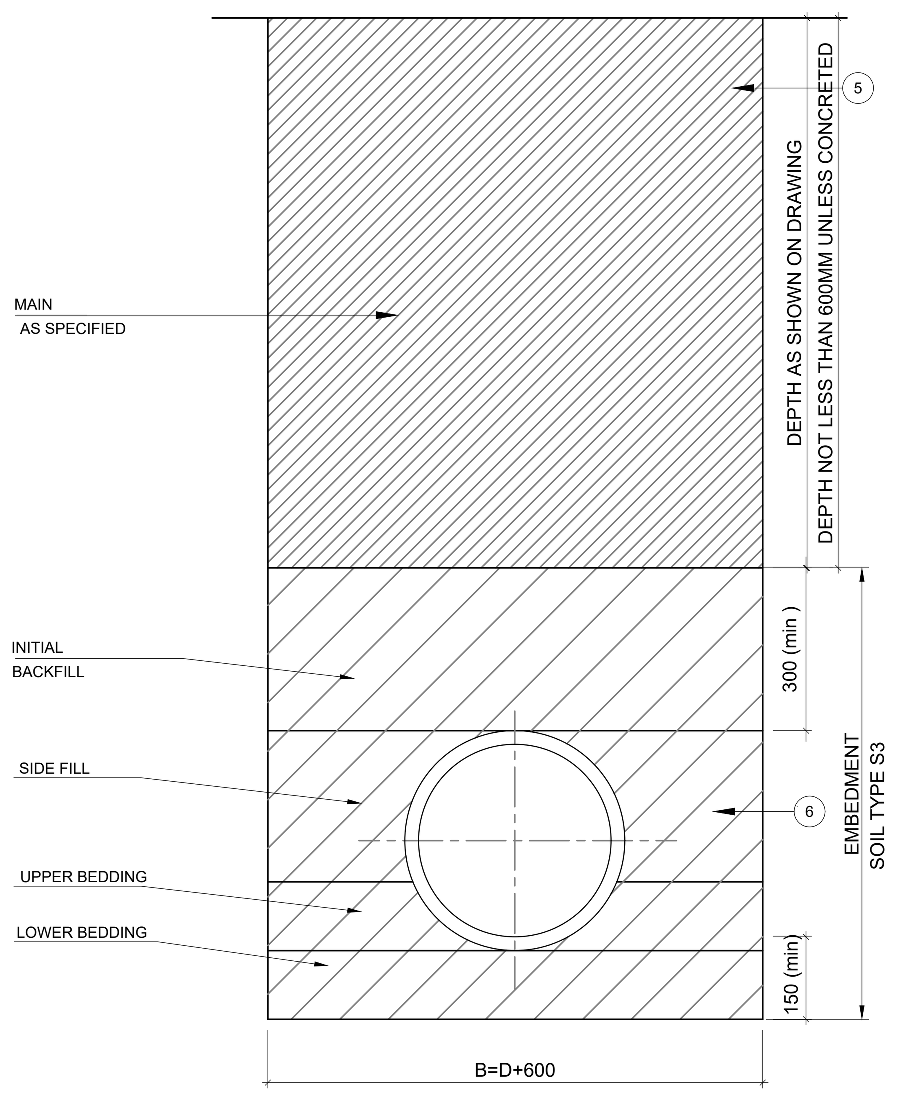
PIPE PROTECTION AT SURFACED ROAD CROSSING



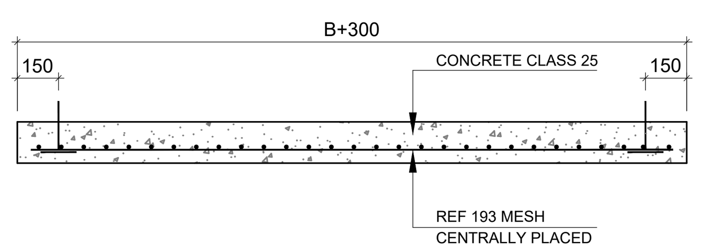
PIPE PROTECTION AT UNSURFACED ROAD CROSSING



TYPICAL TRENCH EXCAVATION AND BACKFILLING FOR FERROUS PIPES

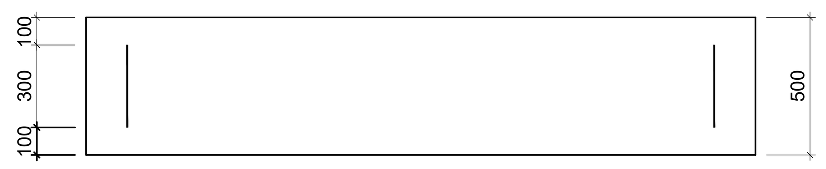


PRECAST CONCRETE LOAD SPREADER BEAM



SECTION THROUGH SPREADER BEAM

1:10



PLAN

1:10

SPECIAL NOTES

1. INSTEAD OF A CONCRETE SPREADER BEAM, A CONCRETE PIPE OR CULVERT WITH SUFFICIENT INTERNAL BORE TO FACILITATE INSERTION OF PIPES COULD BE USED IF APPROVED/INSTRUCTED BY THE ENGINEER.
2. FOR THRUST-BORED ROAD CROSSING, A STEEL SLEEVE SHALL BE PROVIDED WITH INTERNAL DIAMETER ADEQUATE TO ACCOMODATE PIPE AND JOINT FOR EASY REMOVAL.

LEGEND :

D PIPE OUTSIDE DIAMETER

B TRENCH WIDTH (SEE TABLE)

1 BEDDING COMPRISING OF APPROVED GRANULAR BEDDING MATERIAL (SAND) COMPACTED IN 50 mm LAYERS TO A THICKNESS OF 100mm OR AS DIRECTED BY THE ENGINEER'S REPRESENTATIVE.

2 APPROVED GRANULAR BEDDING MATERIAL COMPACTED IN LAYERS AS PER NOTE 2. CAREFUL TAMPING ON EITHER SIDE OF THE PIPE SHOULD BE MAINTAINED TO ENSURE EQUAL PRESSURE ON BOTH SIDES OF THE PIPE.

3 APPROVED GRANULAR BEDDING MATERIAL COMPACTED IN SHALLOW LAYERS TO A MAXIMUM OF 150 mm THICK AND MINIMUM 75 mm THICK, FOR TYPE S3.

4 AS IN 3 ABOVE, BUT EXCESSIVE TAMPING TO BE AVOIDED.

5 NORMAL BACKFILL MATERIAL PROPERLY RAMMED IN LAYERS. NOT EXCEEDING 150 mm THICK.

6 APPROVED GRANULAR BACKFILL MATERIAL COMPACTED TO 90 % MPD IN LAYERS AS PER NOTE 2.

TYPICAL TRENCH WIDTHS FOR PIPES

NOMINAL DIAMETER D (mm)	80	100	150	200	250	300
WIDTH OF TRENCH B (m)	0.70	0.70	0.75	0.80	0.85	0.90

B = D + 0.6 m (LIMITED TO A MINIMUM OF 0.6 m)

TABLE 1 : MATERIAL DESCRIPTION CHART

SOIL TYPE	DESCRIPTION	GROUP SYMBOL
S1	GRAVEL – SINGLE SIZE	GW
S2	GRAVEL – GRADED	GP
S3	SAND AND COARSE GRAINED SOILS WITH LESS THAN 12% FINES.	GF

TABLE 2 : COMPACTION CHART GUIDE

% MPD	SOIL TYPE	COMPACTION METHOD	
		THICKNESS OF LAYER (mm)	No. OF PASSES
90	S1 S2 S3	150 150 75	1 2 2

NOTES:

1. MINIMUM TRENCH WIDTH TO BE NORMAL PIPE DIAMETER PLUS 600 mm.
2. THE LOWER & UPPER BEDDING INCLUDING THE SIDE FILL SHALL BE COMPACTED IN LAYERS WHOSE DEPTH SHALL NOT EXCEED 75 mm NOR HALF THE NOMINAL PIPE DIAMETER WHICHEVER IS THE LESSER.
3. IN GENERAL, THE METHOD OF ATTAINING THE REQUIRED COMPACTION WILL BE ASCERTAINED AS FOLLOWS :
   (i) THE ENGINEER'S REPRESENTATIVE WILL IDENTIFY, CLASSIFY AND AGREE THE SOIL TYPE OF EMBEDMENT MATERIAL AVAILABLE FROM THE TRENCH.
   (ii) THE SITE SOIL TYPE WILL BE COMPARED WITH THOSE ON THE MATERIAL DESCRIPTION CHART [SEE TABLE 1]
   (iii) THE COMPACTION METHOD REQUIRED IS THEN SELECTED FROM THE COMPACTION CHART FOR THE APPROPRIATE SOIL TYPE AND CLASS OF EMBEDMENT [SEE TABLE 2]
4. NOT ALL SOILS ARE GIVEN IN TABLE 1. IT SHOULD BE NOTED THAT :
   (i) FINED GRAINED SOILS WITH HIGH PLASTICITY MAY NOT BE USED AS BACKFILL
   (ii) FINED GRAINED SOILS WITH LOW PLASTICITY MAY BE CONDEMNED FOR USE AS BACKFILL IF THE CONTRACTOR HAS DIFFICULTY IN ATTAINING THE REQUIRED COMPACTION.
5. WHERE SITE MATERIAL IS CONDEMNED, IMPORTED MATERIAL SHALL BE USED. THIS SHALL BE A WELL GRADED SOIL FROM FINES UPTO 20 mm GRAVEL OR AS APPROVED BY THE ENGINEER'S REPRESENTATIVE.
6. WHERE SOME DOUBT EXISTS AS TO THE COMPACTIBILITY OF THE SOIL AS DEFINED ABOVE, RECOURSE SHALL BE MADE TO THE MODIFIED PROCTOR DENSITY TEST. THE SITE AND LABORATORY TESTS SHALL BE CARRIED OUT TO TESTS 14 B AND 12 RESPECTIVELY TO SSRN 601
7. IF STONES OR ROCK ARE PRESENT, IMPORTED BEDDING MATERIAL OF MIN. 150 mm THICK SHALL BE REQUIRED AS APPROVED BY THE ENGINEER'S REPRESENTATIVE. AT DESIGNATED ROAD CROSSINGS THE BEDDING SHALL HAVE A MINIMUM THICKNESS OF 150 mm.
8. THE BACKFILL SHALL BE PLACED IN LAYERS AS DEFINED ABOVE, EACH LAYER SHALL BE RAMMED WITH A SMALL VIBRATORY RAMMER. THE LIKELY REQUIRED NUMBER OF PASSES OF THE RAMMER IS GIVEN IN TABLE 2. HOWEVER 90% MPD SHALL BE ACHIEVED OF ALL TIMES.
9. ONLY WHEN THERE IS 300 mm COVER OVER THE PIPE MAY HEAVIER COMPACTING EQUIPMENT BE USED. THE REMAINDER OF THE BACKFILL SHALL BE SUITABLY COMPACTED IN KEEPING WITH THE REINSTATEMENT OF THE GROUND TO BE CARRIED OUT. THIS SHALL BE AGREED UPON WITH THE ENGINEER'S REPRESENTATIVE.
10. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS STATED OTHERWISE.

NOTES

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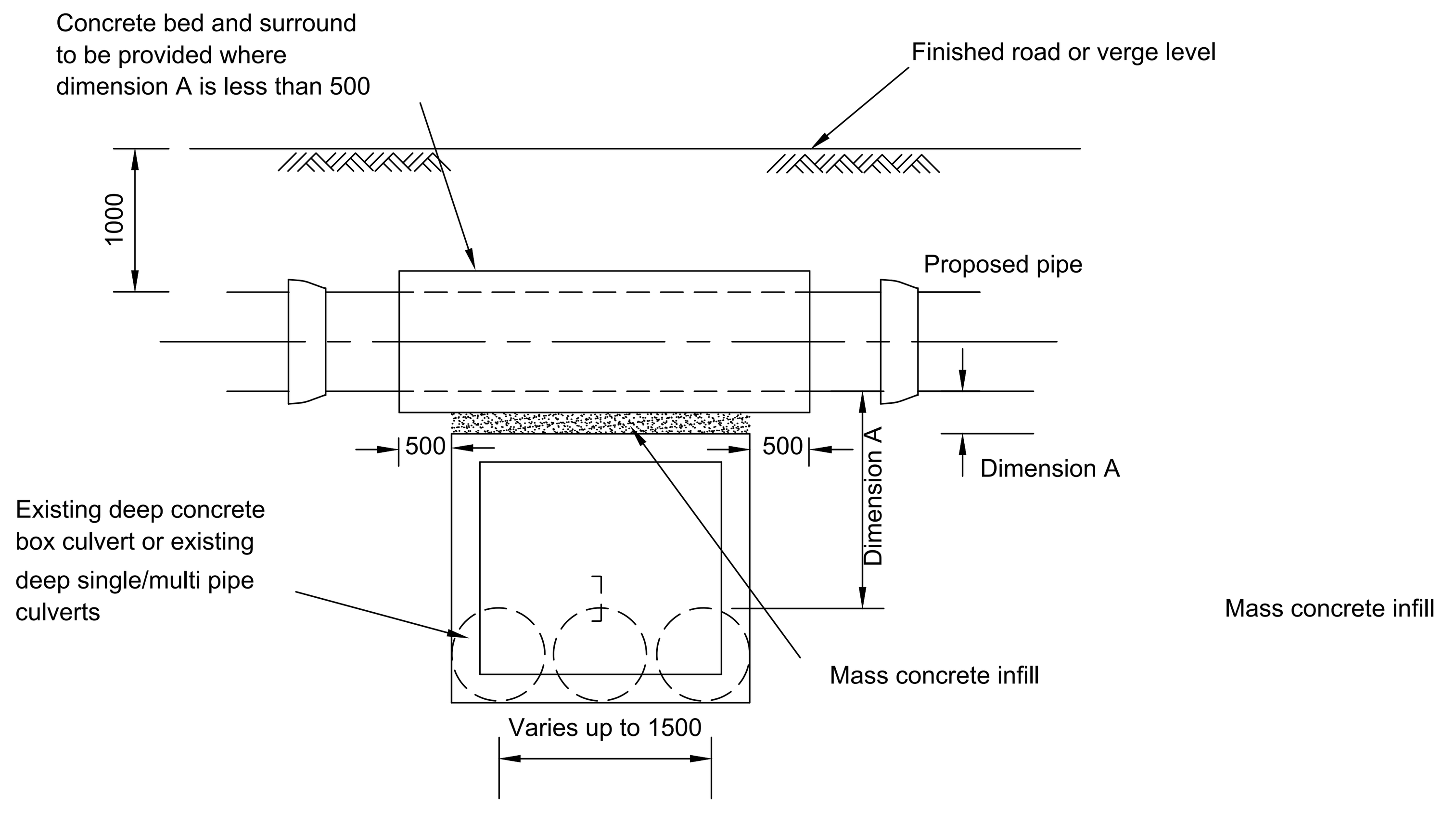
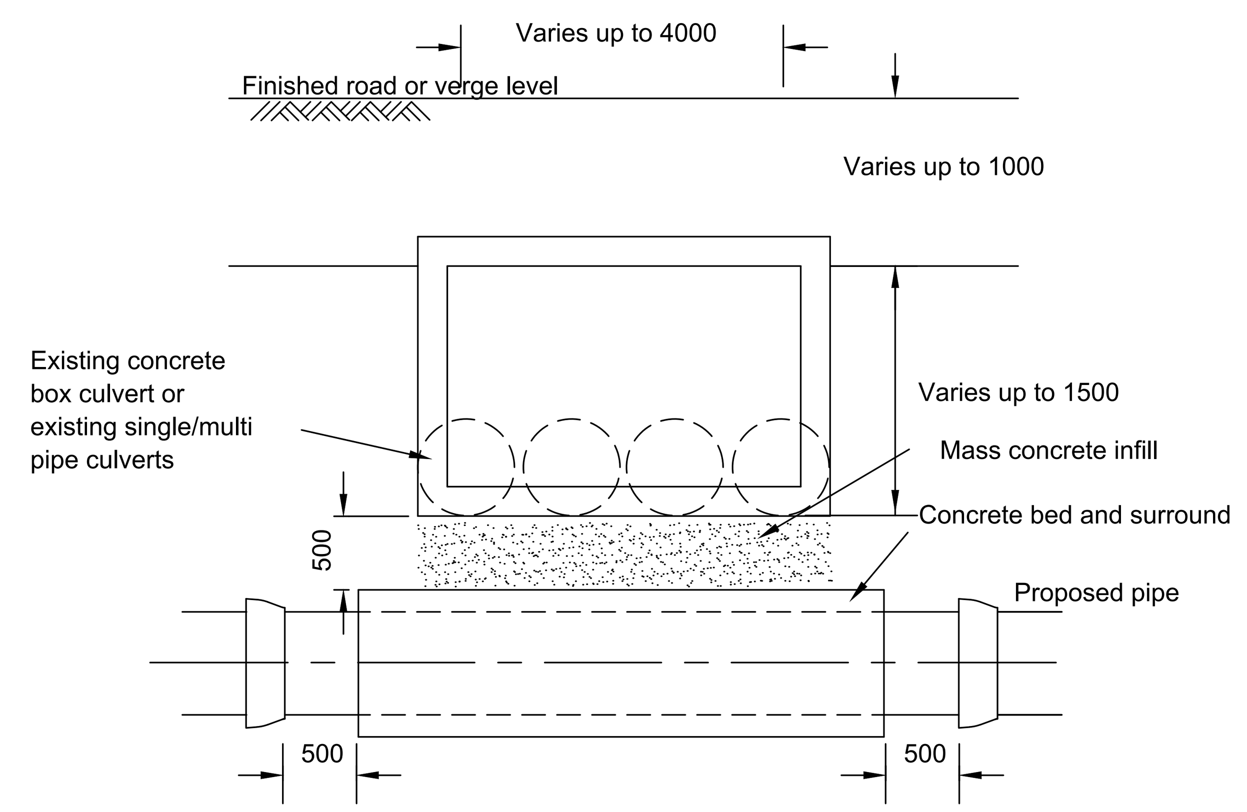


