SECTION(SOPS) **STANDARD OPERATING PROCEDURES**

{ 1 }FINANCE SECTION WORKFLOWS

PAYROLL

- Checking of monthly payroll updates from HR office
- Process payment vouchers for staff salaries and Deductions
- Drawing of cheques for the above
- Filling of statutory returns and generating payment Eslips
- Depositing Payments with the relevant institutions/bank
- Filling documents

SUPPLIES AND SERVICES AND OTHER BILLS

- Verification of supplies and services documents from procurement section
- Invoicing supply and services received, deducting all withholding taxes thereof
- Process payment vouchers and cheques for payment
- Filling and remitting withholding taxes
- Filling documents

PREPARATION OF FINANCIAL REPORTS

- Reconciling payments and receipts
- Generating ledgers
- Populating data for financial reports
- Producing financial reports

{ 2}GIS WORKFLOW AND STANDARD OPERATING PROCEDURES

Among the key functions of the GIS section is the collection, analysis, and dissemination of geospatial data to support decision-making across various departments. To achieve this effectively, there is a need for seamless and structured flow of information between departmentandtheGISsection.

To facilitate this coordination and ensure timely and accurate execution of tasks, we have formulated clear Standard Operating Procedures (SOPs) and workflow guidelines. These workflows aim to streamline communication, eliminate redundancies, and promote accountability across departments whenever GIS services are required. Below is the proposed GIS workflow framework for your review, input, and subsequent adoption for circulation and implementation.

CATEGORY I: MAPPING AND UPDATING OF CUSTOMER RECORDS

1) NEW CONNECTION DATA

After a new connection is completed, the data should be updated indicating the account, its location and the route/pipeline from which it is getting the water from.

i. New connection attributes including land parcel numbers are captured during the application process while location and pipeline data is captured during ground installation.
ii. The GIS assistants generates these reports from the system on a monthly basis for verification and update.
iii. Where the pipeline is captured the GIS assistants loads the coordinates into GIS software and verifies that the connections location data is in the proximity of the assigned pipeline.
iv. Where there are disparities he/ she refers to the land parcel data captured during the application process and generates the correct connection location/ pipeline.
v. Where challenges arise in the verification process the assistant liaises with the metering assistant who installed the account to provide the correct pipeline and customer location through the company metering officer.
vi. This is followed by and updating of the corrected data in company geodatabase as well as the ERP system.
vii. The section then generates reports for updated account records are then generating on a monthly basis to ensure all accounts created within the month are captured adequately for ease of meter reading in the subsequent month.

2) EXISTING CONSUMER ACCOUNTS

a. Update of data after relocation

i. Account relocation data is received from the following sources:
   a. KOBO reports of meter relocations forwarded monthly to the GIS section by the Company Metering Officer.
   b. System-generated reports highlighting proximity mismatches between the meter reading location and customer location (quarterly).
   c. Reports from the revenue and Non-Revenue water sections identifying inaccurately assigned customer accounts, flagged by meter readers and Non-revenue water technicians.

   Field data collected by GIS Assistants using GPS handsets following a memo from the Distribution and the Non-Revenue sections indicating account or pipeline relocations.

ii. GIS Assistants load the new coordinates into GIS software to verify whether the routes, zones, and pipelines provided in relocation reports align with existing system data.

iii. Where the data aligns, the assistant updates the corrected information in both the company geodatabase and ERP system.

iv. Where discrepancies exist, the assistant references land parcel attribute data to identify which entry corresponds correctly to the parcel location and makes the necessary updates in the systems.

v. If challenges arise during verification, the assistant liaises with the Metering Assistant who performed the relocation or the meter reader who identified the error. These verifications are channelled through the Company Metering Officer and the Revenue Officer, respectively.

vi. Reports for updated account records are generated monthly to ensure that all relocated or updated accounts are captured adequately for seamless meter reading in the subsequent month.

3) DATA DORMANTING REQUESTS

After prolonged service interruptions, affected customer accounts may be marked as dormant upon request from the distribution team.

i. The Operations and Maintenance Officer (OMO) from the Distribution team initiates a request for dormant account data. The request specifies the affected area and pipelines with prolonged service disruption.

ii. The GIS Assistant identifies the specified areas in the geodatabase and generates a list of customer accounts affected by the interruption.

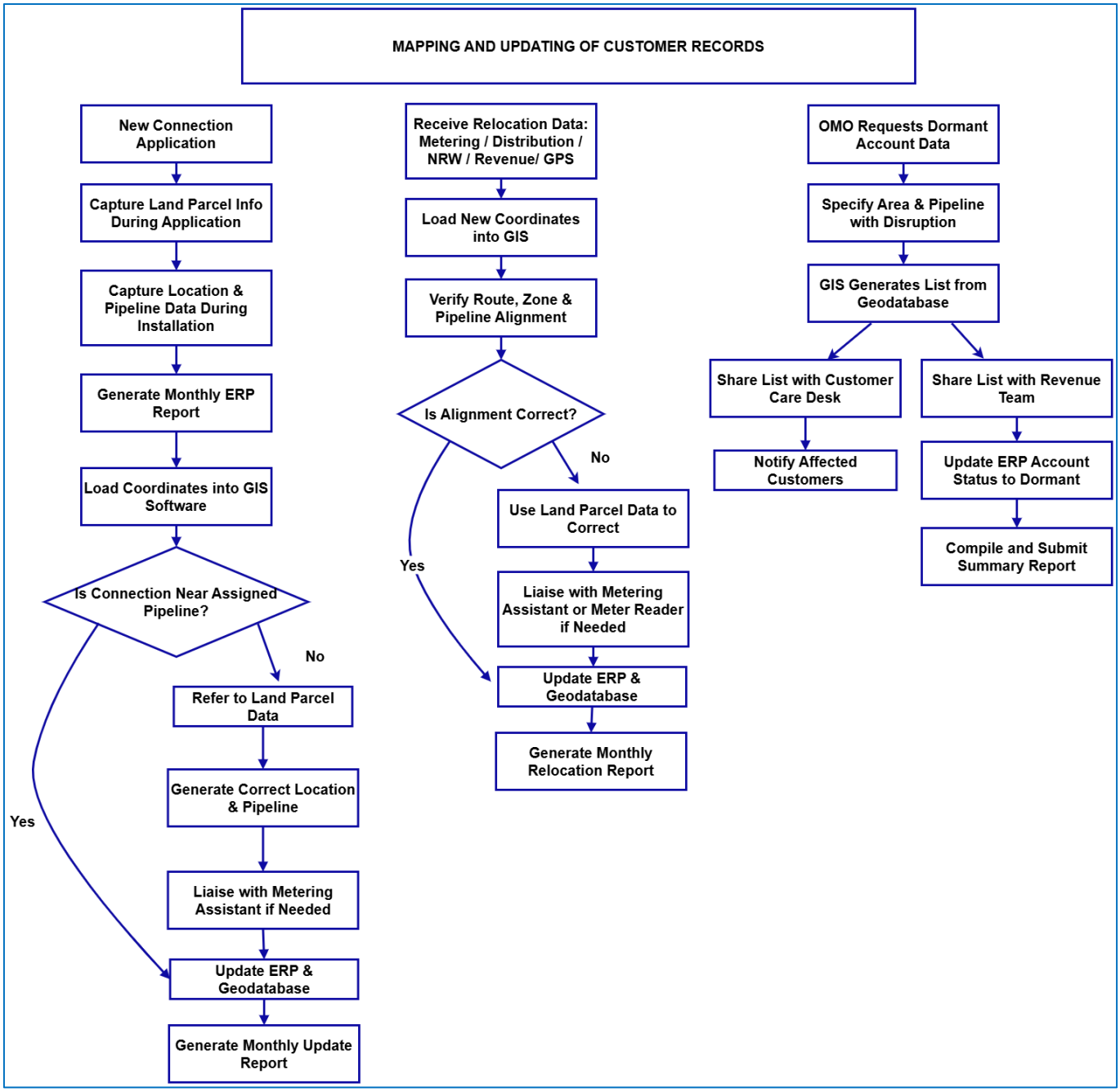
iii. The list of affected customers is shared with the Customer Care Desk to facilitate customer notification regarding the status change.

iv. The same list is forwarded to the Revenue Generation Team for updating the status of each identified account to Dormant within the ERP system.

v. The GIS section compiles a summary report of the updated accounts.

Refer to the detailed workflows and corresponding flowchart below.

Figure 1: MAPPING AND UPDATING OF CUSTOMER RECORDS FLOW



CATEGORY II: MAPPING OF PIPELINES AND APPURTENANCES

i. Pipeline and appurtenance mapping data is received from the following sources:
   a. KOBO reports from the Operations & Maintenance (O&M) team following repairs, replacements, or extensions of pipelines and associated infrastructure.
   b. Field data collected by GIS Assistants using GPS-enabled mapping devices after receiving memos from the Distribution and O&M sections regarding changes to pipeline infrastructure.

ii. GIS Assistants use handheld GPS devices and other ground-mapping tools to verify and capture the spatial location of pipelines and appurtenances on-site.

iii. The assistants record coordinates, pipe sizes, and appurtenance details (e.g., valves, hydrants, washouts, air valves) for each location during field mapping.

iv. The captured data is loaded into GIS software (e.g., ArcMap) to check for consistency and accuracy against existing geospatial records.

v. Where the data aligns, the assistant updates the pipeline and appurtenance details in both the company's geodatabase.

vi. In case of inconsistencies, the assistant references base maps, previous engineering drawings, or consults with the O&M team for clarification before making updates.

vii. If further verification is needed, the GIS Assistant liaises with the O&M officer technician who reported or conducted the work.

viii. Weekly summaries of mapping updates are compiled to track ongoing changes and ensure the GIS system reflects current ground conditions.

ix. A monthly report is generated detailing all mapping activities and updates.

CATEGORY III: PROJECT IDENTIFICATION AND DESIGN

Project identification and design data is received from the following sources:

a. Management requests for survey of expansive areas for overhaul projects.
b. Requests from the OMO and Distribution team for pipeline rehabilitation and survey for water supply and sewage projects

1) Design of Minor Works Projects:

i. The OMO and Distribution teams write a request for the rehabilitation of specific pipelines or a minor section of pipelines.

ii. A survey reconnaissance is carried out based on desk work, considering the already existing network.

iii. After necessary approval, a topographic survey is carried out.

iv. A demand analysis, drawings, and Bill of Quantities (BOQs) are generated.

v. The data from the demand analysis, including pipe sizes and drawings, are updated in the GIS database as proposed.
vi. A report is generated indicating the new design, demand analysis, and the BOQs for the pipelines.
vii. The report is submitted to the supervisor for changes and filing.
viii. Once the project is implemented, updates are made to the geodatabase, indicating the pipelines as existing.

2) Design of Overhaul Projects:

i. The project is identified by management, who writes a request for the survey of large or expansive areas.
ii. A survey reconnaissance is carried out based on desk work, considering the existing network.
iii. After necessary approval, a topographic survey is carried out.
iv. A demand analysis, drawings (including pipelines and appurtenances), and BOQs are generated for the area.
v. The data from the demand analysis, including pipe sizes and appurtenances, are updated in the GIS database as proposed.
vi. A design report is generated indicating the new design, demand analysis, and the BOQs for the pipelines.
vii. The report is submitted to the supervisor for changes and filing.
viii. Once the project is implemented, updates are made to the geodatabase, indicating the pipelines as existing.

CATEGORY IV: DATA ANALYSIS

1) Consumption pattern analysis

i. Data for consumption pattern analysis is obtained from the following sources:
    a. Water consumption data extracted from the ERP system.
    b. Metering records for household and commercial consumers.
    c. Complaint data related to billing, metering, and water supply issues.
ii. Consumption data is sorted by consumer category (household vs. commercial).
iii. Peak demand periods are identified through trend analysis of usage patterns.
iv. Unusual consumption patterns such as sudden spikes or drops are flagged and investigated.
v. Zones with frequent complaints are identified and flagged for further review.
vi. Reports are generated summarizing findings, with recommendations for improved demand management.

vii. Reports are submitted to the Commercial and Operations departments for implementation.

2) CATEGORY VI: BILLING AND REVENUE COLLECTION ANALYSIS

i. Billing and revenue data is sourced from the following:
   a. Billing records downloaded from the ERP system.
   b. Revenue collection data per zone retrieved monthly.
ii. Monthly comparisons are made between revenue collected and billed water volume per zone.
iii. Collection efficiency per zone is assessed and flagged where necessary.
iv. Historical trends are used to forecast revenue and project billing estimates.
v. A comprehensive report is compiled, highlighting key insights and anomalies.
vi. Reports are submitted to the Finance and Commercial departments for review and action.

3) CATEGORY VII: METERING EFFICIENCY AND ACCURACY ANALYSIS

i. Data used for metering analysis is gathered from the following sources:
   a. Manual and smart meter readings retrieved from the ERP system.
   b. Reports of meter failures submitted by field staff.
   c. Meter installation dates and lifespan data from metering records.
ii. Comparisons are conducted between manual and smart meter readings to identify inconsistencies.
iii. Meter accuracy is evaluated, and discrepancies are flagged for follow-up.
iv. Meters nearing the end of their service life or those showing frequent failure are identified.
v. Efficiency reports are generated and include recommendations for meter upgrades or replacements.
vi. Reports are submitted to the Metering and Technical teams for decision-making.

4) CATEGORY VIII: PIPELINE AND INFRASTRUCTURE CONDITION ANALYSIS

i. Data for infrastructure condition analysis is collected from the following:
   a. Pipeline maintenance and repair records.
   b. GIS data showing the location and age of existing pipelines.
   c. Reports of pipe bursts and leaks submitted by field teams.
ii. GIS tools are used to visualize pipeline conditions and identify aging assets.

iii. High-risk areas with frequent pipeline failures are mapped and flagged.
iv. Pipeline repair response times are assessed to identify areas of operational delay.
v. Condition reports are generated with recommendations for pipeline rehabilitation.
vi. Findings are submitted to the Operations and Maintenance department for follow-up.

5) CATEGORY IX: DEMAND FORECASTING AND CAPACITY PLANNING

i. Data for demand forecasting is sourced from the following:
    a. Historical water consumption data retrieved from ERP.
    b. Seasonal variation reports generated from monthly and annual usage trends.
    c. Population growth statistics and new connection data from the Commercial section.
ii. Trend analysis is performed to project future water demand per zone.
iii. Supply deficits are identified by comparing projected demand against current production capacity.
iv. Resource planning is conducted to determine required infrastructure upgrades and resource allocation strategies.
v. Recommendations are developed for meeting peak demand periods and managing supply.
vi. A capacity planning report is prepared and submitted to Management for review and implementation.

{3}REVENUE PROCESS

A. Meter Reading/ Collection

- Assignment of the meter reading/ debt collection books.
- Downloading of the books by the revenue clerk
- Actual reading of the meter off line/on line.
- Revenue collection of current and accrued bills.
- Meter data uploaded to billing system on daily basis twice a day

B. Data Validation

- Validate readings/ Flag exceptions (flag anomalies, zero/negative usage)
- Cross-check readings with historical usage (e.g., leaks, unusually high usage)
- Send for inspection what is require interventions before billing
- Apply tariff structure

C. Invoice Generation, verification and approval

- Auto-generate invoice in system
- Include:
    - Billing period
    - Consumption in m^3
    - Breakdown of charges
    - Due date and payment options
    - reviews bulk billing run
    - Approve or correct flagged bills

D. Bill Delivery

- Sent via:
    - Email
    - SMS/notification through E.R.P

E. Payment Collection

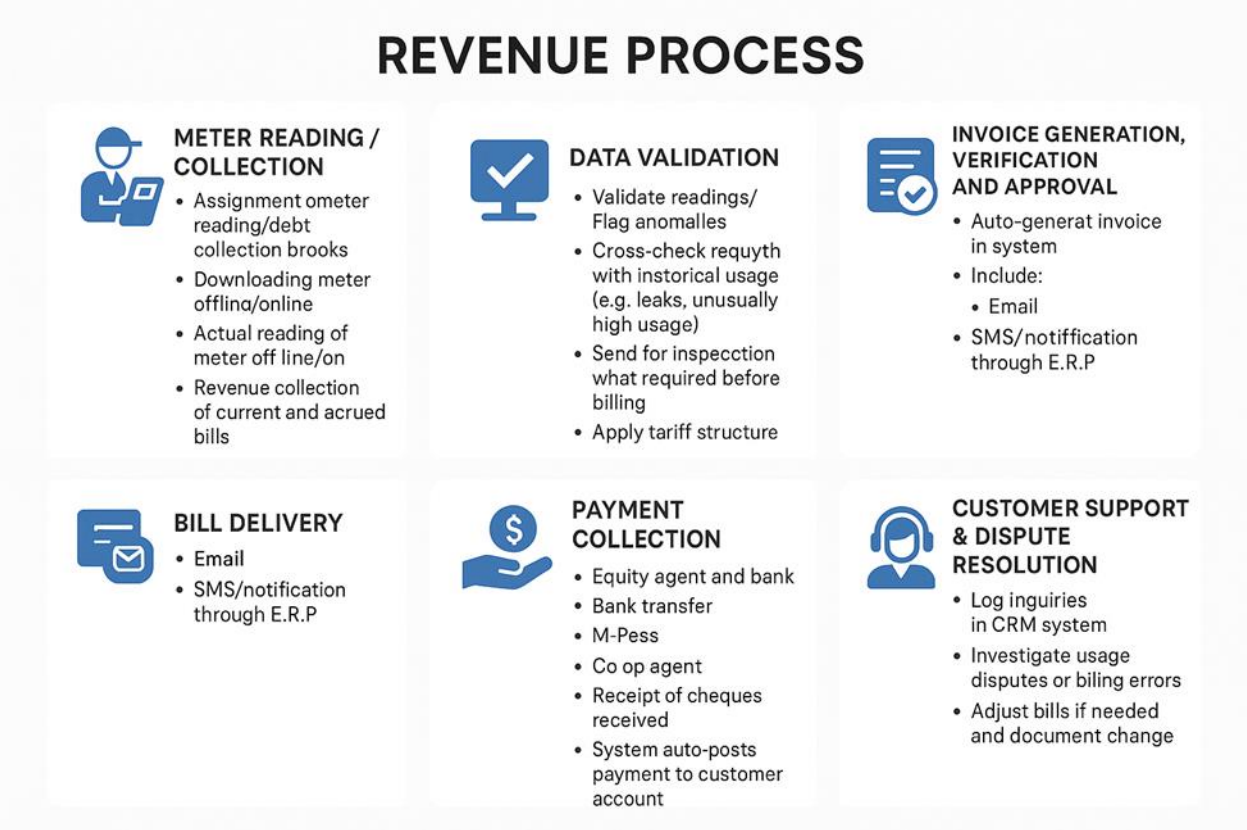
- Payments received via:
    - Equity agent and bank
    - Bank transfer
    - M-pesa
    - Co op agent
    - Receipt of cheques received
    - System auto-posts payment to customer account

F. Reconciliation

- Match payments with invoices
- Generate daily/monthly reconciliation reports
- Flag and follow up on overdue accounts

G. Customer Support & Dispute Resolution

- Log inquiries in CRM system
- Investigate usage disputes or billing errors
- Adjust bills if needed and document change



{ 4} **Human resource workflow and standard operating procedures**

1. ISSUANCE OF WORK TICKETS

1. Provide the previous work ticket. If lost;

   a) Provide a police abstract and OB number.
   b) Write a letter addressed to thee MD on when and where the work ticket got lost.
   c) If on leave; provide the work ticket for whoever had the motorcycle/car while you were on leave.

2. Confirm whether all entries on fuel and oil are clearly indicated against the invoice number.

3. Confirm on the indicated speedometer readings for correct distance covered throughout the month, the fuel drawn.

4.

TRAINING AND DEVELOPMENT

1. Invitation for the training.

2. A memo written following the training needs analysis, on development of a skills in ascertain department.

3. A memo requesting training for all staff for an incident or occurrence.

4. The memo is forwarded to the MD for advice or guidance on the specifics of the training.

5. Comment on the essentiality of the training, the objective and the positivity or the training expectations

6. If the training is deemed essential for a department, section or staff, it's approved and the MD gives the go ahead to facilitate the training.

7. Heads of departments are consulted on individuals to partake the training, a look at previous training on the same to avoid duplication of candidates.