SECTION A-A



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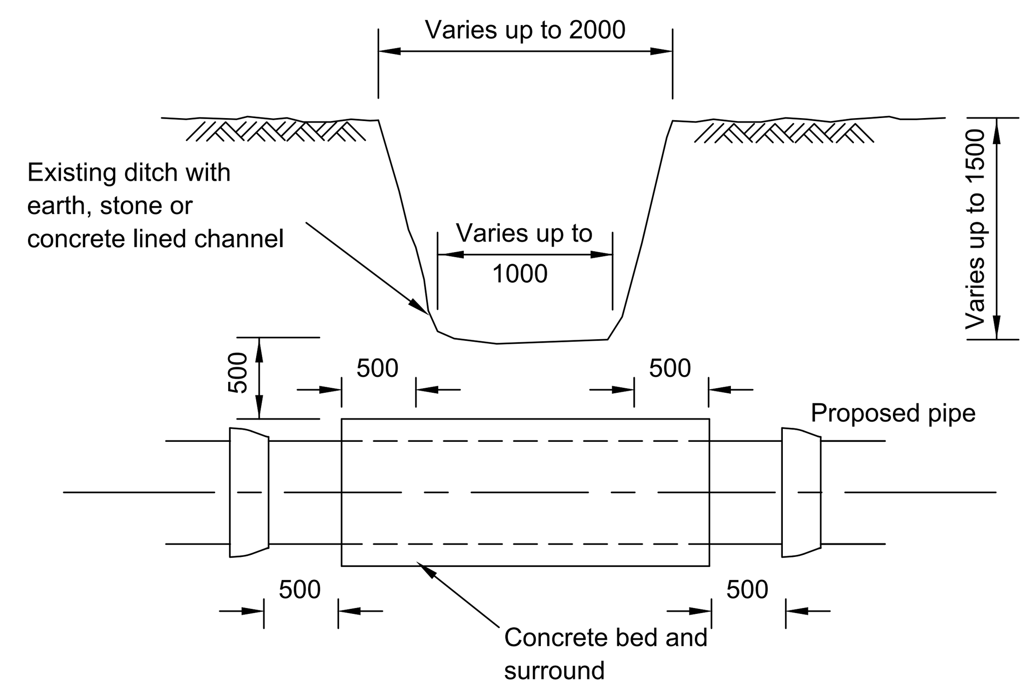

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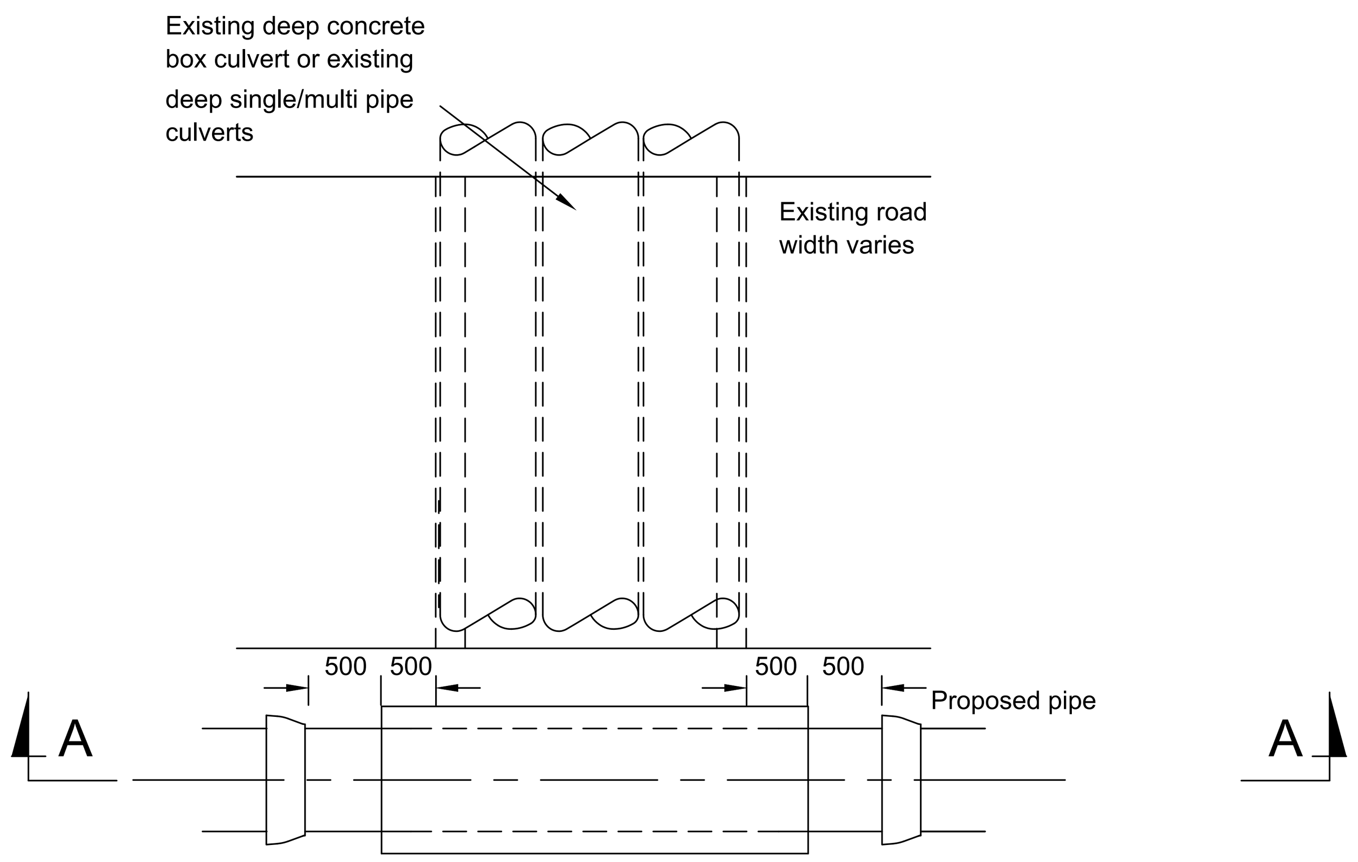
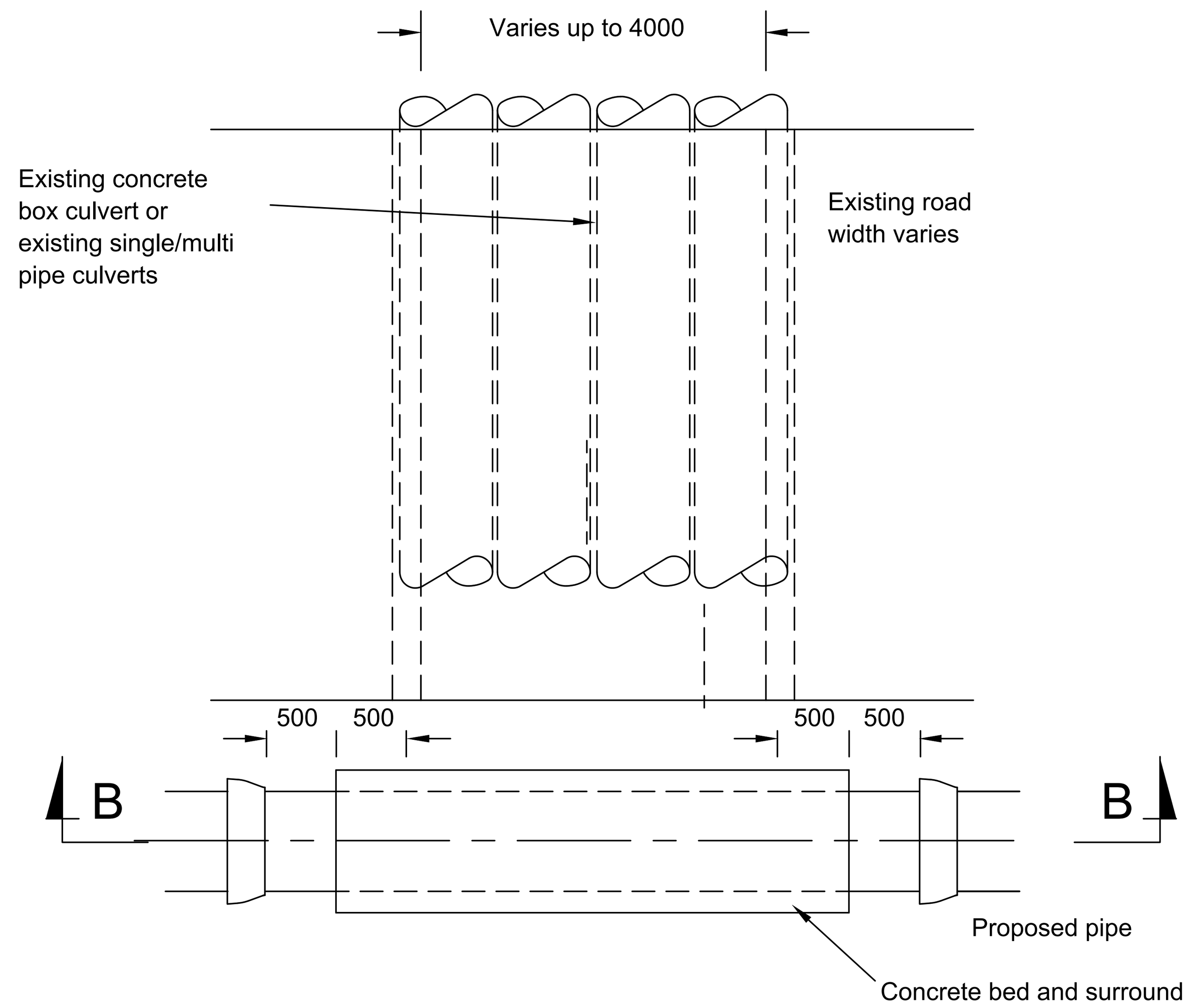


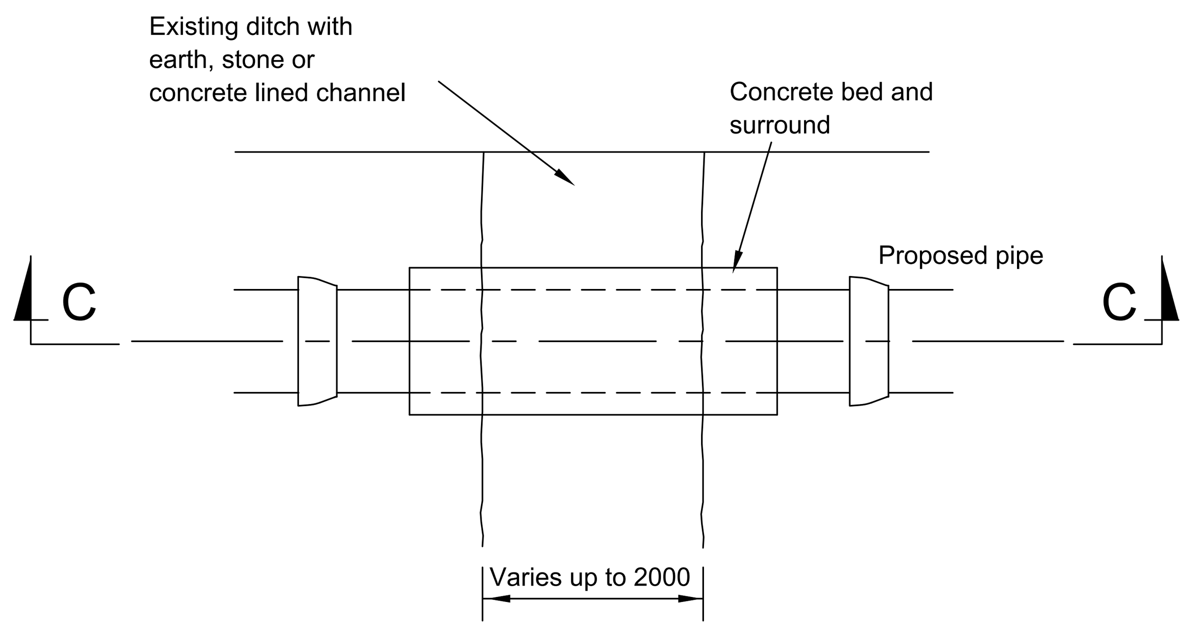
PLAN

TYPICAL CULVERT OVERCROSSING



PLAN

TYPICAL CULVERT UNDERCROSSING



PLAN

DITCH UNDERCROSSING

NOTES

SCALE ON A1: HORIZONTAL:1:1500

INDEX	NOTES:	DATE	SIGNED

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Culvert and Ditch Crossing Details

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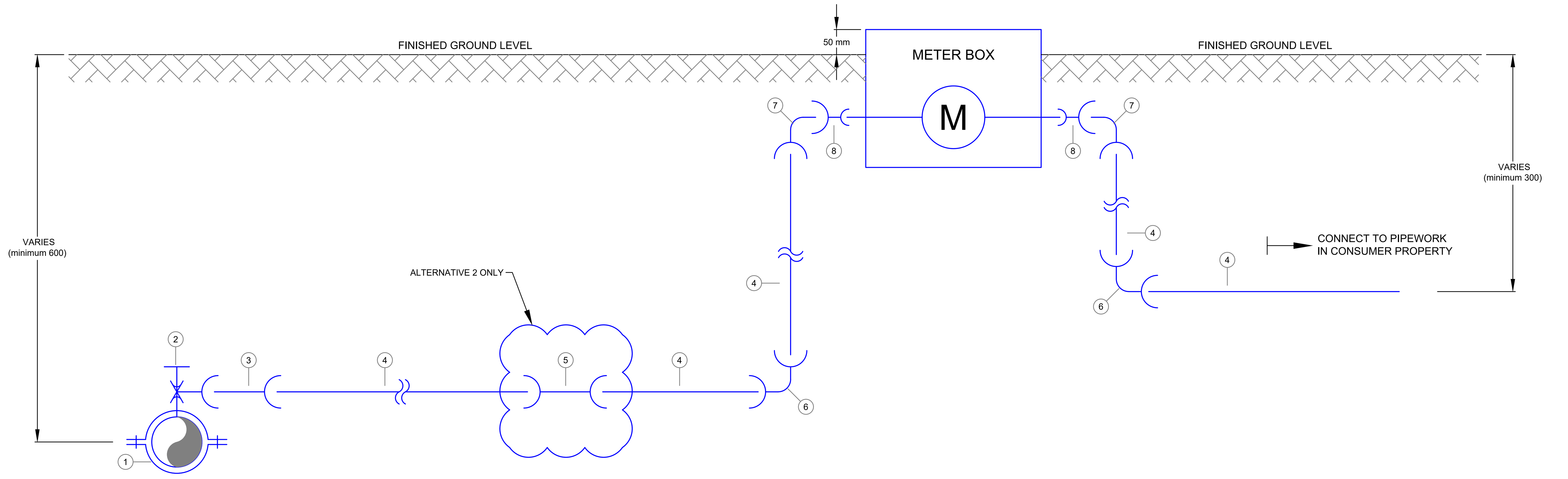
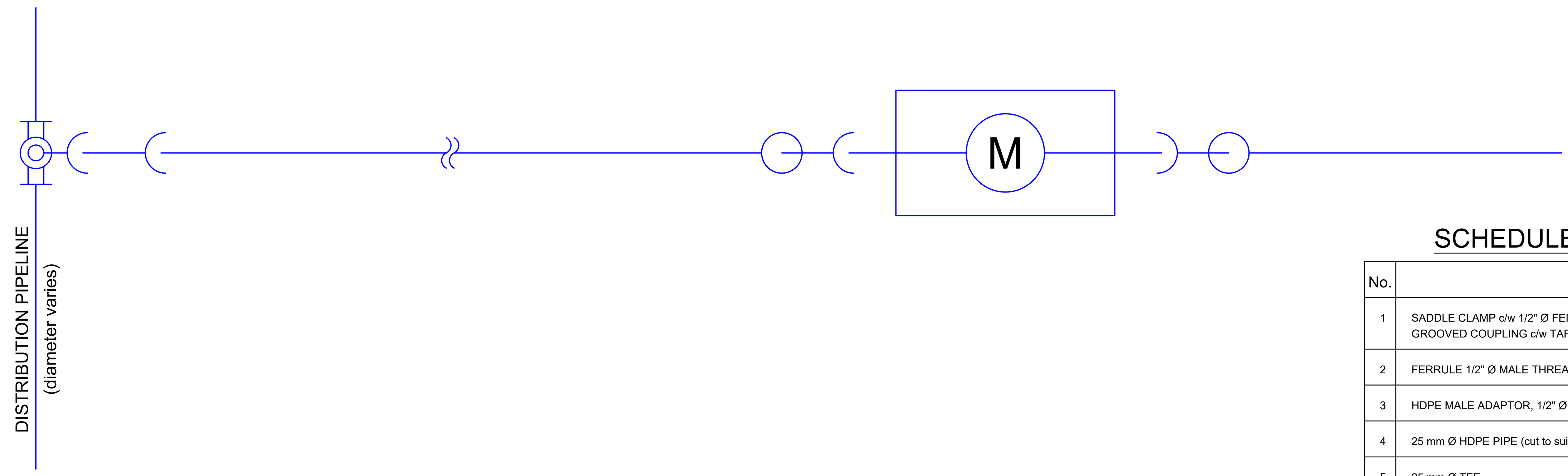
NOTES