8. Memo is raised with the staff going the training, once approved, accts facilitate the training.

9. Once the training is complete, the staff who went for the training are to provide a report on the training.

PAYROLL ADMINISTRATION

1. Close previous month payroll

2. File all necessary changes of the month

3. Effect changes, check for irregularities.

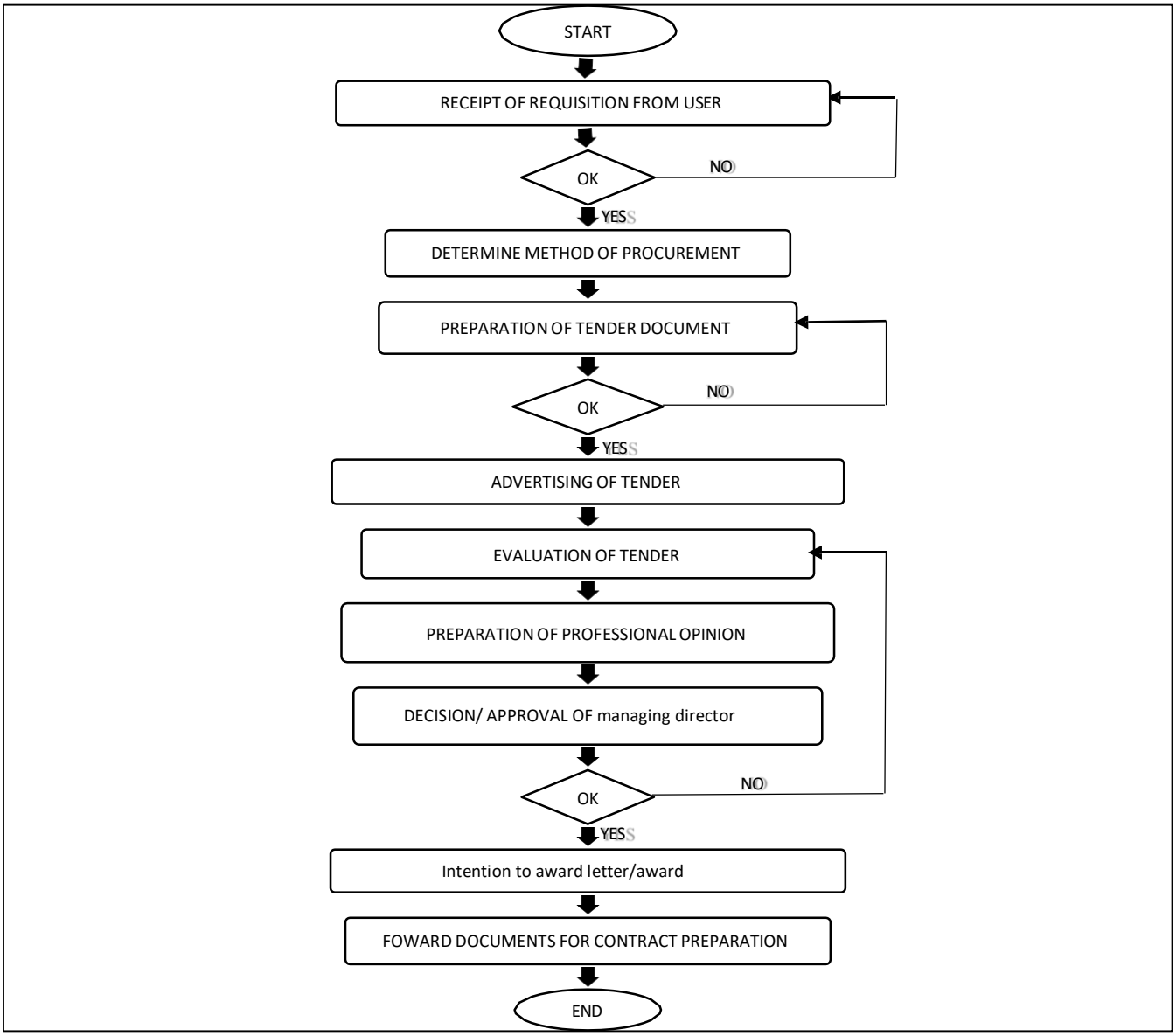
4. Send to the accountant for cheque processing

5. Approval from the commercial manager

PROCUREMENT PROCESS AND STANDARD OPERATING SYSTEM

S/No.	**Process Details/Description**	**Resources**	**Timeline**
1	plans from user debarment and aproaved budget		
2	procurement plan		
3.	Receipt of requisition from user department	Procurement plan Approved Memo	1 day
4	Determination of Method of Procurement	PPADA, 2015 PPADR, 2020	1 day
5	Preparation of Tender/Quotation documents	Specifications/ requirements PPRA Standard document. PPAD, 2015 PPADR, 2020	1 week
6.	Advertisement of tenders /request for quotations	Public procurement information portal. The Authority website Newspapers	2 days
7	Opening of tenders	Tender opening register forms.	1 day

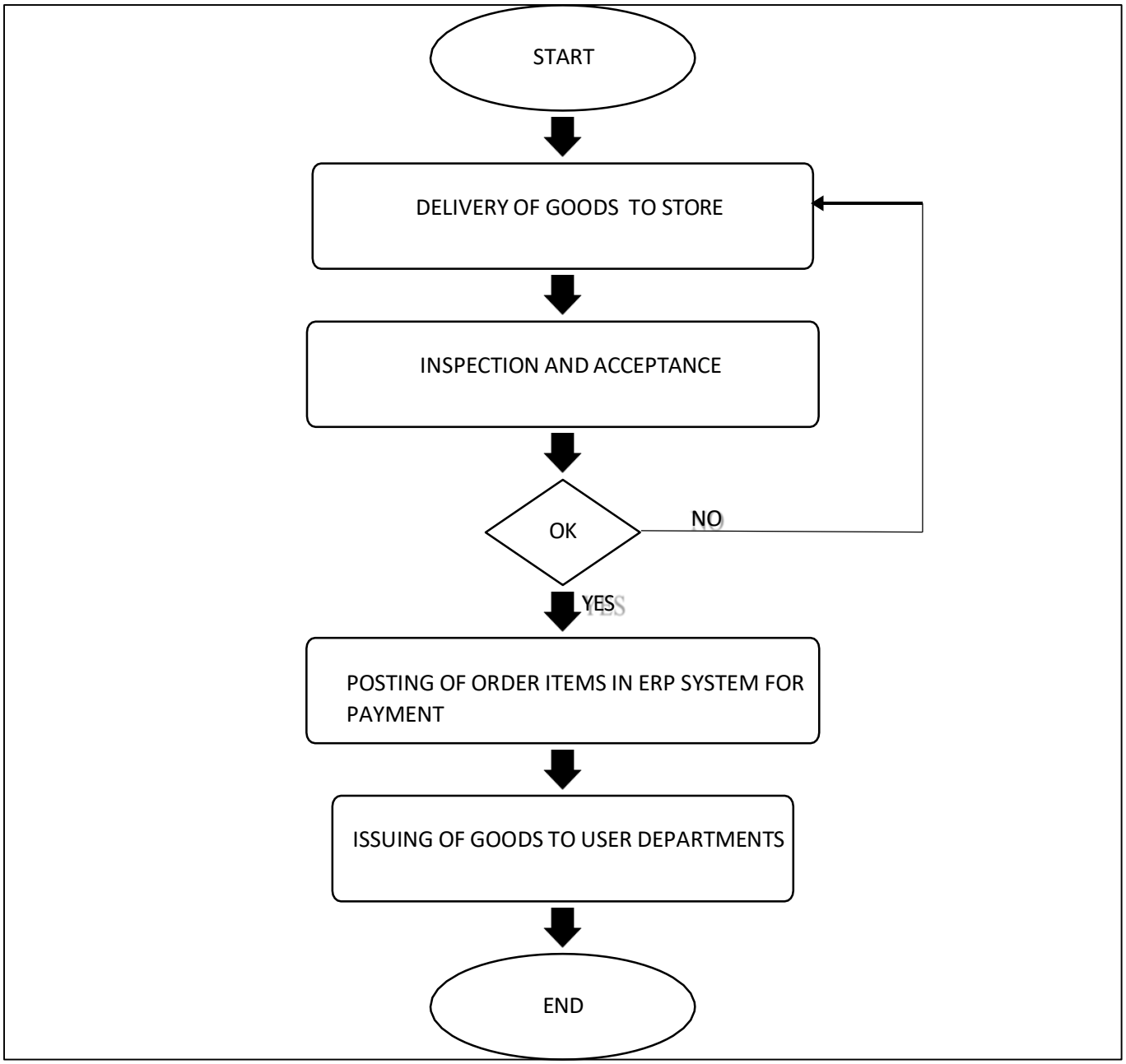
8.	Evaluation of Tenders	appointed commiteees	Tender Evaluation Report	Appointed te committee Evaluation re
9.	Preparation of professional opinion	Tender evaluation report	Professional Opinion	Signed profess opinion
10.	Decision of Award by the accounting officer	Professional opinion Signed evaluation report	Accounting Officer Approval	Approval of t the Accounti
11	Notification of intention to award/outcome to participating bidders	Approval of the Accounting officer	Notification of intention to award/ Notification outcome Letters Debriefing letters	briefing minu
12	Contract preparation/ preparation of LPO/LSO	Successful Bid/registered bidders	Contract document/ LPO/LSO	LSO/LPO


START
RECEIPT OF REQUISITION FROM USER
OK
NO
YES
DETERMINE METHOD OF PROCUREMENT
PREPARATION OF TENDER DOCUMENT
OK
NO
YES
ADVERTISING OF TENDER
EVALUATION OF TENDER
PREPARATION OF PROFESSIONAL OPINION
DECISION/ APPROVAL OF managing director
OK
NO
YES
Intention to award letter/award
FOWARD DOCUMENTS FOR CONTRACT PREPARATION
END

Procedure details

Receiving and inspection of the goods.

No.	Process Details/Description	Resources	Output	Measure
1	Delivery of goods to the stores	Delivery notes Goods delivered notes invoice	Delivered goods	Signed delivery n invoices
2	Inspection and acceptance of goods against specification on the LPO	LPO/LSO Specifications requisition	Received goods in store	Inspection and Ac Certificate GRN
5	Posting of received order items to Stores ERP System	delivery note invoice LPO	Posted items in the ERP system	Updated stores le system
6	Forwarding the invoices to procurement	LPO Delivery note invoice inspection Goods Received Note		LPO Delivery note invoice inspection Goods Received
7	verifying and forwarding to accounts department for payment	Delivery note invoice inspection Goods Received Note	verified documents	Delivery note invoice inspection Goods Received Requisition
7	Issuing of Goods to the User Departments	Approved User store requisition	Goods received by user	signed Stores issu

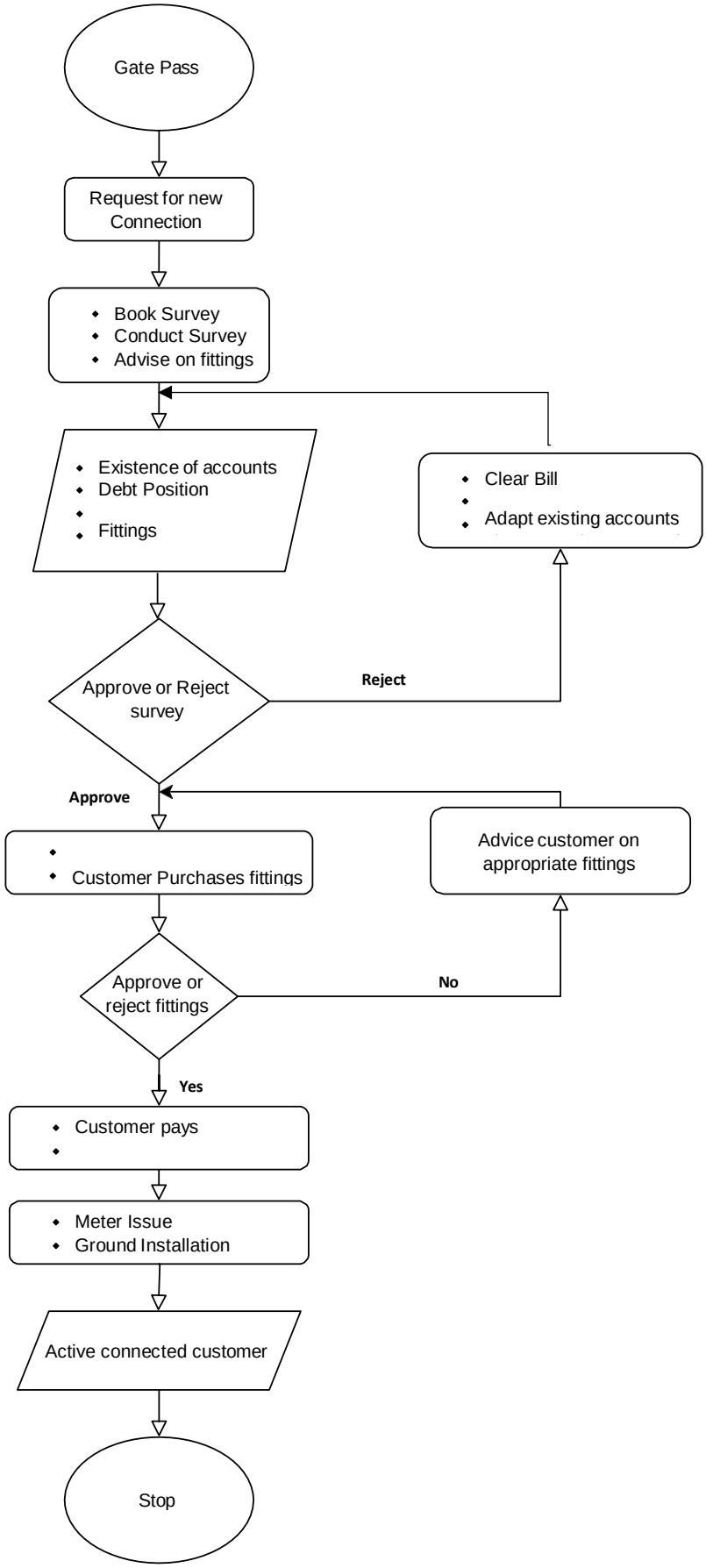

START
DELIVERY OF GOODS TO STORE
INSPECTION AND ACCEPTANCE
OK
NO
YES
POSTING OF ORDER ITEMS IN ERP SYSTEM FOR PAYMENT
ISSUING OF GOODS TO USER DEPARTMENTS
END

WORK FLOW SCHEDULE FOR CUSTOMER CARE SECTION CRITICAL DAY TO DAY OFFICE OPERATIONS.

NEW CONNECTION

1) Customer records a gate pass with customer particulars and nature of complaint/compliment
2) A prospective customer expresses interest for a water connection where he/she avails the mandatory document.
3) The documents are keyed in the system to generate a survey form and forwarded to the **MT** for action.
4) The customer is advised on the steps to undergo for the new connection to be done.
5) When the customer is not connectable the reasons to be clearly documented by the **MO** for communication to the customer and necessary attachments to be done
6) Upon confirmation of the viability the customer buys fittings as advised by the surveyor
7) The prospective customer visits the customer care desk with the hard copies of the documents together with the fitting inspection form duly signed where an application is filled, he/she is issued with an account number and payment of the requisite charges is done.
8) The customer is taken through on the tariff and the agreement form details by the **CRA**.
9) The metering section takes over for meter installation hence to billing section

NEW CONNECTION APPLICATION PROCEDURES



METER ISSUES, RECONNECTION, ACCOUNT TERMINATION, METERING OF FLAT RATES, METER RELOCATIONS AND RELEVANT ISSUES

1) Customer records a gate pass with customer particulars and nature of complaint/compliment
2) Customer care records the complaint via a ticket with details of complaint.
3) Customer care advices on payments where payments are required
4) Ticket forwarded to the **MO**
5) The **MO** delegates the works to relevant staff to undertake the duties which includes but not limited to inspection, servicing, testing, reconnection etc.
6) The staff passes back the ticket to the **MO** with progress of works done/recommendations.
7) Where surcharges are to be done the **MO** to clearly indicate necessary evidence be attached on the ticket for the same to be effected.
8) The **MO** passes the ticket to the customer care desk with recommendation or action for the customer care to communicate to the customer and close the ticket

BILLING, DISCONNECTION, PAYMENTS, ILLEGALITIES

1) Customer records a gate pass with customer particulars and nature of complaint/compliment
2) Customer care records the complaint via a ticket with details of complaint and attach relevant documents where applicable.
3) Ticket is passed to **ARO**
4) The ARCO delegates the works to relevant staff to undertake the duties which includes but not limited to meter rereading, account status confirmation etc.
5) The staff passes back the ticket to the **ARO** with progress of works done/recommendations.
6) Where the works cannot be done due to lack of materials the **ARO** raises necessary memos and reference of the same quoted on the ticket when passing to customer care desk for action.
7) Where surcharges are to be done the **ARO** to clearly indicate and necessary evidence be attached on the ticket for the same to be effected.
8) The **ARO** passes the ticket to the customer care desk with recommendation or action for the customer care to communicate to the customer and close the ticket

NO WATER, BURST AND LEAKAGES AND OTHER RELATED ISSUES

1) Customer records a gate pass with customer particulars and nature of complaint/compliment
2) Customer care records the complaint via a ticket with details of complaint.
3) Ticket is passed to **TO/OMO**

4) The **TO/OMO** delegates the works to relevant staff to undertake the duties which includes but not limited to burst and leak repairs, line patrols, flow monitoring etc.
5) The staff passes back the ticket to **TO/OMO** with progress of works done/recommendations.
6) Where the works cannot be done due to lack of materials the **TO/OMO** raises necessary memos and reference of the same quoted on the ticket when passing to customer care desk for action
7) The **TO/OMO** passes the ticket to the customer care desk with recommendation or action for the customer care to communicate to the customer and close the ticket

LETTERS, EMAILS

1) Customer care records the complaint via a ticket with details of complaint/works together with the attachment of the stamped and serialized letter.
2) File the stamped and serialized letter to the customer complaint file and furnish the customer with a copy of the same.
3) File forwarded to the **MD** for information.
4) Ticket is passed to the relevant supervisor.
5) The supervisor delegates the works to relevant staff/ **DC** to undertake the duties as per the issue/complaint.
6) Where the works were delegated to the staff for action the staff passes back the ticket to the supervisor with progress of works done/recommendations.
7) The supervisor passes the ticket to the customer care desk with recommendation or action for the customer care to communicate to the customer and close the ticket

INTERNAL REQUESTS/ ISSUES

1) Customer care or staff records the complaint via a ticket with details of complaint/works
2) Ticket is passed to the relevant supervisor.
3) The supervisor delegates the works to relevant staff to undertake the duties as per the issue/complaint.
4) Where surcharges are to be done the supervisor to clearly indicate and necessary evidence be attached on the ticket for the same to be effected.
5) Where the works were delegated to the staff for action the staff passes back the ticket to the supervisor with progress of works done/recommendations.
6) The supervisor passes the ticket to the customer care desk with recommendation or action for the customer care to communicate to the customer and close the ticket

CALLS, WHATSAPP, FACEBOOK AND OTHER SOCIAL PLATFORMS

1) Customer care records the complaint via a ticket with details of complaint/works with necessary attachments where applicable
2) Ticket is passed to the relevant supervisor.

3) The supervisor delegates the works to relevant staff to undertake the duties as per the issue/complaint.
4) Where the works were delegated to the staff for action the staff passes back the ticket to the supervisor with progress of works done/recommendations.
5) The supervisor passes the ticket to the customer care desk with recommendation or action for the customer care to communicate to the customer and close the ticket

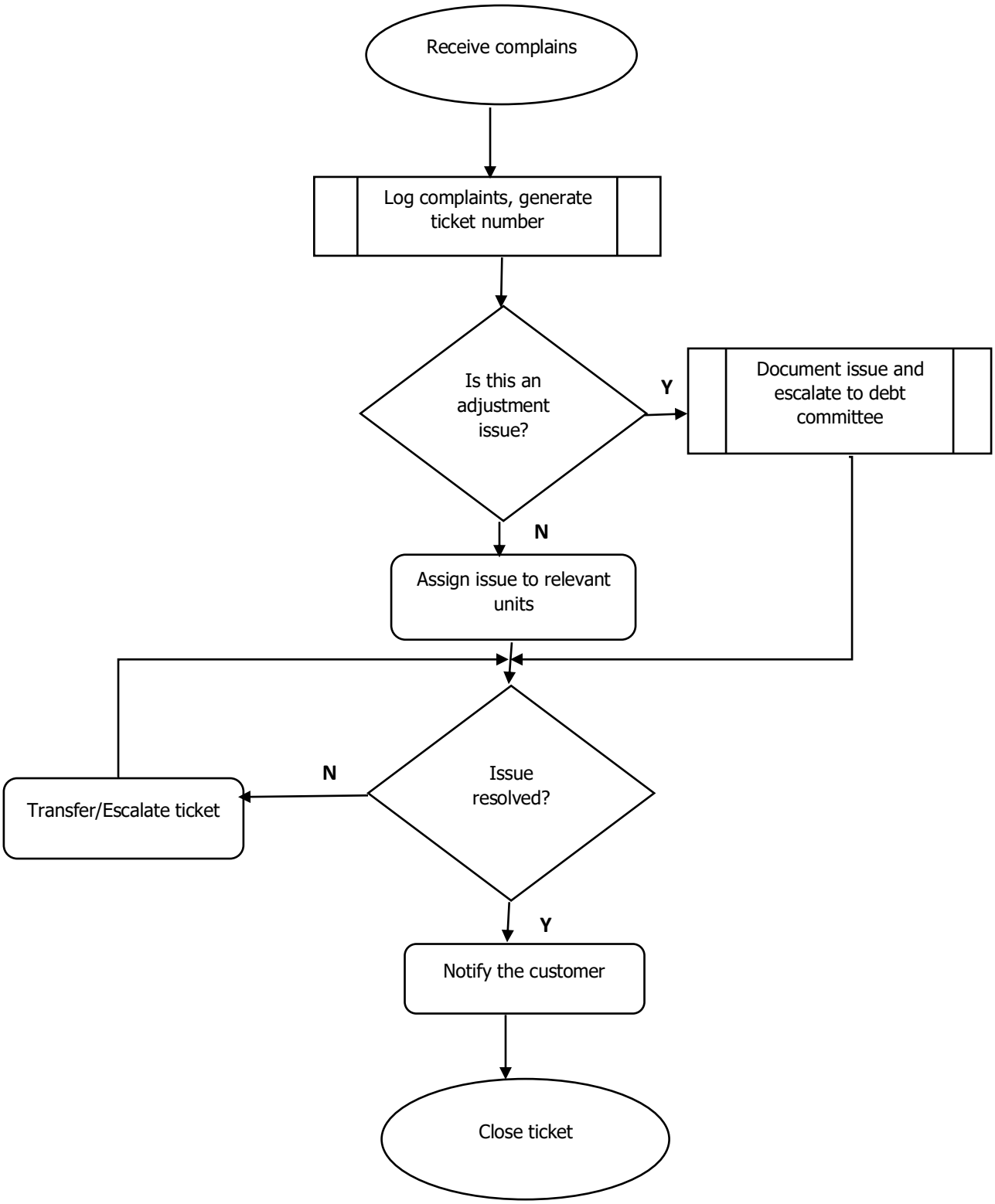
Issues that needs attachments/supporting documents

1. Self-reconnection
2. Meter tampering
3. Meter bypass
4. Payment transfers
5. Nonreflecting payments
6. Change of tenancy
7. Letters
8. WhatsApp issues with images
9. Emails
10. Supply line interference

ACRONYMS

MD- Managing Director
MO- Metering Office
TO- Technical Officer
ARO- Assistant Revenue Officer
DC – Debt Committee
OMO- Operations and Maintenance Officer
CRA – Customer Relation Assistant
MT – Metering Technicians

COMPLAIN HANDLING PROCEDURES



OPERATION OF THE TREATMENT FACILITIES

Intake Weir and Screens

Coarse Screens are provided at the Intake Chambers to prevent entry of large sized stones as well as other floating debris. Fine Screens are also provided in the Channel to prevent entry of debris greater than 10mm entering into the Pipeline.