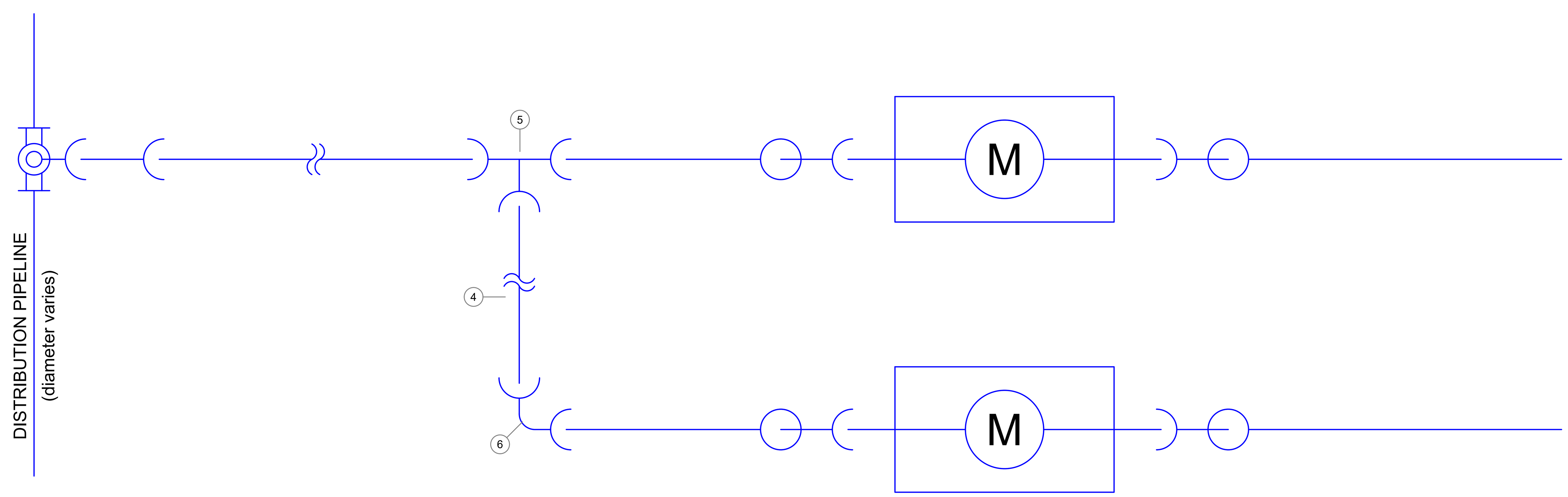
SECTIONAL ELEVATION



ALTERNATIVE 1: LAYOUT PLAN

SCHEDULE OF PIPEWORK & FITTINGS

No.	DESCRIPTION	ALT. 1	ALT. 2
1	SADDLE CLAMP c/w 1/2" Ø FEMALE OUTLET FOR FERRULE or GROOVED COUPLING c/w TAP OFF PROVISION	1 No.	1 No.
2	FERRULE 1/2" Ø MALE THREADED, 1/2" Ø FEMALE SIDE OUTLET	1 No.	1 No.
3	HDPE MALE ADAPTOR, 1/2" Ø MALE x 25 mm Ø COMPRESSION JOINT	1 No.	1 No.
4	25 mm Ø HDPE PIPE (cut to suit and re-use existing pipework)	1 No.	1 No.
5	25 mm Ø TEE	-	1 No.
6	25 mm Ø ELBOW	2 No.	5 No.
7	25 mm Ø / 3/4" Ø FEMALE THREADED ELBOW	2 No.	4 No.
8	3/4" Ø x 1/2" Ø REDUCING BUSH or 3/4" UNIVERSAL CONNECTOR	2 No.	4 No.



ALTERNATIVE 2: LAYOUT PLAN

SCALE ON A1: HORIZONTAL:1:1500

INDEX:	NOTES:	DATE	SIGNED
	.	.	
	.	.	.
	.	.	.

REVISION AND ISSUES

CLIENT:

CONSULTANT: GFA Consulting Group GmbH

CONTRACT: Reform of the Water Sector Programme Phase II in Zambia (RWS II)

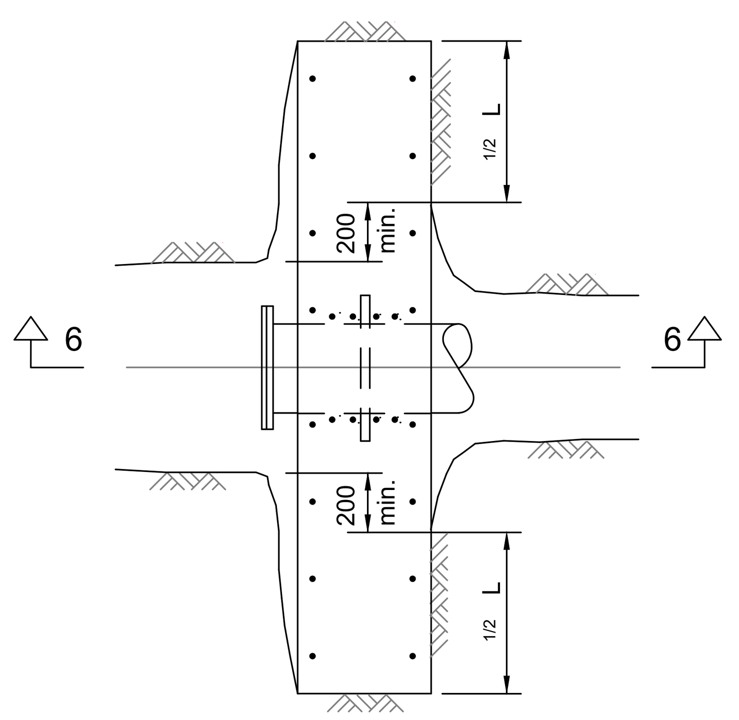
TITLE: Consumer Connection Detail

REFERENCE DRAWINGS:

DESIGNED: CHI	DATE:	SHEET.No.: 01 OF 01
DRAWN: CHI	NOV 2021	
CHECKED: CHI	NOV 2021	
APPROVED: KAM	NOV 2021	

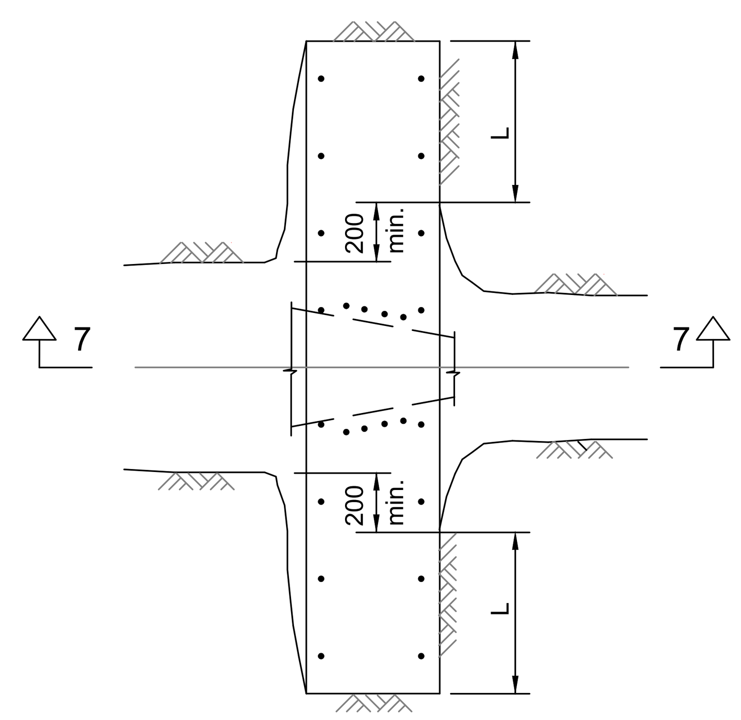
PROJECTION: UTM 35 South / WGS 84 / metric

DRWG.No.: GFA-GIZ-SPWS-SD-004



PLAN

END CAPS

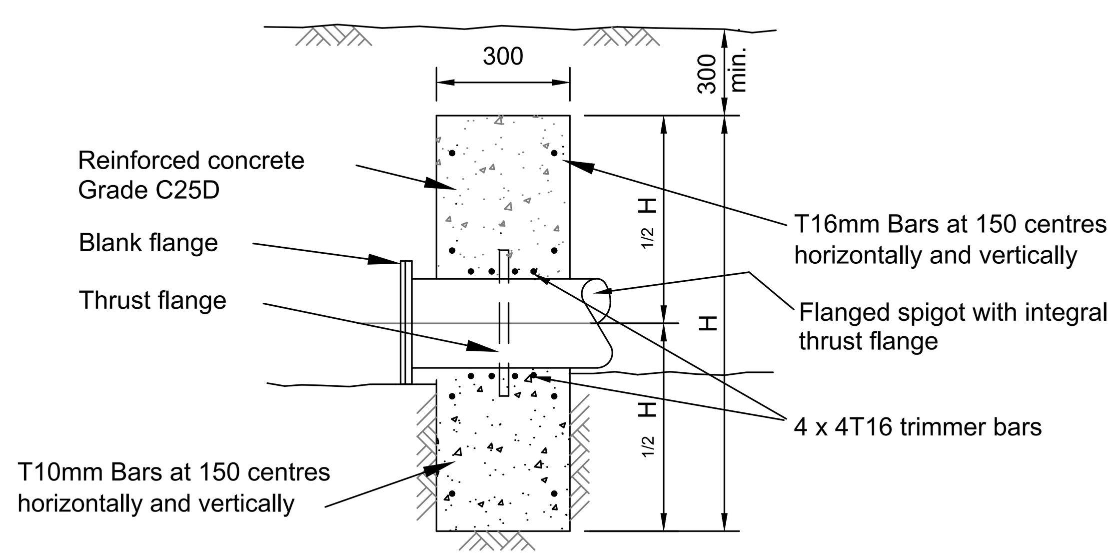


PLAN

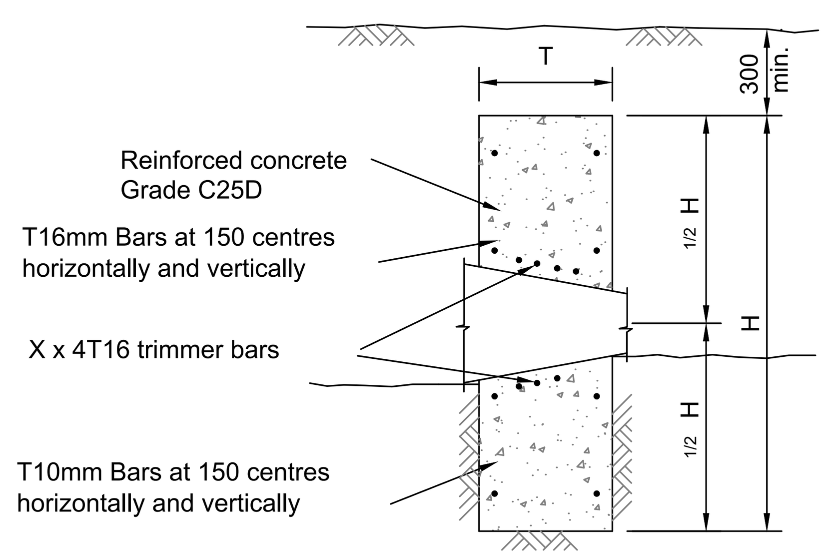
TAPERS

Pipe Diameter	60 masl TEST PRESSURE			
	H	L	T	X
700/550	900	1500	500	4
650/500	800	1500	500	4
600/450	750	1500	500	4
550/400	700	1400	500	4
500/400	600	1100	400	3
450/350	550	1000	400	3
400/300	500	1000	400	3
350/250	450	900	300	3
300/200	450	800	300	3
250/200	300	500	250	3
200/150	250	500	200	3
150/100	200	400	200	2
100/80	200	300	200	2

Pipe Diameter	100 masl TEST PRESSURE			
	H	L	T	X
700/550	1100	2000	600	5
650/500	1000	2000	600	5
600/450	1000	1900	600	5
550/400	900	1900	600	5
500/400	800	1300	500	4
450/350	700	1300	500	4
400/300	650	1300	400	3
350/250	600	1200	400	3
300/200	550	1100	400	3
250/200	400	700	300	3
200/150	350	600	300	3
150/100	300	500	300	3
100/80	200	300	200	2



SECTION 6 - 6



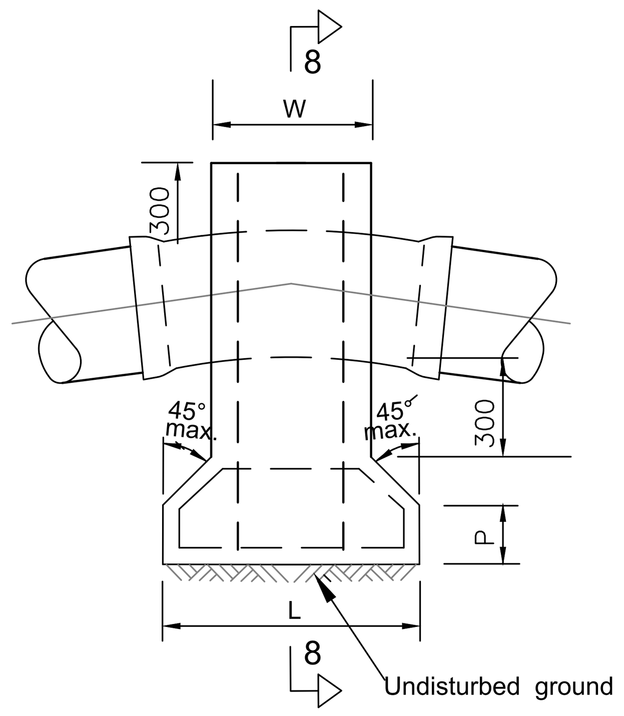
SECTION 7 - 7

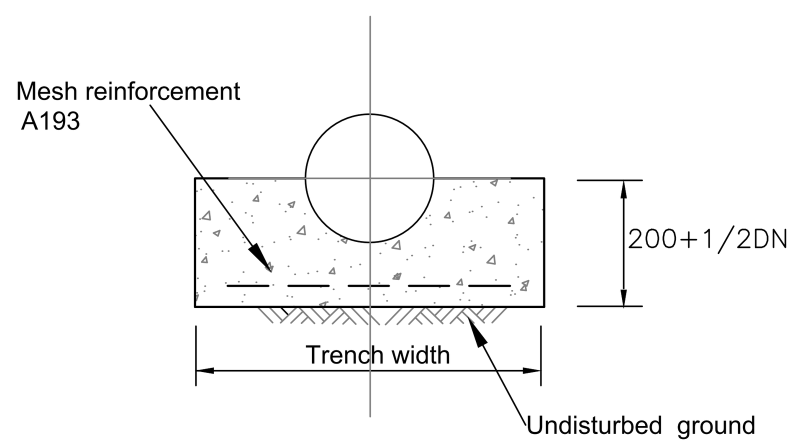
60 masl TEST PRESSURE

Pipe Diameter	90°		45°		22.5°		11.25°		TEES/END CAP	
	H	L	H	L	H	L	H	L	H	L
700	1200	2700	1200	2200	900	1500	700	1200	1500	2300
650	1800	2300	1200	1900	900	1300	700	1000	1500	2000
600	1600	2300	1200	1600	900	1100	700	700	1500	1200
550	1600	1900	900	1800	700	1200	500	1000	1200	1800
500	1200	2100	900	1500	700	1000	500	800	1200	1500
450	1200	1700	900	1200	700	800	500	600	900	1600
400	1200	1300	900	1000	500	900	500	500	900	1300
350	800	1500	600	1100	500	700	400	500	900	1000
300	800	1100	600	800	500	500	400	400	600	1100
250	500	1300	400	800	300	600	300	400	600	700
200	500	800	400	500	300	400	300	300	400	700
150	300	800	200	600	200	300	200	200	400	700
100	300	300	200	300	200	200	200	200	400	400
80	400	400	300	300	200	200	150	150	300	300

100 masl TEST PRESSURE

Pipe Diameter	90°		45°		22.5°		11.25°		TEES/END CAP	
	H	L	H	L	H	L	H	L	H	L
700	2100	3900	1500	2900	1200	1900	900	1500	1800	3200
650	2100	3400	1500	2500	1200	1600	900	1300	1800	2800
600	1800	3300	1300	2500	900	1800	900	1100	1800	2400
550	1800	2800	1300	2100	900	1500	700	1200	1500	2400
500	1500	2800	1100	2100	900	1300	700	1000	1500	2000
450	1500	2300	1100	1700	700	1300	700	800	1200	2000
400	1500	1800	1100	1300	700	1100	500	900	1200	1600
350	1000	2000	800	1400	700	800	500	700	1200	1200
300	1000	1500	800	1000	500	800	500	500	800	1300
250	1000	1000	600	900	500	600	300	600	800	900
200	600	1100	600	600	300	600	300	400	500	900
150	600	600	400	500	300	300	200	300	500	500
100	300	600	300	300	200	200	200	200	300	400
80	400	400	300	300	200	200	200	200	400	400





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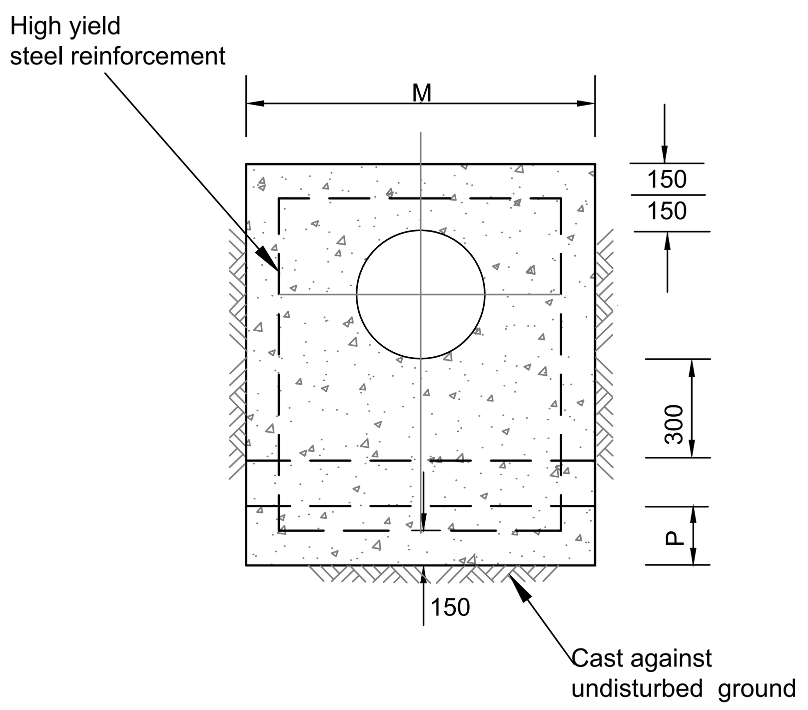

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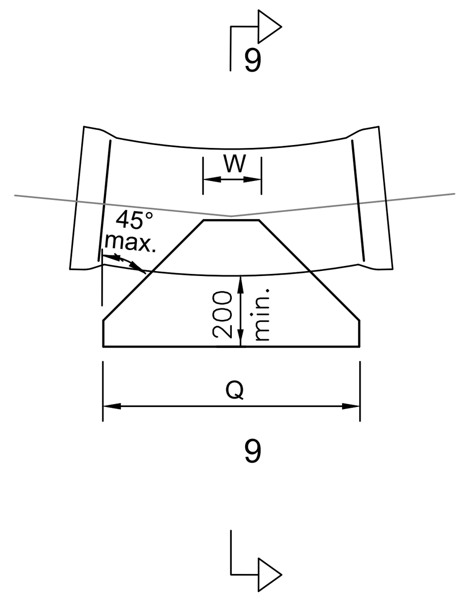


Pipe Diameter	60 masl TEST PRESSURE				
	L	M	P	Q	W
400	1100	1100	300	400	150
300	800	800	300	400	150
400	1300	1300	300	500	150
300	1500	1500	300	500	150

Pipe Diameter	100 masl TEST PRESSURE				
	L	M	P	Q	W
400	1300	1300	300	500	150
300	1000	1000	300	400	150
400	1500	1500	300	600	150
300	1700	1700	300	600	150

11.25° VERTICAL BEND

NOTES

SCALE ON A1: HORIZONTAL:1:1500

INDEX NOTES: DATE SIGNED

REVISION AND ISSUES

CLIENT:

CONSULTANT: GFA Consulting Group GmbH

CONTRACT:

Reform of the Water Sector Programme Phase II in Zambia (RWS II)

TITLE:

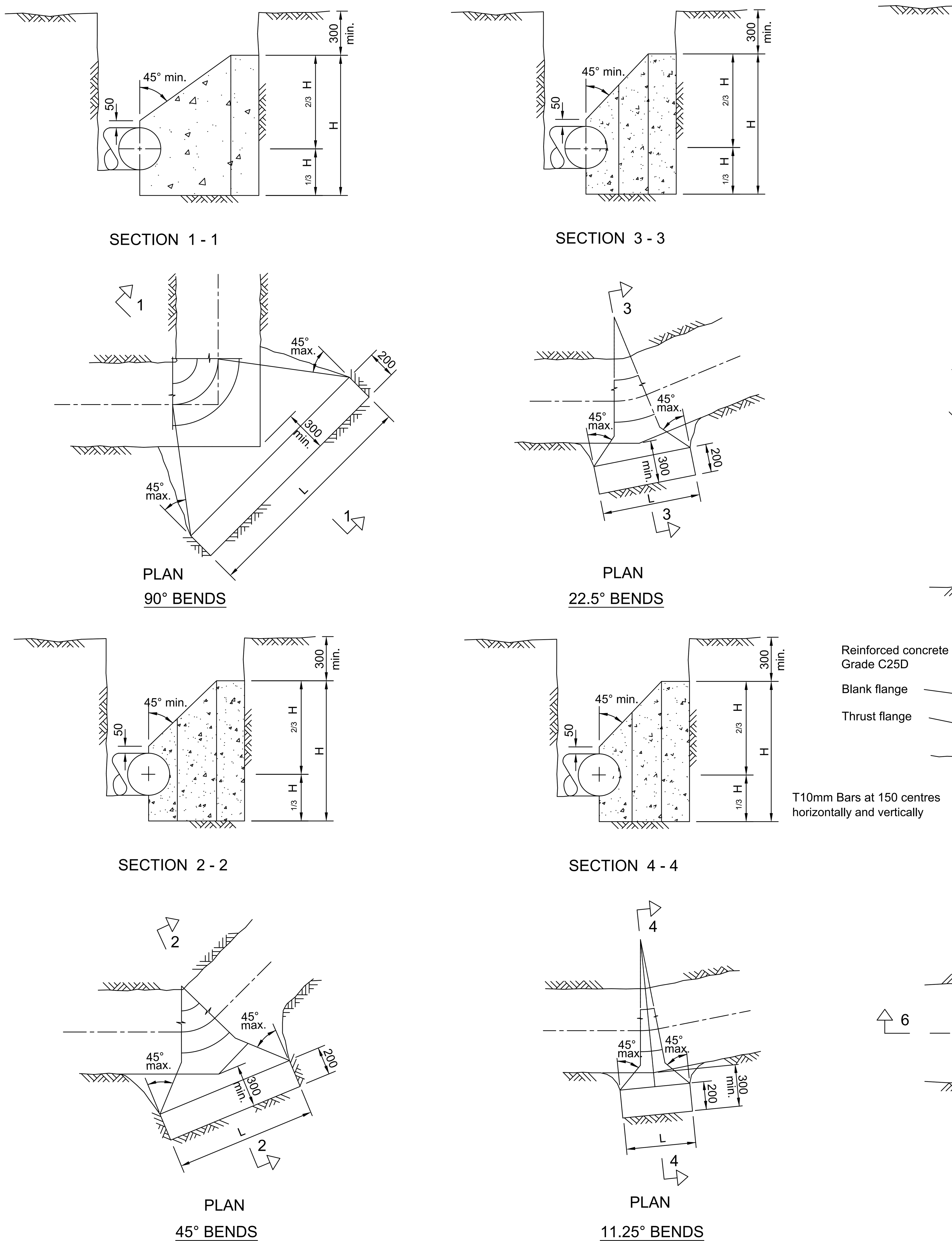
Thrust Blocks Detail

REFERENCE DRAWINGS:

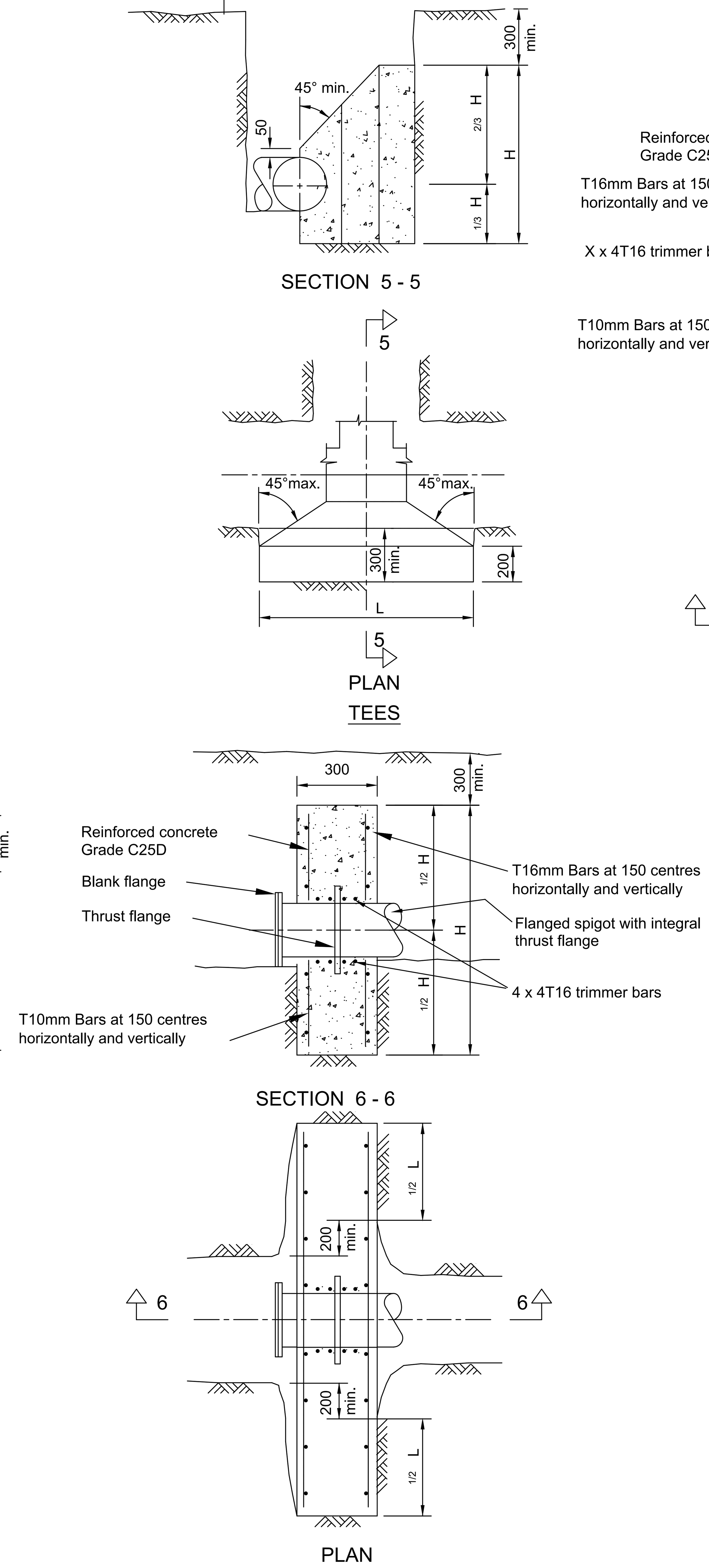
DESIGNED:	CHI	DATE:	SHEET.No.:
DRAWN:	CHI	NOV 2021	01 OF 02
CHECKED:	CHI	NOV 2021	
APPROVED:	KAM	JNOV 2021	

PROJECTION: UTM 35 South / WGS 84 / metric

DRWG.No.: GFA-GIZ-SPWS-SD-005

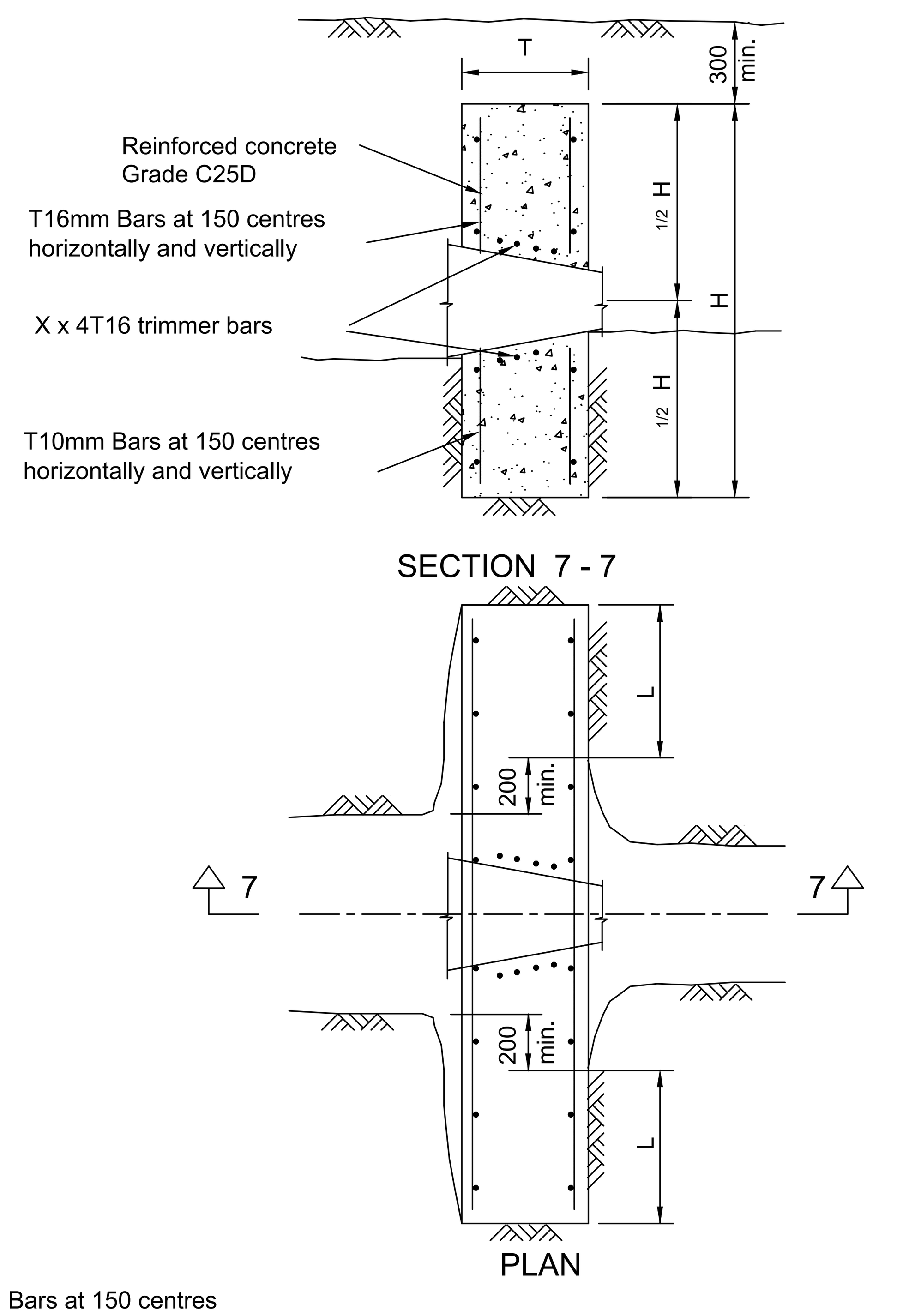


HORIZONTAL BENDS



TEES

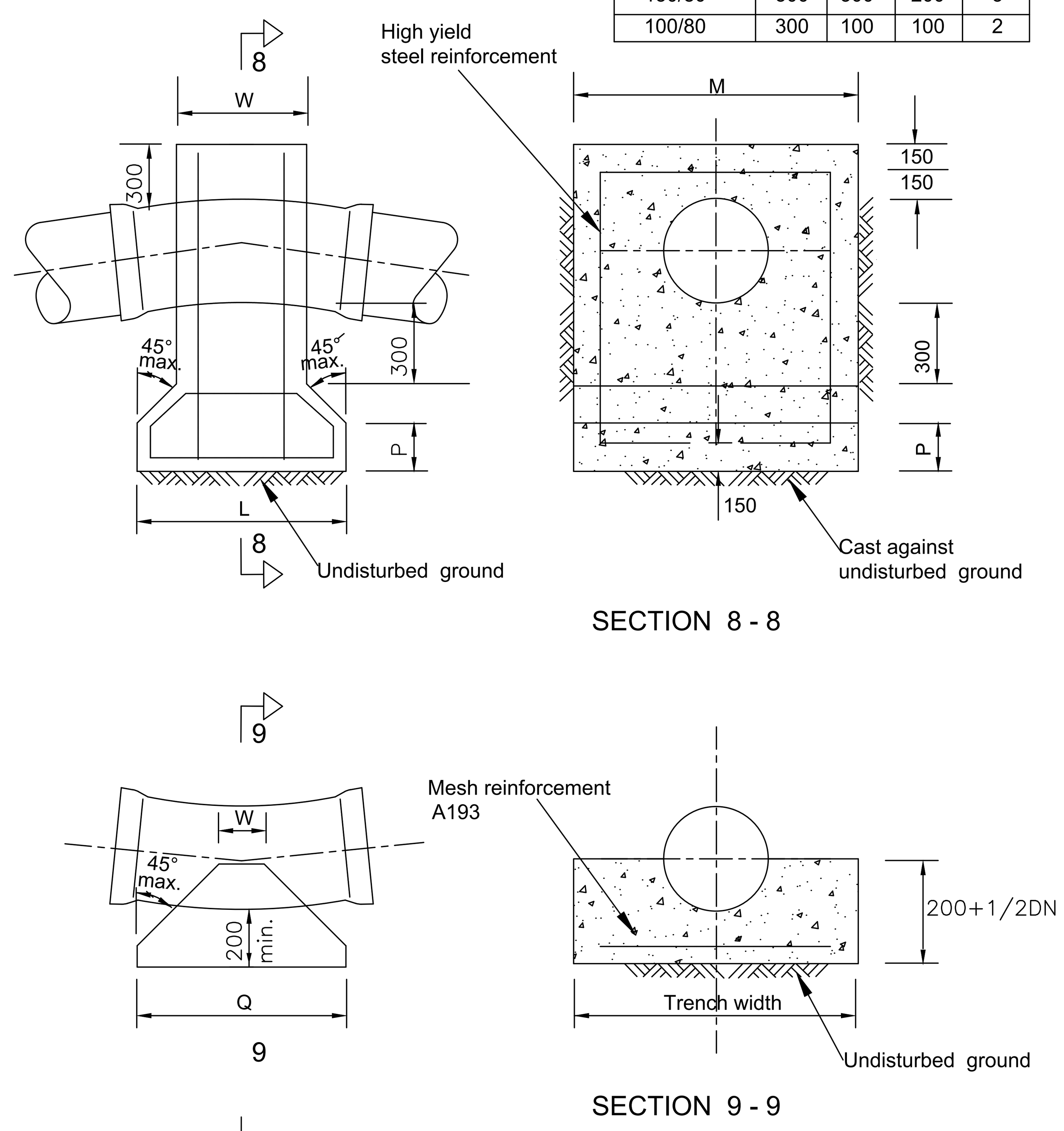
END CAPS



TAPERS

Pipe Diameter	120 masl TEST PRESSURE			
	H	L	T	X
600/400	1800	600	450	4
600/300	1800	800	600	5
450/400	1000	300	200	3
400/350	1000	200	200	3
400/300	1000	400	300	3
400/250	1000	600	300	3
400/200	1000	700	450	4
300/250	800	200	200	3
300/200	800	400	300	3
300/150	800	500	300	3
250/200	700	200	200	3
250/150	700	400	300	3
200/150	600	200	200	3
200/100	600	300	300	3
150/100	500	200	200	3
150/80	500	200	200	3
100/80	300	100	100	2