The tasks described below are to be carried out for the Intake Works on routine basis as described. All observations, inspection results and Tasks performed should be recorded on Task Record **Sheets No. F101** and **F102** as provided

a) Daily Tasks

1. Inspection of the Coarse Screen for any abnormality, e.g. floating debris and removal of the same.
2. Inspection of the Fine Screens for debris, especially leaves and removal of the same.

b) Weekly Tasks

1. Inspection for any erosion at edges of the Weir Structure including the sides and front edge of the Apron;
2. Inspection of the Fine/ Coarse Screen Chamber for debris and silt, especially after heavy rains/ floods when siltation may occur and remove the debris/silt manually.

c) Monthly Tasks

1. De-silting of the Weir using the Scour Penstocks;
2. Trimming of grass, bushes etc.
3. Cutting overgrown trees.

d) Annual Tasks

1. Checking and greasing all the Penstocks;
2. Paint all metal parts of all structures situated at the Intake;
3. Cutting overgrown trees.

Raw Water Gravity Main (RWGM)

Task Schedule for Raw Water Gravity Main

The Tasks described below are to be performed regularly at the periods indicated:

All observations, inspection results and Tasks performed should be recorded on the **Task Record Sheets No. F104** and **F105** provided in **Section 2, page 2-9** and **2-10** respectively of this O&M Manual.

a) Daily Tasks

1. Patrol the Pipeline to detect leaks or any damage to the Pipe or Fittings and report to the WPO immediately. Signs of potential landslides and any erosion along the pipeline should be addressed immediately;
2. Check for any damage to Chambers, Chamber Covers, Marker Posts and report to the Technical Manager.

b) Monthly Tasks

1. Check functioning of the Section Valves by shutting and opening.
2. Operate the Wash-Out Valves to ensure de-silting of the Pipeline.
3. Check the Chambers along the Pipeline for any leakages and remove accumulated debris if any.

c) Annual Tasks

1. Inspect the Valve Gear mechanisms.
2. Inspect all metal structures pertinent to the Raw Water Gravity Main.
3. Paint all the metal structures.

Water Treatment Works

Introduction

The Treatment Works is where raw water is made potable for distribution to Consumers. There are different operations to be carried out in the treatment of water. The functions of these Facilities are described in the order in which they are involved in the treatment process, as listed below.

- Stilling Well and Raw Water Inlet/Chemical Dosing Channel.
- Chemical Mixing Tanks and Chemical Storage Room.
- Flocculation and Sedimentation in hopper bottom Sedimentation Tanks.
- Filtration in Rapid Gravity Sand Filters.
- Disinfection by Hypochlorite solution at Chlorine Building.
- Clear Water Reservoir.
- Backwash Pump House.
- Backwash Lagoon.
- Sludge Drying Beds.
- Backwash Tank.

The locations of these facilities are shown in the Layout Plan of the Treatment Works

Brief Description of the Treatment Facilities

a) Stilling Well and Inlet Channel

Stilling Wells are provided to receive raw water from both Intakes. The Stilling Well is provided to allow for a tranquil flow into the Treatment Works. The Stilling Well is also provided with a scour arrangement.

volumetric flow meters have been installed upstream of the Stilling Well to facilitate the measurement of incoming Raw Water.

From the Stilling Well, the raw water flows into the Chemical Dosing Channel. The Dosing Channel is for dosing of the raw water with Aluminum Suphate and Soda Ash and Flash Mixing of the chemicals.

b) Chemical Storage, Mixing and Dosing Building

The buildings are built with Natural Stone Walling and the walls plastered and painted both internally and externally. The buildings is roofed and Gypsum ceiling is also provided.

The Chemical Rooms are for storing all chemicals used at Treatment Works for a minimum period of 4 weeks.

Dosing is carried out in the conventional manner using chemicals which are locally available. The chemicals used are Aluminium Sulphate (Alum) for coagulation and Soda Ash for pH adjustment.

Alum and Soda Ash are obtained in solid form. These chemicals are then put into Mixing Tanks where they are dissolved in water to form a solution of the required strength to treat the incoming raw water. The chemicals are manually loaded into the Tanks and mixing is carried out by electrically driven Mixers. Gravity Chemical Solution Dosers are provided for regulating flow of mixed chemicals to the dosing point at the Dosing Channel. Alum and Soda Ash solutions of the required strength are conveyed to the dosing point by 38mm dia uPVC pipes.

c) Sedimentation Tanks

From the Chemical Dosing Channel, the water flows to the Flow Splitting Chamber where it splits to the Old and New Sedimentation Tanks via DN 300 and DN 450mm Pipeline respectively. The DN 450 Pipeline is equipped with a Section Valve that connects to the Raw Water Inlet Channel (0.6m wide x1.5m deep) running across the width of the three hopper bottom Sedimentation Tanks adjacent to each other. This Channel distributes the water to all the three Sedimentation Tanks. Each Sedimentation Tank has internal plan dimensions of 10m x 10m and is 6.7m deep.

Water enters the Tanks through a 350mm dia. Pipe from the Raw Water Inlet channel. The flow is controlled by a manually operated Penstocks. The upward flow of water through the settling floc provides contact between the settling floc and the smaller residual flocs moving upward with the water. This favours the formation of larger floc through the agglomeration of the fine material thereby enhancing faster clarification.

4 Nr. galvanized mild steel troughs, 200mm deep x 250mm wide, with “V” Notches, each 10m long, are provided near the top of each Tank to decant water after sedimentation and empty into a 0.7m wide x 1.765m deep settled water channel from which the water enters the Rapid Sand Filters.

Each Sedimentation Tank has a concrete sludge concentration pocket for bleeding-off of the Sludge. Sludge is drawn from the sludge blanket zone into the concentration pocket and from there it is drawn off through ND 80mm dia. Cement Mortar Lined Steel Pipes to the Sludge Draw-Off Chamber.

Each Sedimentation Tank is also provided with a 150mm diameter Sludge Draw-Off Pipe from bottom of the vertical hopper for periodic discharging of Sludge settled at the bottom of the Tank. This Sludge Draw-Off operates under hydrostatic pressure and discharge the accumulated sludge into the Sludge Draw-Off Chamber. Two Sludge Draw-Off Chambers are provided, one for Sedimentation Tanks No. 1 and 2 and another for Sedimentation Tank No. 3. The sludge is then drained into 2 No. Sludge Drying Beds provided on Site. These 150mm diameter pipes will also allow for completely draining the Sedimentation Tanks for maintenance purpose.

Access Walkways with hand railing have been provided, running along the length of the Tanks. The Settled Water Channel is covered with precast Concrete Slabs, which also serve as a Walkway to provide access to the Filters.

d) Rapid Gravity Sand Filters and Filter Gallery

Water from the Decanting Troughs in the Sedimentation Tanks discharges into the Settled Water Channel covered with removable pre-cast concrete slabs. The top of these slabs are used as a walkway.

Water from the settled Water Channel enters each of the Filters through a 350mm circular orifice. The flow into each Filter is regulated by a 350mm circular Penstock mounted on each Filter Inlet. There are 3 No. Filters, each 6800mm (L) x 4400mm (B) internally, and 5.125m deep.

Each Filter has an Inlet Channel. Each Inlet Channel has 3 No. 200mm dia. Orifices in its base and a deflector plate fixed under each orifice to dissipate the energy of the incoming water and prevent it from impinging directly on to the Filter Sand Bed and possibly dislocating the filter media.

The Filter Sand Bed is 750mm deep and supported on 450mm deep layers of graded gravel. The effective size of sand is 0.7mm, with a uniformity Coefficient of 1.5.

The filtered water is collected in a central channel constructed at the bottom, in the middle of each Filter and from where it flows into a common Filtered Water Channel in the Filter Gallery through a 400mm diameter Pipe reducing to 250mm diameter after Filter Drain Valve and Wash water Inlet.

Filtered Water in the Filter Water Channel is transmitted to the 750m^3 Clear Water Tank located adjacent to the Filter Gallery through a 1200mm long x 700mm deep rectangular opening in the filtered water channel. Turbulence is created as the clear water falls from the filtered water channel into the Clear Water Tank. Here, chlorine is dosed in form of solution (Hypochlorite Solution) to take advantage of the turbulence created and achieve efficient mixing of the chlorine solution.

The backwashing of Filters is be done by water, which enters at the bottom of the filters through perforated uPVC laterals. There are 64 number, 100mm diameter, uPVC laterals per filter and each lateral has 12 pairs of 10mm diameter orifices through which water pass during filtration and backwashing. The wash water overflows into 2 No. collection troughs per filter running longitudinally inside the filters and then into a wash water channel from where it is conveyed to the Backwash Water Lagoons for recirculation into the System.

For wash water requirements of the Filters, a ground level reinforced concrete 250m^3 capacity is provided at a high elevation within the Treatment Works Site to provide a TWL of 1897.58masl to allow for backwashing by gravity. The Backwash Tank is supplied by pumping water from the Clear Water Tank by 2 Nr Pumps (1 duty, 1 standby) via a 150mm diameter Steel Pipe rising main. Provision is made in the Backwash Tank to serve other demands at the Treatment Works Site such as water for Chemical Mixing, water for use in the Administration Building, Staff Housing, cleaning, etc.

The controls for the wash water Inlet, wash water Outlet, filtered water Outlet are operated from the Filter Control Room. The operation is carried out manually.

e) Chlorine Mixing and Dosing Building

A new Chlorine Mixing and Dosing Building was built with Natural Stone Walling and the walls plastered and painted internally. The building is roofed with blue colored "Galsheet" roofing sheets. Gypsum ceiling has been provided.

The building is a single two sided open room building measuring 4.1m x 3.6m and located next to the Clear Water Tank. It houses Tanks for mixing of Hypochlorite Powder.

Two Mixing Tanks, each 1.2m long x 1.2m wide x 1.0m deep, are provided in the Chlorine Mixing Room. Both Tanks are used for the mixing of Hypochlorite Powder. Physio-chemical analysis of the raw water indicated that post-conditioning using Soda Ash is not necessary. However, should the need arise due to improbable change in the raw water quality, one of the Chlorine Mixing Tank can be converted to mix Soda Ash.

The chemicals are loaded manually and mixing done by electrically driven Mixers. Two gravity Dosers are provided to regulate the flow of hypochlorite solution for dosing.

The Hypochlorite Powder is mixed in the Chlorine Mixing Tanks and then conveyed to the chlorination point by means of 38mm diameter uPVC pipes laid in a concrete channel and dosed through an opening in the Clear water Tank roof slab at a location where the filtered water drops into Clear Water Tank, taking advantage of the turbulence created during the fall, for efficient mixing.

f) Clear Water Tank

A Reinforced Concrete Tank, 24.95m long x 10m wide x 3m deep, of capacity 750m^3 has been constructed to allow for a minimum chlorine contact time of 30 minutes and to supplement existing Storage Tanks to supply water to majority of Mukurwe-ini Sub-County by gravity flow. The Tank has 1 No. baffle walls to prevent short circuiting and stagnation of water within the Tank. Inlet into the Tank is by free fall of water via a 1200mm x 700mm opening from the Filtered Water Channel. 2 No. Manholes with ladders have been provided to allow access into the Tank and also for natural lighting purposes. The Tank is also been provided with an overflow and scour arrangement for periodic cleaning, as well as vent pipes to ensure proper ventilation and air circulation.

g) Backwash Pump House

The Pump House measuring 8.5m (L) x 5.3m (W) (internal dimensions) is located adjacent to the Clear Water Tank and houses the following:

- Two number centrifugal pumps (1 duty, 1 standby) to pump water to the high elevation ground level reinforced concrete Backwash Tank (Capacity 250m^3) to be used for Backwashing of the Existing and New Filters.