Pipe Diameter	160 masl TEST PRESSURE			
	H	L	T	X
600/400	1800	800	450	4
600/300	1800	1100	600	5
450/400	1000	300	200	3
400/350	1000	300	200	3
400/300	1000	500	300	3
400/250	1000	700	300	3
400/200	1000	900	450	4
300/250	800	300	200	3
300/200	800	500	300	3
300/150	800	700	300	3
250/200	700	300	200	3
250/150	700	500	300	3
200/150	600	300	200	3
200/100	600	400	300	3
150/100	500	200	200	3
150/80	500	300	200	3
100/80	300	100	100	2



11.25° VERTICAL BEND

120 masl TEST PRESSURE

Pipe Diameter	90°		45°		22.5°		11.25°		TEES/END CAP	
	H	L	H	L	H	L	H	L	H	L
400	1300	1900	1100	1300	800	900	600	600	1300	1400
350	1300	1500	1000	1100	700	800	500	600	1200	1200
300	1200	1200	900	900	600	700	400	500	1000	1100
250	1000	1000	700	800	500	600	400	400	800	900
200	800	900	600	600	400	500	300	400	700	700
150	600	700	500	500	300	400	200	300	500	600
100	400	500	300	400	200	300	150	200	400	400
80	400	400	300	300	200	200	150	150	300	400

160 masl TEST PRESSURE

Pipe Diameter	90°		45°		22.5°		11.25°		TEES/END CAP	
	H	L	H	L	H	L	H	L	H	L
400	1300	2600	1300	1400	1000	1000	700	700	1300	1800
350	1300	2000	1200	1200	800	900	600	600	1300	1400
300	1200	1600	1000	1100	700	800	500	600	1200	1200
250	1200	1200	900	900	600	700	400	500	1000	1000
200	900	1000	700	700	500	500	400	400	800	800
150	700	800	500	600	400	400	300	300	600	700
100	500	500	400	400	300	300	200	200	400	500
80	400	500	300	400	200	300	200	200	400	400

Pipe Diameter	120 masl TEST PRESSURE				
	L	M	P	Q	W
400	1300	1300	300	400	150
300	1000	1000	300	400	150

Pipe Diameter	160 masl TEST PRESSURE				
	L	M	P	Q	W
400	1500	1500	300	500	150
300	1100	1100	300	400	150

NOTES

SCALE ON A1: HORIZONTAL:1:1500

INDEX | NOTES: | DATE | SIGNED

REVISION AND ISSUES

CLIENT: german cooperation — giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

CONSULTANT: GFA Consulting Group GmbH

CONTRACT: Reform of the Water Sector Programme Phase II in Zambia (RWS II)

TITLE: Thrust Block Detail

REFERENCE DRAWINGS:

DESIGNED: CHI	DATE:	SHEET.No.:	
DRAWN: CHI	NOV 2021	02 OF 02	
CHECKED: CHI	NOV 2021		
APPROVED: KAM	NOV 2021		

PROJECTION: UTM 35 South / WGS 84 / metric

DRWG.No.: GFA-GIZ-SPWS-SD-005

MULUNDU RGC WATER DISTRIBUTION NETWORK DRAWINGS COVER PAGE

NOTES

SCALE ON A1: NTS

INDEX	NOTES:	DATE	SIGNED

REVISION AND ISSUES

CLIENT:

CONSULTANT: GFA Consulting Group GmbH

CONTRACT:
Reform of the Water Sector Programme Phase II in Zambia (RWS II)

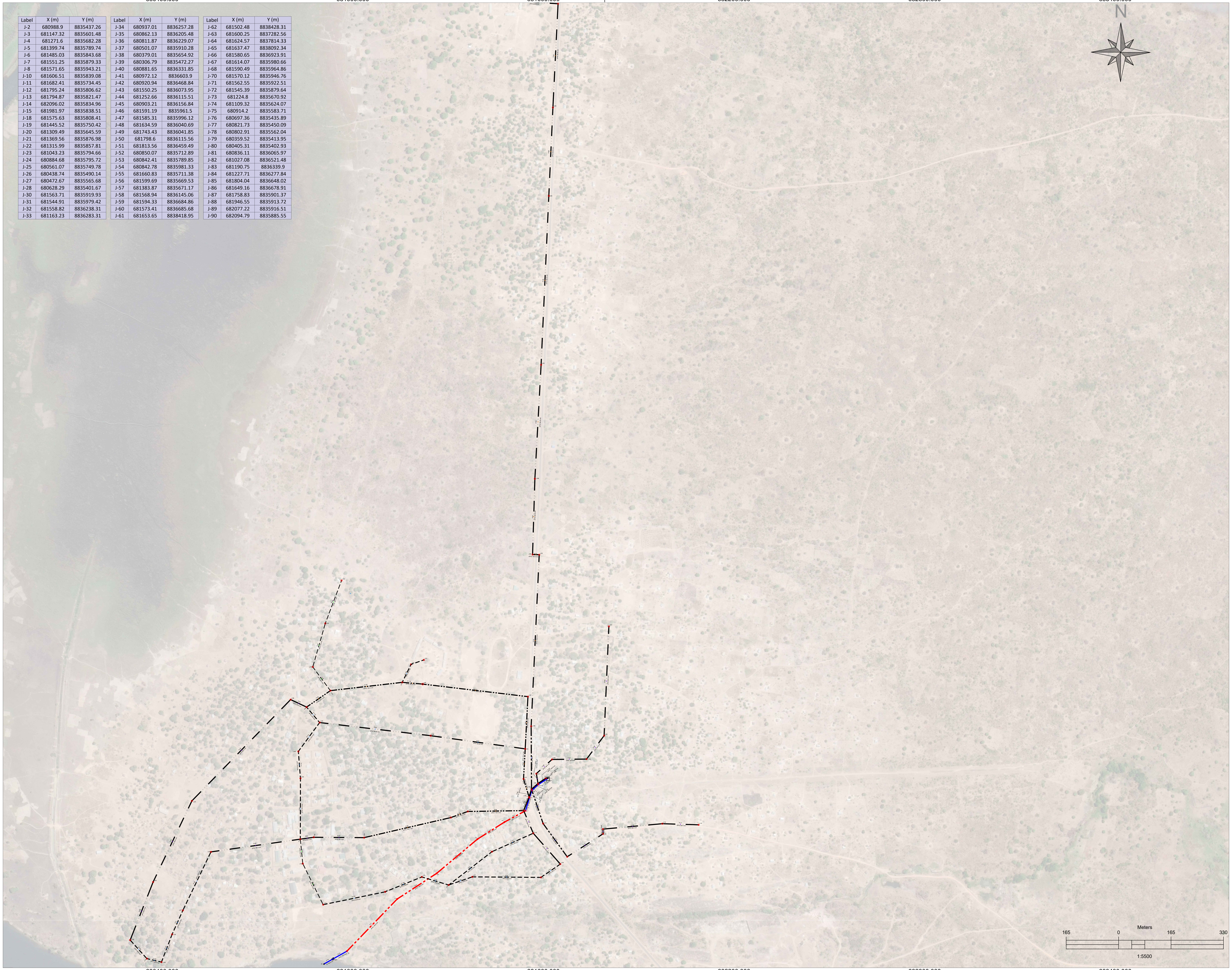
TITLE:
Mulundu RGC Water Distribution Network Drawing Cover Page

REFERENCE DRAWINGS:

		DATE:	SHEET.No.:
DESIGNED:	CHI		01 OF 01
DRAWN:	CHI	NOV 2021	
CHECKED:	CHI	NOV 2021	
APPROVED:	KAM	NOV 2021	

PROJECTION: UTM 35 South / WGS 84 / metric

DRWG.No.: GFA-GIZ-MUL-DN-000



Label	X (m)	Y (m)
J-2	680988.9	8835437.26
J-3	681147.32	8835601.48
J-4	681271.6	8835682.28
J-5	681399.74	8835789.74
J-6	681485.03	8835843.68
J-7	681551.25	8835879.33
J-8	681571.65	8835943.21
J-10	681606.51	8835839.08
J-11	681682.41	8835734.45
J-12	681795.24	8835806.62
J-13	681794.87	8835821.47
J-14	682096.02	8835834.96
J-15	681981.97	8835838.51
J-18	681575.63	8835808.41
J-19	681445.52	8835750.42
J-20	681309.49	8835645.59
J-21	681369.56	8835876.98
J-22	681315.99	8835857.81
J-23	681043.23	8835794.66
J-24	680884.68	8835795.72
J-25	680561.07	8835749.78
J-26	680438.74	8835490.14
J-27	680472.67	8835565.68
J-28	680628.29	8835401.67
J-30	681563.71	8835919.93
J-31	681544.91	8835979.42
J-32	681558.82	8836238.31
J-33	681163.23	8836283.31

Label	X (m)	Y (m)
J-34	680937.01	8836257.28
J-35	680862.13	8836205.48
J-36	680811.87	8836229.07
J-37	680501.07	8835910.28
J-38	680379.01	8835654.92
J-39	680306.79	8835472.27
J-40	680881.65	8836331.85
J-41	680972.12	8836603.9
J-42	680920.94	8836468.84
J-43	681550.25	8836073.95
J-44	681252.66	8836115.51
J-45	680903.21	8836156.84
J-46	681591.19	8835961.5
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J-51	681813.56	8836459.49
J-52	680850.07	8835712.89
J-53	680842.41	8835789.85
J-54	680842.78	8835981.33
J-55	681660.83	8835711.38
J-56	681599.69	8835669.53
J-57	681383.87	8835671.17
J-58	681568.94	8836145.06
J-59	681594.33	8836684.86
J-60	681573.41	8836685.68
J-61	681653.65	8838418.95

Label	X (m)	Y (m)
J-62	681502.48	8838428.31
J-63	681600.25	8837282.56
J-64	681624.57	8837814.33
J-65	681637.47	8838092.34
J-66	681580.65	8836923.91
J-67	681614.07	8835980.66
J-68	681590.49	8835964.86
J-70	681570.12	8835946.76
J-71	681562.55	8835922.51
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J-73	681224.8	8835670.92
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J-83	681190.75	8836339.9
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J-87	681758.83	8835901.37
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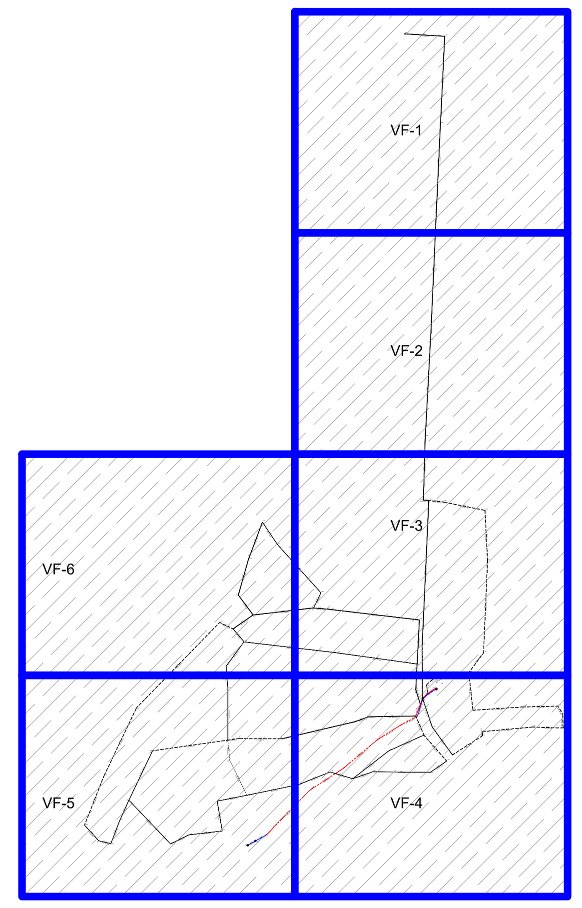
J-90	682094.79	8835885.55

NOTES

KEY MAP



LEGEND

UPGRADING OF EXISTING DISTRIBUTION NETWORK
- OD 160mm (ID 148.9mm) uPVC Class 9
- OD 110mm (ID 102.4mm) uPVC Class 9
- OD 75mm (ID 68.4mm) uPVC Class 9
- OD 50mm (ID 45.6mm) uPVC Class 9

NEW INSTALLATIONS IN THE DISTRIBUTION NETWORK
- OD 160mm (ID 148.9mm) uPVC Class 9
- OD 75mm (ID 68.4mm) uPVC Class 9
- OD 50mm (ID 45.6mm) uPVC Class 9

EXISTING AND RETAINED PIPES IN DISTRIBUTION NETWORK
- OD 160mm (ID 148.9mm) uPVC
- ND 100mm GI
- OD 110mm (ID 103.4mm) uPVC
- OD 75mm (ID 68.4mm) uPVC
- OD 50mm (ID 45.6mm) uPVC
- OD 40mm (ID 36.4mm) uPVC
- Existing Intake (Reservoir)
- Network Junctions (Tee/ Bends)
- Pump

SCALE ON A1: HORIZONTAL:1:1500

INDEX	NOTES:	DATE	SIGNED

REVISION AND ISSUES

CLIENT: german cooperation; giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

CONSULTANT: GFA Consulting Group GmbH

CONTRACT:
Reform of the Water Sector Programme Phase II in Zambia (RWS II)

TITLE: Mulundu Rural Growth Center Small Piped Water Supply Scheme.
(OverView Map)

REFERENCE DRAWINGS:

DESIGNED:	CHI	DATE:		SHEET.No.:
DRAWN:	CHI	NOV 2021		01 OF 01
CHECKED:	CHI	NOV 2021		
APPROVED:	KAM	NOV 2021		

PROJECTION: UTM 35 South / WGS 84 / metric

DRWG.No.: GFA-GIZ-MUL-DN-001

Label	X (m)	Y (m)	Label	X (m)	Y (m)	Label	X (m)	Y (m)
J-2	680988.9	8835437.26	J-34	680937.01	8836257.28	J-62	681502.48	8838428.31
J-3	681147.32	8835601.48	J-35	680862.13	8836205.48	J-63	681600.25	8837282.56
J-4	681271.6	8835682.28	J-36	680811.87	8836229.07	J-64	681624.57	8837814.33
J-5	681399.74	8835789.74	J-37	680501.07	8835910.28	J-65	681637.47	8838092.34
J-6	681485.03	8835843.68	J-38	680379.01	8835654.92	J-66	681580.65	8836923.91
J-7	681551.25	8835879.33	J-39	680306.79	8835472.27	J-67	681614.07	8835980.66
J-8	681571.65	8835943.21	J-40	680881.65	8836331.85	J-68	681590.49	8835964.86
J-10	681606.51	8835839.08	J-41	680972.12	8836603.9	J-70	681570.12	8835946.76
J-11	681682.41	8835734.45	J-42	680920.94	8836468.84	J-71	681562.55	8835922.51
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J-14	682096.02	8835834.96	J-45	680903.21	8836156.84	J-74	681109.32	8835624.07
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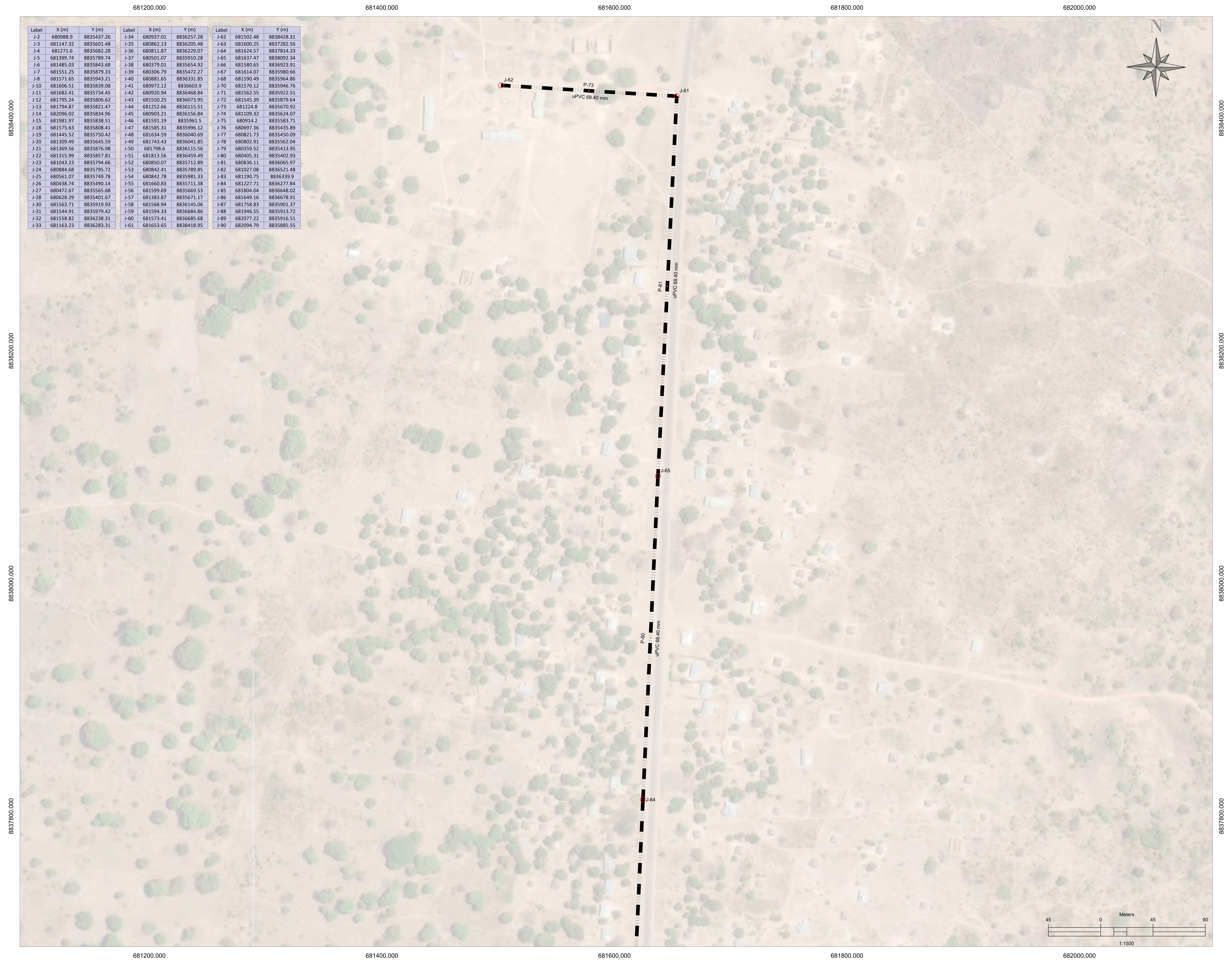
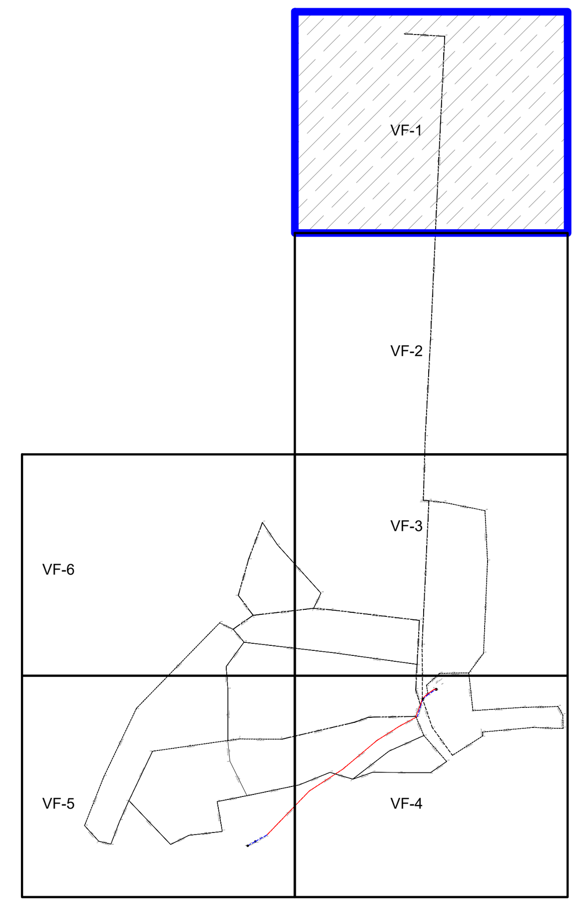
J-20	681309.49	8835645.59	J-49	681743.43	8836041.85	J-78	680802.91	8835562.04
J-21	681369.56	8835876.98	J-50	681798.6	8836115.56	J-79	680359.52	8835413.95
J-22	681315.99	8835857.81	J-51	681813.56	8836459.49	J-80	680405.31	8835402.93
J-23	681043.23	8835794.66	J-52	680850.07	8835712.89	J-81	680836.11	8836065.97
J-24	680884.68	8835795.72	J-53	680842.41	8835789.85	J-82	681027.08	8836521.48
J-25	680561.07	8835749.78	J-54	680842.78	8835981.33	J-83	681190.75	8836339.9
J-26	680438.74	8835490.14	J-55	681660.83	8835711.38	J-84	681227.71	8836277.84
J-27	680472.67	8835565.68	J-56	681599.69	8835669.53	J-85	681804.04	8836648.02
J-28	680628.29	8835401.67	J-57	681383.87	8835671.17	J-86	681649.16	8836678.91
J-30	681563.71	8835919.93	J-58	681568.94	8836145.06	J-87	681758.83	8835901.37
J-31	681544.91	8835979.42	J-59	681594.33	8836684.86	J-88	681946.55	8835913.72
J-32	681558.82	8836238.31	J-60	681573.41	8836685.68	J-89	682077.22	8835916.51
J-33	681163.23	8836283.31	J-61	681653.65	8838418.95	J-90	682094.79	8835885.55



NOTES

KEY MAP



LEGEND

UPGRADING OF EXISTING DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC Class 9
- OD 110mm (ID 102.4mm) uPVC Class 9
- OD 75mm (ID 68.4mm) uPVC Class 9
- OD 50mm (ID 45.6mm) uPVC Class 9

NEW INSTALLATIONS IN THE DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC Class 9
- OD 75mm (ID 68.4mm) uPVC Class 9
- OD 50mm (ID 45.6mm) uPVC Class 9

EXISTING AND RETAINED PIPES IN DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC
- ND 100mm GI
- OD 110mm (ID 103.4mm) uPVC
- OD 75mm (ID 68.4mm) uPVC
- OD 50mm (ID 45.6mm) uPVC
- OD 40mm (ID 36.4mm) uPVC
- Existing Intake (Reservoir)
- Network Junctions (Tee/ Bends)
- Pump

SCALE ON A1: HORIZONTAL:1:500

INDEX:	NOTES:	DATE	SIGNED

REVISION AND ISSUES

CLIENT:

CONSULTANT: GFA Consulting Group GmbH

CONTRACT:

Reform of the Water Sector Programme Phase II in Zambia (RWS II)

TITLE: Mulundu Rural Growth Center Small Piped Water Supply Scheme.
(View Frame-1)

REFERENCE DRAWINGS:

DESIGNED: CHI	DATE:	SHEET.No.: 01 OF 01
DRAWN: CHI	NOV 2021	
CHECKED: CHI	NOV 2021	
APPROVED: KAM	NOV 2021	

PROJECTION: UTM 35 South / WGS 84 / metric

DRWG.No.: GFA-GIZ-MUL-DN-002

Label	X (m)	Y (m)
J-2	680988.9	8835437.26
J-3	681147.32	8835601.48
J-4	681271.6	8835682.28
J-5	681399.74	8835789.74
J-6	681485.03	8835843.68
J-7	681551.25	8835879.33
J-8	681571.65	8835943.21
J-10	681606.51	8835839.08
J-11	681682.41	8835734.45
J-12	681795.24	8835806.62
J-13	681794.87	8835821.47
J-14	682096.02	8835834.96
J-15	681981.97	8835838.51
J-18	681575.63	8835808.41
J-19	681445.52	8835750.42
J-20	681309.49	8835645.59
J-21	681369.56	8835876.98
J-22	681315.99	8835857.81
J-23	681043.23	8835794.66
J-24	680884.68	8835795.72
J-25	680561.07	8835749.78
J-26	680438.74	8835490.14
J-27	680472.67	8835565.68
J-28	680628.29	8835401.67
J-30	681563.71	8835919.93
J-31	681544.91	8835979.42
J-32	681558.82	8836238.31
J-33	681163.23	8836283.31

Label	X (m)	Y (m)
J-34	680937.01	8836257.28
J-35	680862.13	8836205.48
J-36	680811.87	8836229.07
J-37	680501.07	8835910.28
J-38	680379.01	8835654.92
J-39	680306.79	8835472.27
J-40	680881.65	8836331.85
J-41	680972.12	8836603.9
J-42	680920.94	8836468.84
J-43	681550.25	8836073.95
J-44	681252.66	8836115.51
J-45	680903.21	8836156.84
J-46	681591.19	8835961.5
J-47	681585.31	8835996.12
J-48	681634.59	8836040.69
J-49	681743.43	8836041.85
J-50	681798.6	8836115.56
J-51	681813.56	8836459.49
J-52	680850.07	8835712.89
J-53	680842.41	8835789.85
J-54	680842.78	8835981.33
J-55	681660.83	8835711.38
J-56	681599.69	8835669.53
J-57	681383.87	8835671.17
J-58	681568.94	8836145.06
J-59	681594.33	8836684.86
J-60	681573.41	8836685.68
J-61	681653.65	8838418.95

Label	X (m)	Y (m)
J-62	681502.48	8838428.31
J-63	681600.25	8837282.56
J-64	681624.57	8837814.33
J-65	681637.47	8838092.34
J-66	681580.65	8836923.91
J-67	681614.07	8835980.66
J-68	681590.49	8835964.86
J-70	681570.12	8835946.76
J-71	681562.55	8835922.51
J-72	681545.39	8835879.64
J-73	681224.8	8835670.92
J-74	681109.32	8835624.07
J-75	680914.2	8835583.71
J-76	680697.36	8835435.89
J-77	680821.73	8835450.09
J-78	680802.91	8835562.04
J-79	680359.52	8835413.95
J-80	680405.31	8835402.93
J-81	680836.11	8836065.97
J-82	681027.08	8836521.48
J-83	681190.75	8836339.9
J-84	681227.71	8836277.84
J-85	681804.04	8836648.02
J-86	681649.16	8836678.91
J-87	681758.83	8835901.37
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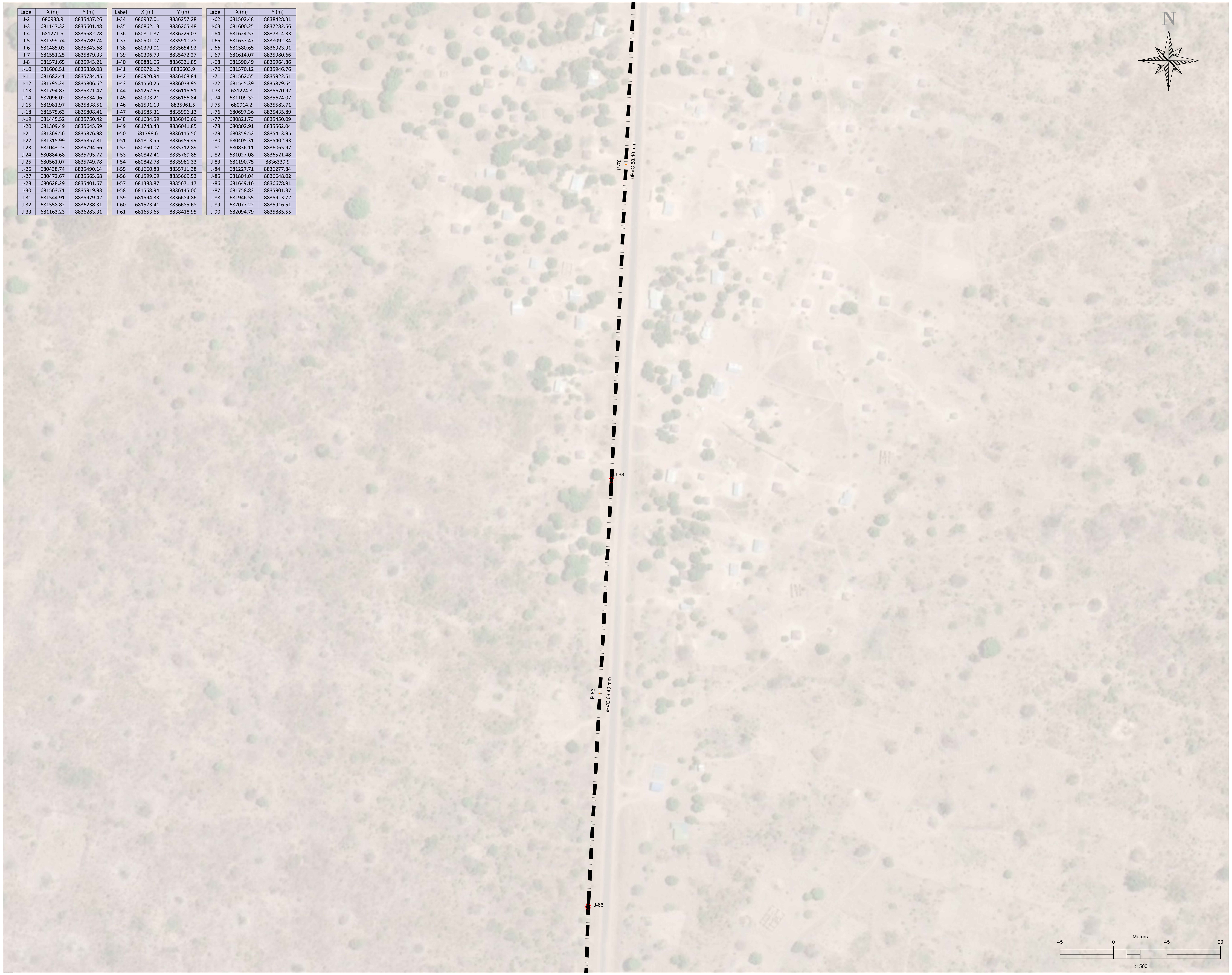
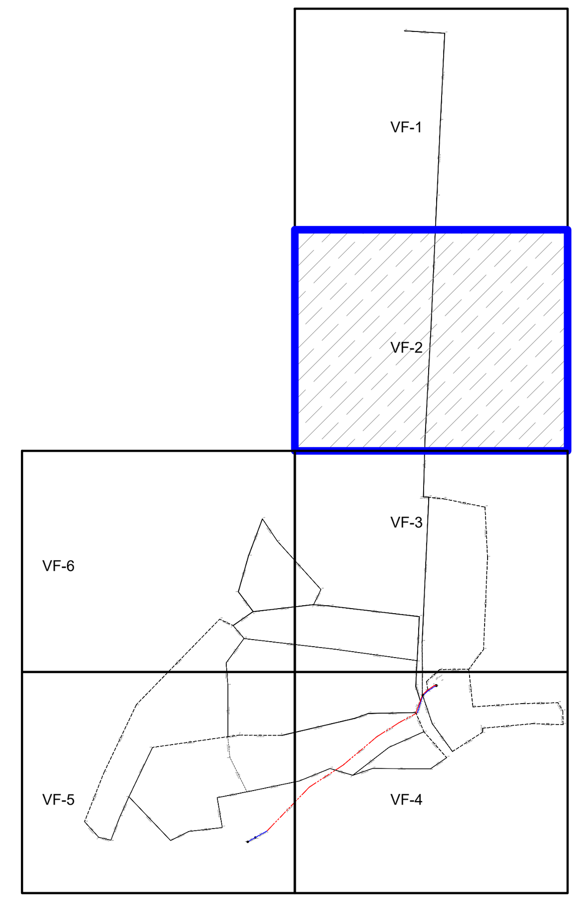
J-89	682077.22	8835916.51
J-90	682094.79	8835885.55



NOTES

KEY MAP



LEGEND

UPGRADING OF EXISTING DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC Class 9
- OD 110mm (ID 102.4mm) uPVC Class 9
- OD 75mm (ID 68.4mm) uPVC Class 9
- OD 50mm (ID 45.6mm) uPVC Class 9

NEW INSTALLATIONS IN THE DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC Class 9
- OD 75mm (ID 68.4mm) uPVC Class 9
- OD 50mm (ID 45.6mm) uPVC Class 9

EXISTING AND RETAINED PIPES IN DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC
- ND 100mm GI
- OD 110mm (ID 103.4mm) uPVC
- OD 75mm (ID 68.4mm) uPVC
- OD 50mm (ID 45.6mm) uPVC
- OD 40mm (ID 36.4mm) uPVC
- Existing Intake (Reservoir)
- Network Junctions (Tee/ Bends)
- Pump

SCALE ON A1: HORIZONTAL:1:1500

INDEX:	NOTES:	DATE	SIGNED
	.	.	
	.	.	.
	.	.	.