The Pump House has two floors, a ground floor at the same level as the Clear Water Tank floor and the first floor 4.5m above it which coincides with the finished ground level outside the Pump House. The first floor forms a platform allowing for access to the ground floor. A floor mounted switch gear control panel has been installed on the first floor. The Pumps are installed on the ground floor so as to ensure positive suction for all the Pumps.

A Gantry with a 1 ton capacity chain block has been provided for the removal of the Pumps and Motors for repairs when breakdowns occur.

A 150mm dia. drainage pipe is provided to convey by gravity any water discharged from the Pumps arising from any malfunction or during routine maintenance.

h) Backwash Lagoon

Washwater from the Filters is conveyed to the Backwash Lagoon via a 375mm diameter Concrete Pipe. The Lagoon (31.8m x 13.9m) has a storage capacity of 1,265m^3.

From the Inlet, the Lagoon Bed slopes at a gradient of 1:100 towards the Suction Inlet end with a 200mm thick reinforced concrete decanting wall located 24m from the Inlet. A 300mm clearance is provided between the reinforced concrete wall and the top water level of the Lagoon. The wall barrier prevents solids from reaching the Suction Chamber.

Water from the Lagoon is recycled using recirculation Pumps located within a Recirculation Chamber situated at the opposite end of the Inlet. The recirculated water is pumped to the Stilling Well where the water undergoes the full treatment process once again.

Two Scour/ Overflow Chambers are incorporated into the design of the Lagoon. One is located adjacent to the Inlet end and the other adjacent to the decanting wall. These Chambers allow for overflow/ and scour water to gravitate to the River Gachinga outfall.

i) Sludge Drying Beds

2 No. Sludge Drying Beds each measuring 11.25m long by 8m wide have been constructed. These Beds receive sludge from the 3 No. Sedimentation Tanks.

The sludge is conveyed by 300mm dia. Socket Spigot Concrete Pipes from the Sedimentation Tanks 2 No. Sludge Draw-Off Chambers and transferred into the Beds via an open concrete channel 400mm wide and 300mm height, located centrally in each Sludge Drying Bed. 100mm wide slots at equal intervals have been provided in the channel walls for sludge distribution from the channel onto the Sludge Drying Beds. This ensures that the sludge spreads uniformly over the Filter Media.

Filter Media comprises of large stones (150mm dia. hardcore) at the bottom, 80mm intermediate gravel layer topped by 80mm layer of coarse sand. To prevent this media from being scrapped out during removal of dry sludge, precast slabs measuring 600mm by 400mm by 50mm thick, with openings to allow supernatant to drain through the media are laid on top. The beds are designed to allow a tractor/ trailer to access the beds so that the sludge can easily be loaded to it and carted away to a dumping site. The tractor path is overlain with precast inter-locking paving blocks measuring 200mm by 100mm by 50mm thick.

Once the supernatant percolates through the Media, it is conveyed via 225mm dia. open ended concrete pipes in the drain channel within the sludge drying beds to a chamber adjacent to it from where it is conveyed by gravity to River Chinga outfall.

j) Backwash Tank

A reinforced concrete Tank, 10.00m diameter and x 3.6m deep, of capacity 250m^3 has been constructed to allow for storage of water to be used for the backwashing of the Filter Beds and domestic use within Chinga Water Treatment Works.

Task Schedule for Operation of the Treatment Works

The following tasks are to be carried out at the Treatment Works on a Daily, Weekly, Monthly and Yearly basis. The items are outlined and then described in detail and in the sequence preferred.

a) <u>Daily Tasks</u>

i) Production Adjustment - Water Quality Tests:

Raw Water	Turbidity, suspended solids, Temperature and pH
Treated Water	Turbidity, pH and residual Chlorine.
Distributed Water	Residual Chlorine and pH

ii) Stilling Well
- Scouring

iii) Preparation of chemical solutions
- Alum
- Soda Ash

iv) Chemical dosage adjustment
- Alum and Soda Ash as per jar test
- Hypochlorite solution

v) Flow Splitting Chamber.
- Rubbish removal
- Scum removal
- Wall brushing
- Inspect sludge depth

vi) Sedimentation Tanks
- Rubbish removal
- Scum removal

vii) Rapid Gravity Sand Filters
- Monitoring of water levels in the Filters
- Brushing of walls
- Back washing

viii) Clear Water Tank
- Manual monitoring of water level in the Tank.

ix) Backwash Pumps
- Clean pump house floor and walls.

x) Volumetric Raw Water Flow Meter reading and recording

xi) Volumetric Treated Water Flow Meter reading and recording

xii) Inspect the Site Facilities and premises

xiii) Tests of residual chlorine at selected distribution points

xiv) Preparation of Daily Report(s)

xv) Filing data

xvi) Evaluation and analyses of collected data

xvii) Preparation of work schedule for the next day.

b) <u>Weekly Tasks</u>

i) Checking of chemical stocks

ii) Flushing of Chemical Dosing Pipes

iii) Checking and washing Sludge Drain Pipes

iv) Preparation of Weekly Report(s)

v) Filling data

vi) Preparation of Work Schedule for the next Week

c) <u>Monthly Tasks</u>

i) Observation of sludge level and desludging of the Sedimentation Tanks

ii) Water Quality Test (Chemical and bacteriological)
- Raw water quality - Taste, odour and colour
- Treated water quality - Hardness, alkalinity and all tests to be done in other laboratories as outlined in Chapter 6
- Distributed water quality - Coliforms

iii) Preparation of Monthly Report(s)

iv) Filling data

v) Evaluation and analyses of collected data

vi) Preparation of Work Schedule for the next Month

vii) Rotate duty and standby Equipment.

d) <u>Annual Tasks</u>

i) Checking of Filter sand for mud balls and media depth

ii) Draining out of Clear Water Tank and Backwash Water Tank

iii) Repainting of all metal structures

iv) Preparation of Annual Report(s)

v) Filling data

vi) Evaluation and analyses of collected data

vii) Preparation of Work Schedule for the next Year

viii) Pump overhaul.

Description of Tasks

i) Daily Tasks

a) Production Adjustment

Water consumption fluctuates not only hourly, but daily and seasonally as well. The water production of the Treatment Works should follow these fluctuations to economise the chemicals to be used in the Works. The water production adjustment is to be carried out after observing the water in the Clear Water Tank and available raw water quantity. The following scenario is considered to illustrate the production adjustment procedure:

Scenario 1: Instance
When the water level in the Clear Water Tank is falling

Operation Procedure
Switch off backwash water pump until the water level rises enough to be able to be pumped using duty pump.

b) Water Quality Tests

Water quality tests should be done for:

- Raw water
- Treated water

The procedures for the tests are fully described in Chapter 6. The tests should be carried out soon after sampling during each working shift. All the tests should be reported to the Plant Manager immediately and should be recorded.

c) Preparation of Chemical Solutions

All chemicals to be used at the Treatment Works are listed below:

- Aluminium Sulphate (Alum)
- Soda Ash
- Calcium Hypochlorite

The most commercial grades of aluminium sulphate have the chemical formula: $Al_2(SO_4)_3 14H_2O$ which includes the water of crystallization weighing 480kg/m^3. Also called Filter Alum or Sulphate of Alumina, Alum is used in the coagulation process. Aluminium Sulphate is available in dry from, either lump or ground, or in liquid form, either purified or unpurified. In the present case, lump type contained in bags is used.

Sodium Carbonate (Na_2CO_3) is commonly known as Soda Ash ($Na_2CO_3.H_2O$). Soda ash is available in white powder (extra light, light, and dense), and is shipped in bags, barrels or bulk. As in the case of alum, the bagged type is used here.

Soda ash is used to supplement the hydroxyl ion's if they are in inadequate concentration for the formation of the insoluble aluminium hydroxide. Assessment of the right amount of Soda ash required should be carried out before the application because addition of too much or too little of it will cause the formation of soluble complexes with aluminium and thus defeat the intended purpose. Optimum precipitation of aluminium hydroxide will take place at pH of 6.5 which should be aimed at. The soda ash can also be dosed at the Clear Water Tank for final pH adjustment if need be.

Calcium Hypochlorite ($CaOCl_2.4H_2O$) with a commercial strength of 65-70% chlorine by weight and density of 840kg/m³ is available as a white granule or powder.

The chemical dissolving work should be carried out during each working shift according to the method described in Chapter 6. The workers should wear protection masks from the powder. The detailed information for the preparation of solutions is explained in **Chapter 6, Section 6.7 on page 6-23**.

d) Chemical Dosage Adjustment

The Chemical Dosage Adjustment should be carried out based upon the Jar Test results during every working shift. For the Jar Test, raw water turbidity, alkalinity, pH and temperature must also be tested. The detailed and further information is explained in **Chapter 6**.

e) Sedimentation Tanks

Using the telescopic leaf rake, remove all floating matter and debris from surface of the Tank. The materials should be disposed of at designated disposal Site. These Sites are dumping pits to be dug at convenient places on the Site. Check whether the supernatant water is flowing equally from every notch of the Decanting Trough. If not, adjust the setting of the Trough by tightening or loosening the bolts. Any debris stuck at the notches should be removed. The troughs should be checked for any sediment which should be cleaned.

Inspect the sludge depth to assess when de-sludging is required. This can be done by attaching a wooden board at right angles to the bottom of a calibrated rod so that the board is horizontal when the board reaches soft sludge and also the firm sludge underlying the more recently deposited materials.

f) Rapid Gravity Sand Filters

The colloidal material and bacteria in the coagulated settled water are absorbed on the gelatinous floc and are removed with the floc during backwashing. All Filters are provided with underdrain Backwash Systems and all Gates and Valves used in the Filters are manually operated.

Valves to be operated during the operation of a typical Filter (Filter Nr 1 in this case) are listed below and shown in **Figures 3.5, 3.6, 3.7 on page 3-18, 3-19, 3-20,** respectively**:**

- Settled Water Inlet Penstock (350mm dia.) Penstock **S1**
- Filtered Water Butterfly Valve (250mm dia.) Valve **A1.**
- Backwash water Inlet Gate Valve (300mm dia.) Valve **B1.**
- Backwash Water Outlet Gate Valve at the Back Wash Water Tank (300mm dia.) Valve **BW**

- Backwash Water Outlet Gate Valve (400mm dia.) Valve **C1.**
- Filter Drain Gate Valve (200mm dia.) Valve **D1.**

The Valves have been numbered sequentially for each Filter.

Though the need for back washing is controlled by the extent of Filter clogging this must be planned so that only one Filter is backwashed at any one time to give enough time to fill the Backwash Tank.

The back washing operation is carried out manually as outlined in the steps below.

Explained below is a typical Backwashing Operation for a Filter Bed. Filter Nr 1 has been used as an example.

Typical Backwashing Operation for Filter No. 1

Step 1: **Close the Settled Water Inlet Penstock S1 to Filter 1** manually. The water level in the filter descends with time;

Step 2: When the water level is at the minimum desired level of about 150mm above the sand bed, **close the Filtered Water Valve A1**. By then, the water should be below the wash-water troughs;

Step 3: **Open Valve C1** for draining the used washwater;

Step 4: **Slowly open Valve B1** so as to fill the washwater Inlet pipe with water.

Step 5: **Slowly Open Valve BW** at the Backwash Tank over a period of 30 seconds for the incoming wash water from the Backwash Tank. Prior to this, ensure that the water level in Backwash Tank is at its maximum.

Step 6: Whilst the filter is backwashing, clean the walls of the filter with water using the hose reels provided and remove scum and other foreign matter present in the filter. When the effluent from the backwashing process looks clean, **Close Valve BW**

Step 7: **Close Valve B1**;

Step 8: **Close Valve C1** after ensuring the water in the wash-water troughs has drained off;

Step 9: **Open the Settled Water Inlet Penstock S1 to Filter 1** slowly so as to avoid undue turbulence and disturbance of the sand bed;

Step 10: **Open the Settled Inlet Valve S1 to Filter 1** fully when the water level is just below the wash-water trough;

Step 11: **Open the Filter Drainage Gate Valve D1** to drain any backwash water which may have remained in the Filter Bed;

Step 12: **Close the Filter Drainage Valve D1** once the effluent is observed to be clean.

Step 13: **Open the Filtered Water Butterfly Valve A1** gradually and partly at first. Regulate rate of filtration using valve A1 to maintain water level in the Filter between top of sand bed and bottom of washout trough.

The Backwashing cycle is repeated. The whole backwashing procedure for each filter should not take more than 10-15 minutes.

Cleaning of the Filter Chambers

- Brush the walls during the backwashing with a splash of water, especially the parts which are normally wet.
- Remove scum and other foreign matter present in the filter, flowing from the Sedimentation Basins.

The Rectangular Treated water tank has a storage capacity of 750m³.

Inlet	:	1200mm x 700mm opening
Outlet Valve	:	1 No. 500mm Dia. gate valve.
Scour Valve	:	200mm Dia. gate valve
Overflow	:	300mm Dia. pipe

➢ Adjustment of the Water Level

- Survey and record the water level.

- Refer to the previous item a) Production Adjustment, for procedure to adjust level.

➢ Prevention of Contamination

- Check whether the access hatch is completely closed on the manhole opening in Treated Water Tank.

- Check whether the nets of the Air Vents installed on the slab are broken.

- Investigate whether any other source of contamination of the Treated Water can be found.

ii) Weekly Tasks

The following tasks are to be performed weekly in addition to the daily tasks described above.

a) Stock – Taking of the Chemicals

Alum, Soda Ash and Calcium Hypochlorite are the chemicals utilised in the Treatment Works. Since all of them should be readily available for the efficient and hygienic operation of the Treatment Works, it is necessary to survey stock quantities weekly.

Check the stock of Alum, Soda Ash and Calcium Hypochlorite as to whether they are more than month's requirements. As for the average consumption chemicals, see the previous items 3.3.4 i (c) "Preparation of Chemical Solution", and (d) "Chemical Dosage Adjustment".

If any chemical stock is less than one month's requirement, report the matter to the Plant Manager to arrange for necessary requisition.

b) Flushing of the Chemical Dosing Pipes (When in Operation)

There is possibility of all the chemical dosing pipes to clog because of the nature of the chemicals especially hypochlorite solution. Every chemical dosing pipe should be flushed weekly. The flushing procedure is similar for all chemical solutions.

The chemical solutions supplied from the dosers are conveyed through 38mm dia. chemical dosing pipes to the dosing channel.

Flushing for all the three solutions is done as follows:

- Ensure that all the chemical solution in the particular tank has been fully used prior to the flushing operation.
- Shut the 38mm dia doser inlet valve.
- Open the 38mm dia. Incoming water supply valve so as to fill the tank halfway.
- Operate the Stirrer and let agitate the water to clean the interior sides of the mixing tank
- Open the 80mm Dia. Scour valve so as to scour the tank.
- Fill the tank once again to about a third volume to rinse it and ensure that the drain is clean once the tank has been fully cleaned.
- Shut the 80mm dia. scour valve once the mixing tank has been cleaned.
- Half fill the tank once again.
- Open the 38mm dia. doser Inlet valve
- Open fully the doser outlet valve to allow clear passage of clear water through the doser into the dosing pipe and into the dosing channel.
- Continue with the process until the water from the dosing pipe at the dosing point is clear.
- Where the flow water seems to be clogging, loose joints near a bend, and check whether there is any clogging.
- Detach the dosing pipe from the doser by loosening the clip holding it in place and clean the pipe by rodding.
- Once the dosing pipe is clear of any obstructions fix it back onto the doser by tightening the clips.
- Once the chemical dosing pipes have been fully flushed and fixed back onto the doser, regulate the dozer valves to suit the dosing requirements and continue normal operations.

In case of failure the operator can manually dose Calcium Hypochlorite to the water in the water tank using clean cans. However, the dosing should be spread throughout the day uniformly.

iii) Monthly Tasks

The monthly tasks consist mainly of desludging the accumulated sediment in the Flocculation Basins and Sedimentation Tanks by means of the desludging pipes controlled by Gate Valves, situated in respective Sludge Draw-Off Chambers. The flocs in the Sedimentation Tank settle to the bottom and the sludge accumulates in the sump provided. Sludge collection should never be allowed to exceed the depth of the sump; otherwise, the upper layer of unsolidified sludge will be subject to scour by the overlying water, incidental to reduced space above. The sludge is removed by Hydrostatic Pressure Method.

Procedure for removal of sludge

Under the operator's daily tasks, determination of sludge distribution and depth in the Sedimentation Tank is carried out. Once a month, each Tank should be desludged. However, only one Tank should be desludged at any given time.

iv) Annual Tasks

The annual tasks to be performed are detailed below:

a) Restoring filter sand to required depth

Filter sand gets reduced due to regular backwashing. The depth of the layer of sand has to be maintained to get proper filtration. The following has to be carried out.

- Close the inlet penstock and let the water drain out.
- Check the depth of the sand media (at a fixed date for every year)
- Add graded sand from the stock yard if the depth of the sand is less than 750mm.
- Make the surface level using flat wooden hoes.
- Backwash the media to stratify it.

b) Removal of Lumps of Mud

Over prolonged period of use of the filters, lumps and mud can form in the filters. These can be removed every **FIVE years** or so, as below.

- Close the inlet penstock
- Let the water drain down through the clean water outlet.
- Sieve the upper portion of the sand to remove the lumps of mud. Be careful to keep the sieved sand away from the remaining sand.
- Start the filtration again.
- Wash the beds more effectively in future to prevent their occurrence.

c) Chemical treatment of Filter Sand

Organic matter, fine clay, oil and the very gelatinous floc formed at times when micro-organisms coagulated or developed in the beds have been found to cement the sand grains and thus cause shrinkage of the sand beds. The

gelatinous film on the sand grains may be removed once in 5 years. The procedure is as follows:

- Backwash the bed thoroughly and lower the water surface to 300mm above the sand level.
- Dissolve about 5-10kg caustic soda in this water surface.
- Lower the water level to about 25mm above the sand level and allow the bed to stand for 6-12 hours before washing the bed thoroughly.

d) Draining the Back Wash Water Tank (BWT)

This Tank should be drained and cleaned once in every 3 years to maintain hygienic conditions. To empty the Tank, open the Scour Valve.

e) Draining the Treated Water Tank

This Tank should be drained and cleaned once in every 3 years to maintain hygienic conditions.

f) Repairing all metal structures

All rust on metal surfaces such as headstocks, railing, spindles, ladders etc. should be removed completely and repainted with appropriate paint and using proper methods.

Treated Water Gravity Main

Details of the Treated Water Gravity Main showing location of valves and washout valves are given in **Section 4 As-Built Drawings (Drawing No. M390/MU/TWGM/01 to Drawing No. M390/MU/TWGM/08.** These drawings are submitted separately as 'As-Built' Drawings.

Task Schedule

The following tasks are to be carried out of the Treated Water Main on a daily, weekly, monthly and yearly basis.

a) Daily Tasks
- Line Patrol
- Inline flow measurement

b) Weekly Tasks
- Measure water consumption

c) Monthly Tasks
- All the recording/ reporting sheets should be submitted to the Superintendent of the Treatment Works on the first Monday of every month. This should contain all the observations for the previous month.
- Evaluate the last activities for making a comment of contribution to the next month's activities so as not to repeat any mistakes if made.
- Checking of air valves and washout valves
- Washout operation.

d) Annual Tasks

- Repainting of all metal structures

Details of Tasks and Operation Procedures

a) Daily Tasks

i) Line Patrol

- Check any signs of water leakage from pipes and valves
  - If any leakage is found, report the condition immediately to get remedial instructions.

- Check any eroded parts along the pipeline route, especially after heavy rains.
- Check any depressed marks caused by heavy traffic over Pipelines.
- Check whether Valve Boxes and Air Valve Chambers are covered by earth, and obtain instructions.

b) Weekly Task

- Estimate the water losses along the Treated Water Main by comparing the meter readings for the inflow (at the Chinga Water Treatment Works) and outflow for the main (at Githagara Storage Tank).

c) Monthly Task

i) Reporting

- All the recording/ reporting Sheets should be submitted to the Superintendent of the Treatment Works on the first Monday of every month. This should contain all the observations for the previous month.
- Evaluate the last activities for making a comment of contribution to the next month's activities so as not to repeat any mistakes made.

ii) Checking of Section Valves, Air and Washout Valves

- Check all valve glands for leakages

- Tighten up the gland bolts, if necessary.

- Grease the screw of the Valve/Gate Headstocks.

- Check the connectors between the Headstock and Spindle above the valves/gates.

iii) Washout Operation

The Washout operation of the Treated Water Gravity Main should be carried out under the supervision of the Water Superintendent. An interval of three years between Washouts may be adequate under normal conditions/ circumstances. The washout operation should be started with opening the nearest Washout Valve from the Treatment Works.

- Open the Washout Valve carefully after ensuring everyone is clear of the outlet.

- Close the Washout Valves when the washed-out water becomes clear and clean.

- Check and confirm that surroundings are not damaged by the Washout operation.

d) <u>Annual Tasks</u>

i) Repainting of All Metal Structures

- Remove all rust on the surface of the metal structures such as Headstocks, Handrails, Ladders, Covers and so forth completely at the appointed date.

- Paint all metal structures with approved paint materials and manner.

ii) Draining-out of the Treated Water Tank

The draining-out should be carried out at the discretion of the Superintendent, together with the necessary arrangements such as informing Consumers concerned, organizing the requisite equipment and labour, and so forth.

All Workers who are in the Reservoir should put on clean clothes and washed shoes (i.e. free of dirt)

- Shut both the Inlet Valves to the Filtered Water Channel from the Filters at the Filter Control Room.

- Shut the Outlet Valve.

- Open the Scour Valve taking care not to harm anyone in the neighbourhood.

- Confirm that all Reservoir insides are in good order.

- Scrub and disinfectant walls and floor.

- Shut the drain Valve.

- Confirm the following, when the Works are over.

- Confirm all Tools and Equipment for the Works brought out from the Reservoir completely.