REVISION AND ISSUES

CLIENT: german cooperation DEUTSCHE ZUSAMMENARBEIT; giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

CONSULTANT: GFA Consulting Group GmbH

GFA CONSULTING GROUP

CONTRACT:

Reform of the Water Sector Programme Phase II in Zambia (RWS II)

TITLE: Mulundu Rural Growth Center Small Piped Water Supply Scheme.
(View Frame-2)

REFERENCE DRAWINGS:

DESIGNED:	CHI	DATE:	SHEET.No.: 01 OF 01
DRAWN:	CHI	NOV 2021	
CHECKED:	CHI	NOV 2021	
APPROVED:	KAM	NOV 2021	

PROJECTION: UTM 35 South / WGS 84 / metric

DRWG.No.: GFA-GIZ-MUL-DN-003

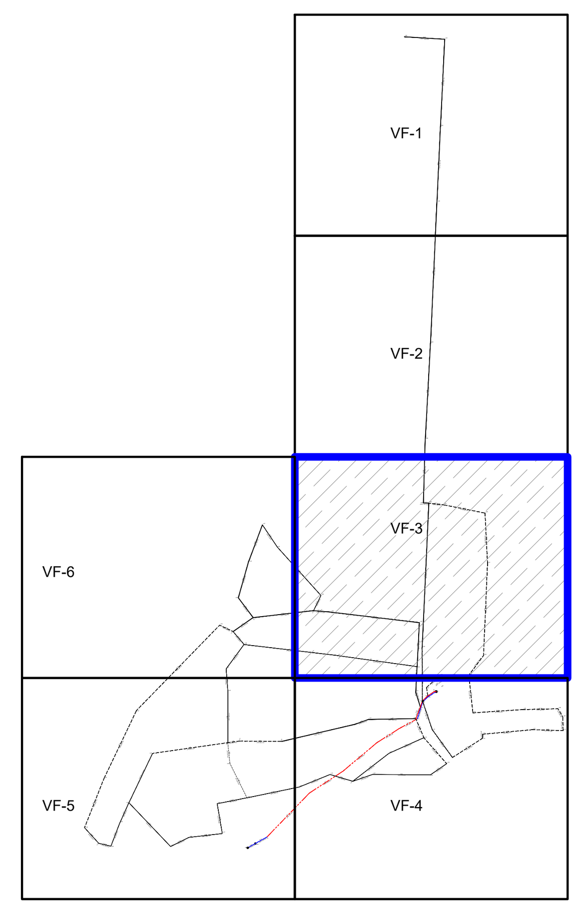
Label	X (m)	Y (m)
J-2	680988.9	8835437.26
J-3	681147.32	8835601.48
J-4	681271.6	8835682.28
J-5	681399.74	8835789.74
J-6	681485.03	8835843.68
J-7	681551.25	8835879.33
J-8	681571.65	8835943.21
J-10	681606.51	8835839.08
J-11	681682.41	8835734.45
J-12	681795.24	8835806.62
J-13	681794.87	8835821.47
J-14	682096.02	8835834.96
J-15	681981.97	8835838.51
J-18	681575.63	8835808.41
J-19	681445.52	8835750.42
J-20	681309.49	8835645.59
J-21	681369.56	8835876.98
J-22	681315.99	8835857.81
J-23	681043.23	8835794.66
J-24	680884.68	8835795.72
J-25	680561.07	8835749.78
J-26	680438.74	8835490.14
J-27	680472.67	8835565.68
J-28	680628.29	8835401.67
J-30	681563.71	8835919.93
J-31	681544.91	8835979.42
J-32	681558.82	8836238.31
J-33	681163.23	8836283.31

Label	X (m)	Y (m)
J-34	680937.01	8836257.28
J-35	680862.13	8836205.48
J-36	680811.87	8836229.07
J-37	680501.07	8835910.28
J-38	680379.01	8835654.92
J-39	680306.79	8835472.27
J-40	680881.65	8836331.85
J-41	680972.12	8836603.9
J-42	680920.94	8836468.84
J-43	681550.25	8836073.95
J-44	681252.66	8836115.51
J-45	680903.21	8836156.84
J-46	681591.19	8835961.5
J-47	681585.31	8835996.12
J-48	681634.59	8836040.69
J-49	681743.43	8836041.85
J-50	681798.6	8836115.56
J-51	681813.56	8836459.49
J-52	680850.07	8835712.89
J-53	680842.41	8835789.85
J-54	680842.78	8835981.33
J-55	681660.83	8835711.38
J-56	681599.69	8835669.53
J-57	681383.87	8835671.17
J-58	681568.94	8836145.06
J-59	681594.33	8836684.86
J-60	681573.41	8836685.68
J-61	681653.65	8838418.95

Label	X (m)	Y (m)
J-62	681502.48	8838428.31
J-63	681600.25	8837282.56
J-64	681624.57	8837814.33
J-65	681637.47	8838092.34
J-66	681580.65	8836923.91
J-67	681614.07	8835980.66
J-68	681590.49	8835964.86
J-70	681570.12	8835946.76
J-71	681562.55	8835922.51
J-72	681545.39	8835879.64
J-73	681224.8	8835670.92
J-74	681109.32	8835624.07
J-75	680914.2	8835583.71
J-76	680697.36	8835435.89
J-77	680821.73	8835450.09
J-78	680802.91	8835562.04
J-79	680359.52	8835413.95
J-80	680405.31	8835402.93
J-81	680836.11	8836065.97
J-82	681027.08	8836521.48
J-83	681190.75	8836339.9
J-84	681227.71	8836277.84
J-85	681804.04	8836648.02
J-86	681649.16	8836678.91
J-87	681758.83	8835901.37
J-88	681946.55	8835913.72
J-89	682077.22	8835916.51
J-90	682094.79	8835885.55

NOTES NOTES

KEY MAP



LEGEND

UPGRADING OF EXISTING DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC Class 9
- OD 110mm (ID 102.4mm) uPVC Class 9
- OD 75mm (ID 68.4mm) uPVC Class 9
- OD 50mm (ID 45.6mm) uPVC Class 9

NEW INSTALLATIONS IN THE DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC Class 9
- OD 75mm (ID 68.4mm) uPVC Class 9
- OD 50mm (ID 45.6mm) uPVC Class 9

EXISTING AND RETAINED PIPES IN DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC
- ND 100mm GI
- OD 110mm (ID 103.4mm) uPVC
- OD 75mm (ID 68.4mm) uPVC
- OD 50mm (ID 45.6mm) uPVC
- OD 40mm (ID 36.4mm) uPVC
- Existing Intake (Reservoir)
- Network Junctions (Tee/ Bends)
- Pump

SCALE ON A1: HORIZONTAL:1:1500

INDEX	NOTES:	DATE	SIGNED

REVISION AND ISSUES

CLIENT:

CONSULTANT: GFA Consulting Group GmbH

CONTRACT:

Reform of the Water Sector Programme Phase II in Zambia (RWS II)

TITLE: Mulundu Rural Growth Center Small Piped Water Supply Scheme.
(View Frame-3)

REFERENCE DRAWINGS:

DESIGNED:	CHI	DATE:	SHEET.No.:
DRAWN:	CHI	NOV 2021	
CHECKED:	CHI	NOV 2021	
APPROVED:	KAM	NOV 2021	

PROJECTION: UTM 35 South / WGS 84 / metric

DRWG.No.: GFA-GIZ-MUL-DN-002

Label	X (m)	Y (m)
J-2	680988.9	8835437.26
J-3	681147.32	8835601.48
J-4	681271.6	8835682.28
J-5	681399.74	8835789.74
J-6	681485.03	8835843.68
J-7	681551.25	8835879.33
J-8	681571.65	8835943.21
J-10	681606.51	8835839.08
J-11	681682.41	8835734.45
J-12	681795.24	8835806.62
J-13	681794.87	8835821.47
J-14	682096.02	8835834.96
J-15	681981.97	8835838.51
J-18	681575.63	8835808.41
J-19	681445.52	8835750.42
J-20	681309.49	8835645.59
J-21	681369.56	8835876.98
J-22	681315.99	8835857.81
J-23	681043.23	8835794.66
J-24	680884.68	8835795.72
J-25	680561.07	8835749.78
J-26	680438.74	8835490.14
J-27	680472.67	8835565.68
J-28	680628.29	8835401.67
J-30	681563.71	8835919.93
J-31	681544.91	8835979.42
J-32	681558.82	8836238.31
J-33	681163.23	8836283.31

Label	X (m)	Y (m)
J-34	680937.01	8836257.28
J-35	680862.13	8836205.48
J-36	680811.87	8836229.07
J-37	680501.07	8835910.28
J-38	680379.01	8835654.92
J-39	680306.79	8835472.27
J-40	680881.65	8836331.85
J-41	680972.12	8836603.9
J-42	680920.94	8836468.84
J-43	681550.25	8836073.95
J-44	681252.66	8836115.51
J-45	680903.21	8836156.84
J-46	681591.19	8835961.5
J-47	681585.31	8835996.12
J-48	681634.59	8836040.69
J-49	681743.43	8836041.85
J-50	681798.6	8836115.56
J-51	681813.56	8836459.49
J-52	680850.07	8835712.89
J-53	680842.41	8835789.85
J-54	680842.78	8835981.33
J-55	681660.83	8835711.38
J-56	681599.69	8835669.53
J-57	681383.87	8835671.17
J-58	681568.94	8836145.06
J-59	681594.33	8836684.86
J-60	681573.41	8836685.68
J-61	681653.65	8838418.95

Label	X (m)	Y (m)
J-62	681502.48	8838428.31
J-63	681600.25	8837282.56
J-64	681624.57	8837814.33
J-65	681637.47	8838092.34
J-66	681580.65	8836923.91
J-67	681614.07	8835980.66
J-68	681590.49	8835964.86
J-70	681570.12	8835946.76
J-71	681562.55	8835922.51
J-72	681545.39	8835879.64
J-73	681224.8	8835670.92
J-74	681109.32	8835624.07
J-75	680914.2	8835583.71
J-76	680697.36	8835435.89
J-77	680821.73	8835450.09
J-78	680802.91	8835562.04
J-79	680359.52	8835413.95
J-80	680405.31	8835402.93
J-81	680836.11	8836065.97
J-82	681027.08	8836521.48
J-83	681190.75	8836339.9
J-84	681227.71	8836277.84
J-85	681804.04	8836648.02
J-86	681649.16	8836678.91
J-87	681758.83	8835901.37
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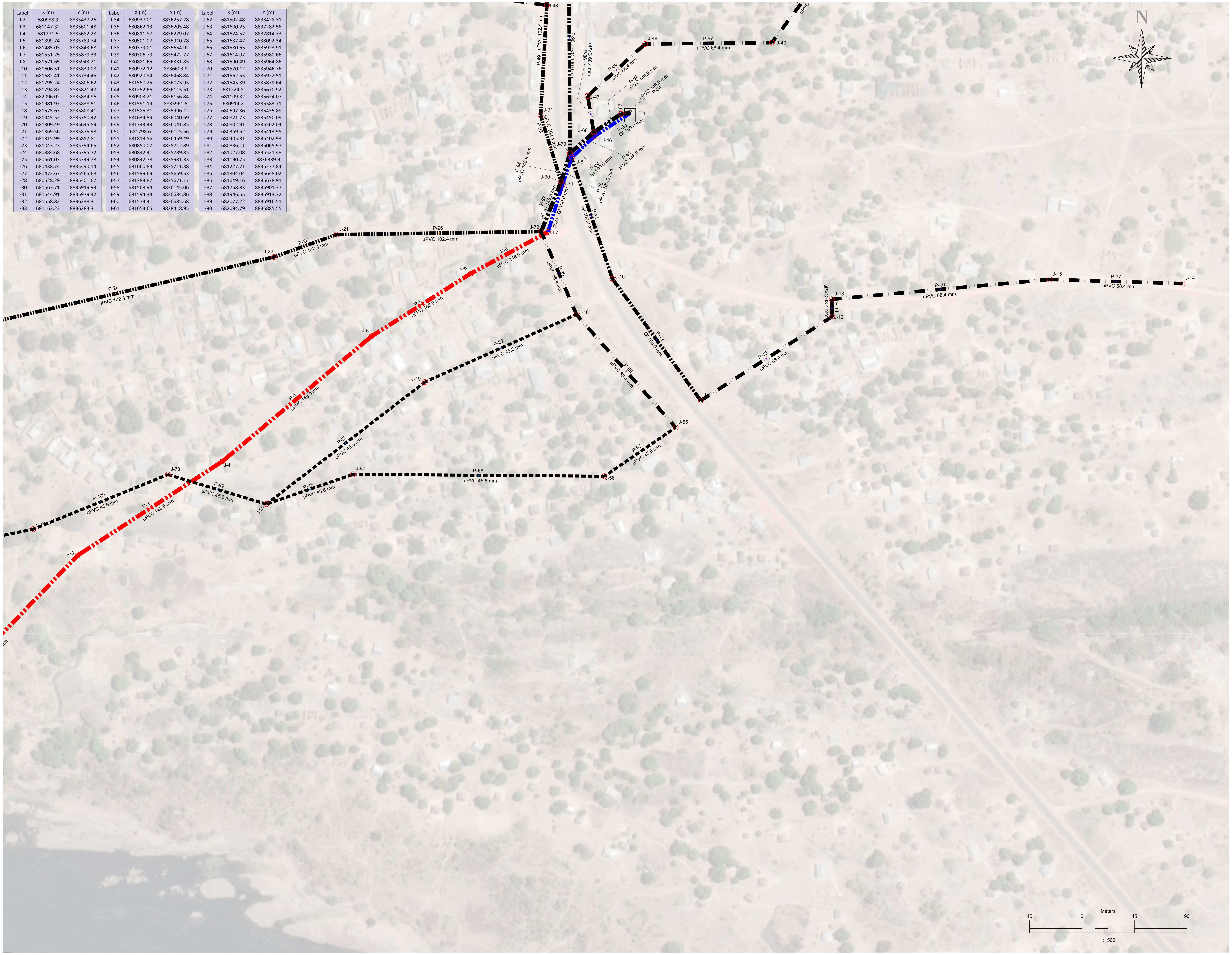
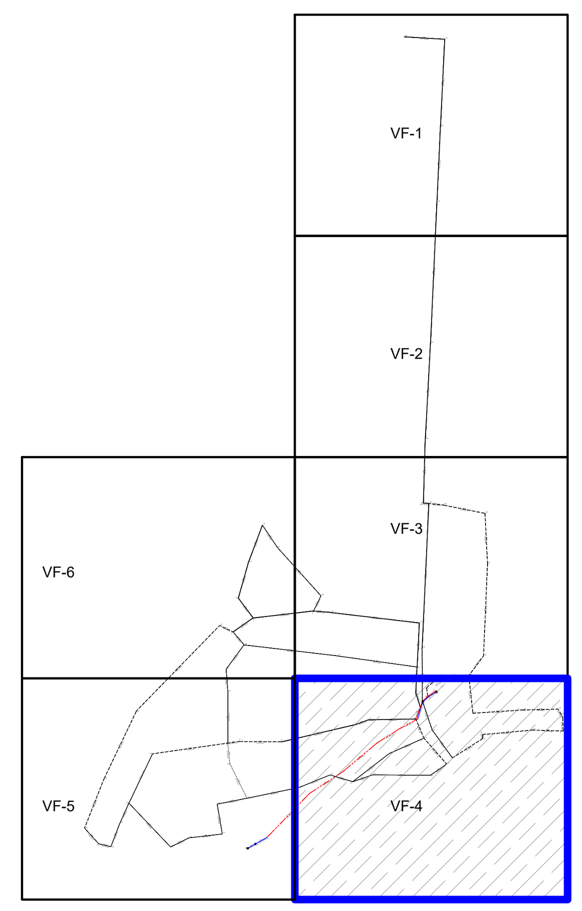
J-89	682077.22	8835916.51
J-90	682094.79	8835885.55





NOTES NOTES

LEGEND

UPGRADING OF EXISTING DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC Class 9
- OD 110mm (ID 102.4mm) uPVC Class 9
- OD 75mm (ID 68.4mm) uPVC Class 9
- OD 50mm (ID 45.6mm) uPVC Class 9

NEW INSTALLATIONS IN THE DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC Class 9
- OD 75mm (ID 68.4mm) uPVC Class 9
- OD 50mm (ID 45.6mm) uPVC Class 9

EXISTING AND RETAINED PIPES IN DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC
- ND 100mm GI
- OD 110mm (ID 103.4mm) uPVC
- OD 75mm (ID 68.4mm) uPVC
- OD 50mm (ID 45.6mm) uPVC
- OD 40mm (ID 36.4mm) uPVC
- Existing Intake (Reservoir)
- Network Junctions (Tee/ Bends)
- Pump

SCALE ON A1: HORIZONTAL:1:1500

INDEX	NOTES:	DATE	SIGNED

REVISION AND ISSUES

CLIENT: german cooperation / giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

CONSULTANT: GFA Consulting Group GmbH

CONTRACT: Reform of the Water Sector Programme Phase II in Zambia (RWS II)

TITLE: Mulundu Rural Growth Center Small Piped Water Supply Scheme. (View Frame-4)

REFERENCE DRAWINGS:

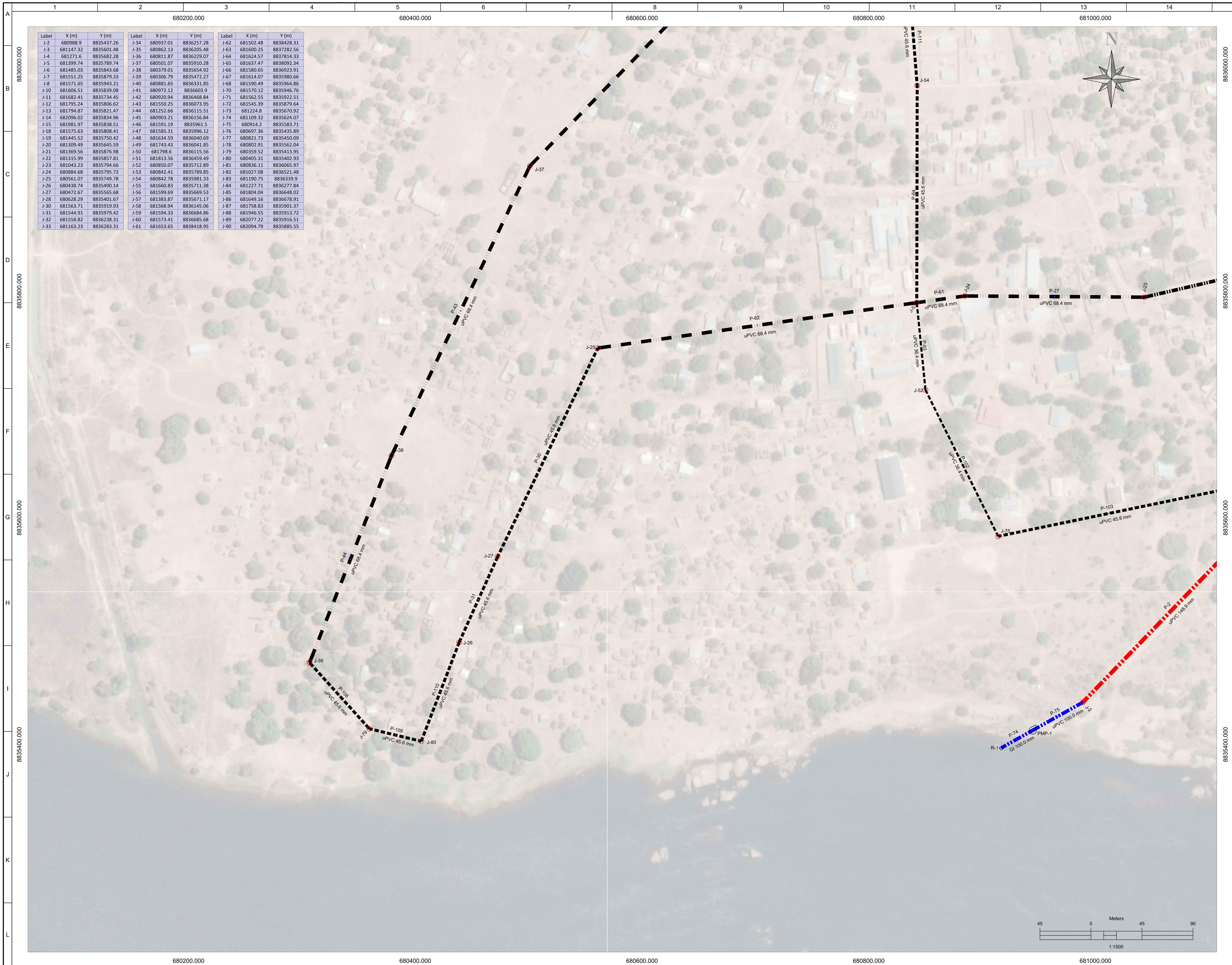
Meters 45 0 45 90 — 1:1500

DESIGNED:	CHI	DATE:		SHEET.No.: 01 OF 01
DRAWN:	CHI	NOV 2021		
CHECKED:	CHI	NOV 2021		
APPROVED:	KAM	NOV 2021		

PROJECTION: UTM 35 South / WGS 84 / metric

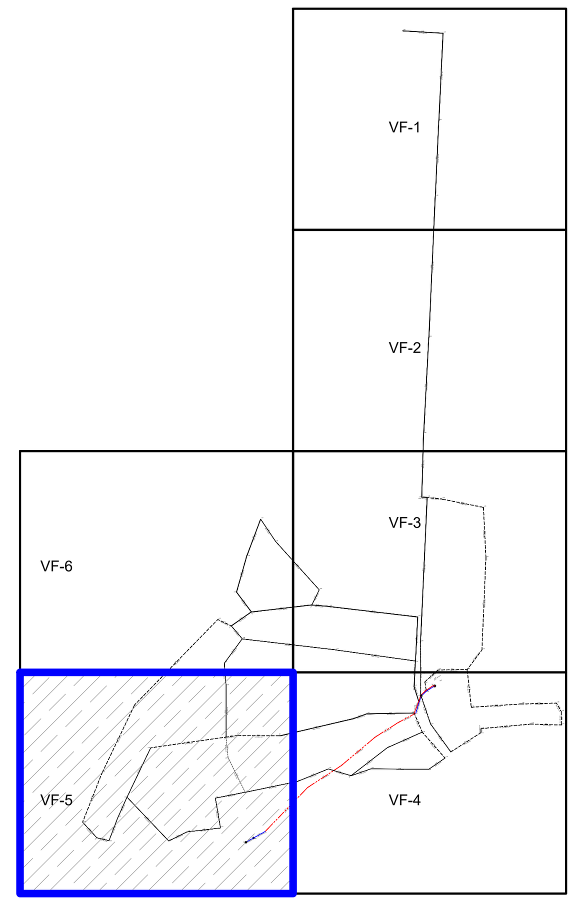
DRWG.No.: GFA-GIZ-MUL-DN-005

Label	X (m)	Y (m)	Label	X (m)	Y (m)	Label	X (m)	Y (m)
J-2	680988.9	8835437.26	J-34	680937.01	8836257.28	J-62	681502.48	8838428.31
J-3	681147.32	8835601.48	J-35	680862.13	8836205.48	J-63	681600.25	8837282.56
J-4	681271.6	8835682.28	J-36	680811.87	8836229.07	J-64	681624.57	8837814.33
J-5	681399.74	8835789.74	J-37	680501.07	8835910.28	J-65	681637.47	8838092.34
J-6	681485.03	8835843.68	J-38	680379.01	8835654.92	J-66	681580.65	8836923.91
J-7	681551.25	8835879.33	J-39	680306.79	8835472.27	J-67	681614.07	8835980.66
J-8	681571.65	8835943.21	J-40	680881.65	8836331.85	J-68	681590.49	8835964.86
J-10	681606.51	8835839.08	J-41	680972.12	8836603.9	J-70	681570.12	8835946.76
J-11	681682.41	8835734.45	J-42	680920.94	8836468.84	J-71	681562.55	8835922.51
J-12	681795.24	8835806.62	J-43	681550.25	8836073.95	J-72	681545.39	8835879.64
J-13	681794.87	8835821.47	J-44	681252.66	8836115.51	J-73	681224.8	8835670.92
J-14	682096.02	8835834.96	J-45	680903.21	8836156.84	J-74	681109.32	8835624.07
J-15	681981.97	8835838.51	J-46	681591.19	8835961.5	J-75	680914.2	8835583.71
J-18	681575.63	8835808.41	J-47	681585.31	8835996.12	J-76	680697.36	8835435.89
J-19	681445.52	8835750.42	J-48	681634.59	8836040.69	J-77	680821.73	8835450.09
J-20	681309.49	8835645.59	J-49	681743.43	8836041.85	J-78	680802.91	8835562.04
J-21	681369.56	8835876.98	J-50	681798.6	8836115.56	J-79	680359.52	8835413.95
J-22	681315.99	8835857.81	J-51	681813.56	8836459.49	J-80	680405.31	8835402.93
J-23	681043.23	8835794.66	J-52	680850.07	8835712.89	J-81	680836.11	8836065.97
J-24	680884.68	8835795.72	J-53	680842.41	8835789.85	J-82	681027.08	8836521.48
J-25	680561.07	8835749.78	J-54	680842.78	8835981.33	J-83	681190.75	8836339.9
J-26	680438.74	8835490.14	J-55	681660.83	8835711.38	J-84	681227.71	8836277.84
J-27	680472.67	8835565.68	J-56	681599.69	8835669.53	J-85	681804.04	8836648.02
J-28	680628.29	8835401.67	J-57	681383.87	8835671.17	J-86	681649.16	8836678.91
J-30	681563.71	8835919.93	J-58	681568.94	8836145.06	J-87	681758.83	8835901.37
J-31	681544.91	8835979.42	J-59	681594.33	8836684.86	J-88	681946.55	8835913.72
J-32	681558.82	8836238.31	J-60	681573.41	8836685.68	J-89	682077.22	8835916.51
J-33	681163.23	8836283.31	J-61	681653.65	8838418.95	J-90	682094.79	8835885.55



NOTES

KEY MAP



LEGEND

UPGRADING OF EXISTING DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC Class 9
- OD 110mm (ID 102.4mm) uPVC Class 9
- OD 75mm (ID 68.4mm) uPVC Class 9
- OD 50mm (ID 45.6mm) uPVC Class 9

NEW INSTALLATIONS IN THE DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC Class 9
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EXISTING AND RETAINED PIPES IN DISTRIBUTION NETWORK

- OD 160mm (ID 148.9mm) uPVC
- ND 100mm GI
- OD 110mm (ID 103.4mm) uPVC
- OD 75mm (ID 68.4mm) uPVC
- OD 50mm (ID 45.6mm) uPVC
- OD 40mm (ID 36.4mm) uPVC
- Existing Intake (Reservoir)
- Network Junctions (Tee/ Bends)
- Pump

SCALE ON A1: HORIZONTAL:1:1500

INDEX:	NOTES:	DATE	SIGNED
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REVISION AND ISSUES

CLIENT: german cooperation DEUTSCHE ZUSAMMENARBEIT; giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

CONSULTANT: GFA Consulting Group GmbH

GFA CONSULTING GROUP

CONTRACT:

Reform of the Water Sector Programme Phase II in Zambia (RWS II)

TITLE: Mulundu Rural Growth Center Small Piped Water Supply Scheme.
(View Frame-5)

REFERENCE DRAWINGS:

DESIGNED:	CHI	DATE:	SHEET.No.: 01 OF 01
DRAWN:	CHI	NOV 2021	
CHECKED:	CHI	NOV 2021	
APPROVED:	KAM	NOV 2021	

PROJECTION: UTM 35 South / WGS 84 / metric

DRWG.No.: GFA-GIZ-MUL-DN-006

Label	X (m)	Y (m)
J-2	680988.9	8835437.26
J-3	681147.32	8835601.48
J-4	681271.6	8835682.28
J-5	681399.74	8835789.74
J-6	681485.03	8835843.68
J-7	681551.25	8835879.33
J-8	681571.65	8835943.21
J-10	681606.51	8835839.08
J-11	681682.41	8835734.45
J-12	681795.24	8835806.62
J-13	681794.87	8835821.47
J-14	682096.02	8835834.96
J-15	681981.97	8835838.51
J-18	681575.63	8835808.41
J-19	681445.52	8835750.42
J-20	681309.49	8835645.59
J-21	681369.56	8835876.98
J-22	681315.99	8835857.81
J-23	681043.23	8835794.66
J-24	680884.68	8835795.72
J-25	680561.07	8835749.78
J-26	680438.74	8835490.14
J-27	680472.67	8835565.68
J-28	680628.29	8835401.67
J-30	681563.71	8835919.93
J-31	681544.91	8835979.42
J-32	681558.82	8836238.31
J-33	681163.23	8836283.31

Label	X (m)	Y (m)
J-34	680937.01	8836257.28
J-35	680862.13	8836205.48
J-36	680811.87	8836229.07
J-37	680501.07	8835910.28
J-38	680379.01	8835654.92
J-39	680306.79	8835472.27
J-40	680881.65	8836331.85
J-41	680972.12	8836603.9
J-42	680920.94	8836468.84
J-43	681550.25	8836073.95
J-44	681252.66	8836115.51
J-45	680903.21	8836156.84
J-46	681591.19	8835961.5
J-47	681585.31	8835996.12
J-48	681634.59	8836040.69
J-49	681743.43	8836041.85
J-50	681798.6	8836115.56
J-51	681813.56	8836459.49
J-52	680850.07	8835712.89
J-53	680842.41	8835789.85
J-54	680842.78	8835981.33
J-55	681660.83	8835711.38
J-56	681599.69	8835669.53
J-57	681383.87	8835671.17
J-58	681568.94	8836145.06
J-59	681594.33	8836684.86
J-60	681573.41	8836685.68
J-61	681653.65	8838418.95

Label	X (m)	Y (m)
J-62	681502.48	8838428.31
J-63	681600.25	8837282.56
J-64	681624.57	8837814.33
J-65	681637.47	8838092.34
J-66	681580.65	8836923.91
J-67	681614.07	8835980.66
J-68	681590.49	8835964.86
J-70	681570.12	8835946.76
J-71	681562.55	8835922.51
J-72	681545.39	8835879.64
J-73	681224.8	8835670.92
J-74	681109.32	8835624.07
J-75	680914.2	8835583.71
J-76	680697.36	8835435.89
J-77	680821.73	8835450.09
J-78	680802.91	8835562.04
J-79	680359.52	8835413.95
J-80	680405.31	8835402.93
J-81	680836.11	8836065.97
J-82	681027.08	8836521.48
J-83	681190.75	8836339.9
J-84	681227.71	8836277.84
J-85	681804.04	8836648.02
J-86	681649.16	8836678.91
J-87	681758.83	8835901.37
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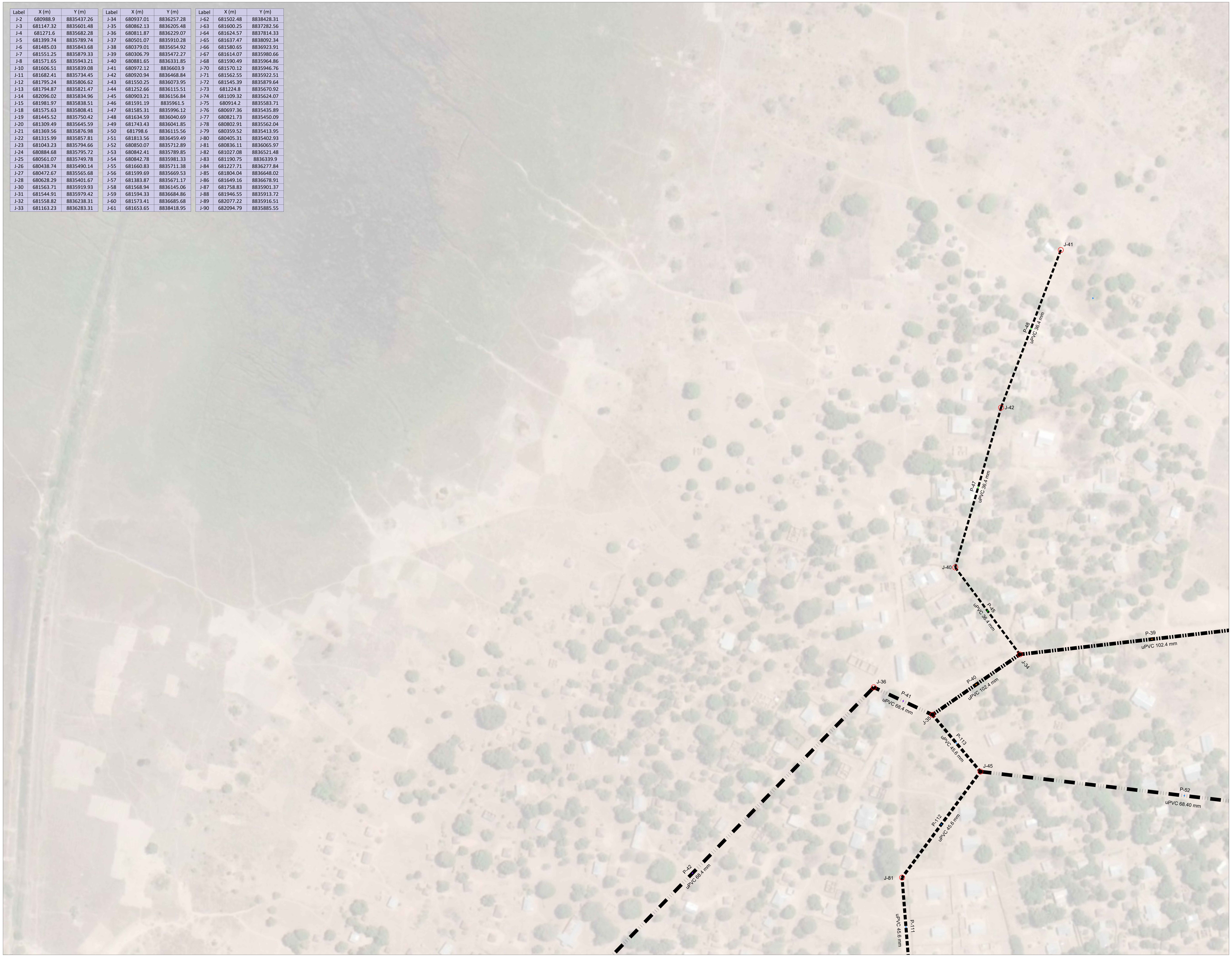
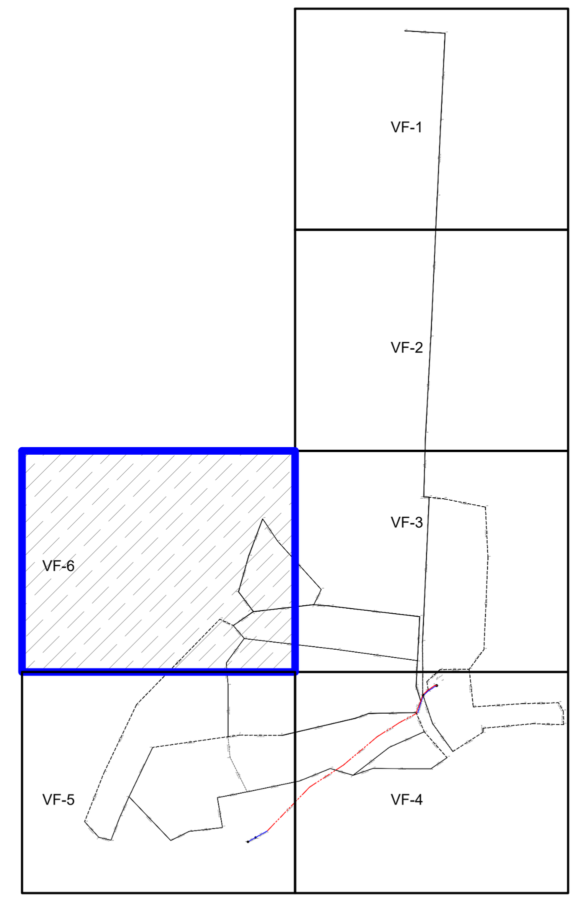
J-89	682077.22	8835916.51
J-90	682094.79	8835885.55



NOTES NOTES

KEY MAP



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REVISION AND ISSUES

CLIENT: german cooperation DEUTSCHE ZUSAMMENARBEIT; giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

CONSULTANT: GFA Consulting Group GmbH

CONTRACT: Reform of the Water Sector Programme Phase II in Zambia (RWS II)

TITLE: Mulundu Rural Growth Center Small Piped Water Supply Scheme.
(View Frame-6)

REFERENCE DRAWINGS:

DESIGNED:	CHI	DATE:	SHEET.No.: 01 OF 01
DRAWN:	CHI	NOV 2021	
CHECKED:	CHI	NOV 2021	
APPROVED:	KAM	NOV 2021	

PROJECTION: UTM 35 South / WGS 84 / metric

DRWG.No.: GFA-GIZ-MUL-DN-007