- Confirm there no spots/places where dirt is left.

- Open both the Inlet and Outlet Valves of the Reservoir.

MECHANICAL AND ELECTRICAL FACILITIES

Following are brief details of the Electro-Mechanical Facilities installed at the Chinga Water Treatment Works. Detailed data and corresponding catalogues are given in Section 3 of this Manual.

a) Backwash Pumps at Treatment Works

Pumps details		**Motor details**	
Make	WILO	Make	TEE
Type	NL 80/160-18.5-2-12-50Hz	Type	4155226
Year	2012	Duty	S1
Discharge Q	127m³/hr	Power Pm	18.5 kW
Head	30.4m	Supply U	400-660V
Speed	2900r/min	Current I	18.1-32.8A
		Cos ϕ	0.91-0.93
		Frequency	60Hz
		Insulation Class	F
		Enclosure	IP 55
Quantity	2	IM	B3
		Bearing	Roller Bearing
Pump 1	Serial No. TR1592939/01	Pump Motor 1	Serial No. 005546M
Pump 2	Serial No. TR1592939/02	Pump Motor 1	Serial No. 1107061
Recharging grease interval 4000hr amount 38 gr. Type SRI grease2		PTC	20°C

Details of the Pressure Gauges are as follows:-

PRESSURE GAUGES FOR ALL PUMPS (Standard Make)

Automatic Pump Pressure Control Switch: 0-7 bar

b) Switch Room

The Switch Room Houses the incoming power supply (KPLC) Electrical Switchboard.

c) Chemical Dosing and Mixing Building

i) ELECTRIC STIRRERS - 4 No.

ii) GRAVITY DOSER- (OPALIUM, FRANCE) - Alum & Soda Ash Solution doser: Model GAMME OPADOS 16, 150/1500Ltr/hr. Quantity 4.

d) Chlorination Storage and Mixing Building

i) ELECTRIC STIRRERS - 2 No.

ii) GRAVITY DOZERS - Chlorine & Soda Ash Solution doser: Model GAMME OPADOS 8, 100/800Ltr/hr. Quantity 2.

e) Miscellaneous Equipment

i) Flanged Gate Valves - AVK

Location of Installation	ND	Qty
Stilling Well Scouring	100	1
Sedimentation Tank Scour	150	3
Filtered Water Outlet	250	3
Wash Water Inlet	300	3
Wash Water Outlet	400	3
Filter Drainage	200	3
Clear Water Tank Scour	200	1
Treated Water Outlet	500	1
Pump House : Backwash Suction	300	2
Pump House : Backwash Delivery	100	2
Backwash Tank Inlet from Backwash Pumps	150	1
Backwash Tank Scour	150	1
Backwash Tank control Valve to Filters	400	1
Domestic Water Supply Valve	50	1

ii) Non Return Valves, AVK

Location	ND	Qty
Backwash Water Pump House : Backwash Delivery	100	2
Treated Water Gravity Main	500	1

iii) Penstocks with Headstocks (HPL Engineering)

Place	ND	Qty
Intake Weir Scour Pipe	150	1
Intake Chamber Outlet Pipe	300	1
Dosed Water channel	350 Dia.	3
Filter Inlet Channel Pipe	350	3

Operation Guidelines

Introduction

The life of the equipment installed in the Chinga Water Treatment Works depends on the safe operation of the Pumps and other associated equipment/ components as per procedures/ instructions mentioned in Chapter 3. As operation of the Pumps is manual, it is essential that procedures/ instruction are known clearly and understood by the operating Personnel.

The operation of the Pumps and other equipment is to be carried out only after the completion of the pre-start checks as recommended in their respective Maintenance Manuals.

Pre-starts checks/ procedures

Ensure:

- Treated Water Tank water level is okay for Pumps.
- Treated Water Tank water level rises up to desired level for Pump.
- Valves should be kept open for both suction and delivery.
- The Section Valves should be kept open on the pumping mains.

Schedule for operation of the pumps.

- Backwash Pump for Backwash Water Tank, 1no. Run & 1 no. Standby.

Note:
Closing & opening Valves should be understood by the operating Personnel.

Electrical Installations

Pump Control Panels

The Motors will trip while any fault occurs and it will give an indication on the same compartment panel board. The control supply is 415V AC and is made available for operation of the individual motor circuit through its MCB and control fuses.

The following items are on the front of the panel.

Id	Item	Function
Main Supply		
A	Ammeter	Measures current
HM	Hour-meter	Elapse time recorder
b0	Duty Selector Switch	Select KPLC Power or Generator
h1	Indicator lamp (Red)	KPLC power available
h2	Indicator lamp (Yellow)	KPLC power in use
h3	Indicator lamp	Generator Power available
H4	Indicator lamp	Generator Power in use

Backwash Pumps		
Backwash Pump 1		
A1	Ammeter	Measures current
1HM	Hour-meter	Elapse time recorder
1b0	Duty Selector Switch	Select Duty and stand by
1b1	Push button	Start the pump
1b2	Push button	Stop the pump
1h2	Indicator lamp	Pump1 ON
1h2	Indicator lamp	Pump1 TRIP
1h3	Indicator lamp	Pump1 Over Heat
Backwash Pump 2		
A2	Ammeter	Measures current for
2HM	Hour-meter	Elapse time recorder
2b1	Push button	Start the pump
2b2	Push button	Stop the pump
2h2	Indicator lamp	Pump2 ON
2h2	Indicator lamp	Pump2 TRIP
2h3	Indicator lamp	Pump1 Over Heat
1b5	Push Button	Lamp Test

The control circuit is provided with control fuses, auxiliary relays, timers, etc of adequate rating to operate the Pumps. For more details refer to circuit diagrams.

Note:

For further Operation & Maintenance Instructions for all equipment, refer to attached Supplier's Manuals in **Section 3** of this O&M Manual**.**

MAINTENANCE OF THE FACILITIES

Proper maintenance of the Facilities is an important requirement for the System to function as designed. Some forms of maintenance might seem to be avoidable at the time, but basic preventive maintenance prevents serious damage to occur which would alleviate the maintenance and repair cost. Where inadequacies are found in the facilities, prompt and effective action should be taken by the persons concerned.

Intake Works and Raw Water Gravity Main

Intake Works

1. Under normal operation, flushing out of sediments and debris upstream of the weir is carried out by raking off. Any floating or trapped objects on the screens should also be removed regularly.

2. **Repainting all Metal Structures -** All metal structures should be checked and repainted as instructed in the operation section. Other moving parts requiring oiling or greasing should be attended to at the same time.

3. **Other Repairs -** Any damage to concrete structures or roof should be attended to as the need arises. For major work, the plan of action should be prepared beforehand and the work executed when everything is ready.

Raw Water Gravity Main

The Raw Water Gravity Main is provided with 11 Nr Washout Gate Valves. The valves drain the silt in the Pipeline through an 80mm diameter Washout Valves similar to other Valves structurally, except for their function. It is common for Valves at Washouts to have deposits of material like sand and gravel carried in the water. These can deposit in the seat of the gate and may prevent the Valve from closing fully. Thus water will leak out through the Washout Valve. In such cases;

- If the Valves cannot be shut, open slightly the Washout Valve again for a while.
- It the water is still leaking, try to open and shut slightly for several times till it shuts.

In such a case, the Valve must not be forced shut with one's full strength.

- Report the condition to the Superintendent if the Valve does not fully close even after trying to open and shut for several times as mentioned above. In such cases, the Superintendent should judge the best remedial action.

Treatment Works Facilities

The operation of the Facilities has been described in Chapter 3.

Stilling Well and Inlet Channel

Repair of Inlet Channel and Stilling Well

In case any repair in the Stilling Well is required, flow of raw water is stopped and the 150mm dia. Scour Valve opened to drain the Stilling Well. This stops the water flow into the Treatment Works and therefore the work programme must be prepared beforehand and all tools and equipment must be available and kept ready.

If the Works involve concreting, time should be allowed for concrete to set and cure. For such work, stopping of the raw water should be timed and planned well, since this is the main supply to Chinga Water Treatment Works. Ensure that the Clear Water Tank is full and the demand of water can be met for the period of closure.

Penstocks at Inlet to Sedimentation Tanks

The Penstocks have to be checked to see if they function smoothly. The following points are to be noted.

- Grease the screw of the headstock whenever necessary.
- Check the connector between headstock and spindle-tighten if loose.
- Ensure the anchor bolts are secure.
- Repaint any metal part which is rusted, after removing rust.

Sedimentation Tanks

- The maintenance is mostly for Pipes, Fittings and Metal Work. For the Gate Valves do the same as described for Penstocks above.
- Handrail. Remove any rust and repaint using approved material and method. Check that all bolts and joints are firmly fastened.
- Repaint any metal which is rusted after removing rust on the ladder in the Sludge Draw-off-Chambers.

Never clean the walls when the Tank is in operation. For any cleaning, the Sedimentation Tanks must be emptied, as follows:

<u>Sedimentation Tanks</u>

- Close the Inlet Penstocks into the Tanks;
- Wait for 2 hours to enable the suspended and flocs-in-motion to settle;
- Open the Sludge Draw-off Valve and let the water drain by hydrostatic pressure;
- Manual aid by means of brushing is necessary to clean the walls and floor completely. All Personnel involved should have the necessary Protective Gear;
- **It should be noted that the thin film of deposits on the walls and floor actually retards chemical attack on the concrete and thus should not be scraped off completely**;

The frequency can be once in a year or depending upon the quality of water, at the discretion of the Superintendent.

For normal desludging operation, the Sedimentation Tank may be operational whilst this is being carried out. Duration of normal desludging shall be decided upon visual observation at the Sludge Drying Beds. Once the sludge has been discharged, wastage of water from the Sedimentation Tank should be stopped by closing the Sludge Draw-off Valve.

Rapid Gravity Sand Filters

a) Metal Structures

Valves

The control devices for each Filter include the inlet Gate Valve, outlet gate valve and gate valves for backwashing operation. All these devices have wheels to facilitate operation.

Pipes

- Check whether any leakage/seepage is observed along the pipes. If found, take necessary action to repair.
- Repaint any rust part with the approved material after removal of any rust.

b) Instrumentation - These are discussed under **Chapter 4**.

c) Replacement of the Filter Media

When the replacement of the Filter Media becomes necessary, take the following measures.

- Close the Inlet Penstock.
- Close the filtered water Valve after the water level drops to about 150mm above the sand bed.,
- Open the Backwash Outlet Valve to drain the bed.
- Take the filter sand out from the Chamber.
- Take out the supporting beds consisting of gravel layers from the chamber very carefully so as not to damage the under-drain pipework.
- Wash the under-drain with clear water.
- Bring in the previously arranged Filter Media through sieving into the Chamber as follows;

Filter Sand

Quality	:	Quartz Sand
Effective size	:	0.7 – 1.0mm
Maximum uniformity Coefficient	:	1.8
Thickness of Filter Bed	:	750mm

Supporting Bed (Gravel):

Layer		Thickness	Size(mm)
Top	1	100mm	2.0 – 5.0
	2	100mm	5.0 – 12.0
	3	100mm	12.0 – 20.0
Bottom	4	150mm	20.0 – 38.0

Backwash thoroughly to stratify the media, and if necessary, the Filter sand too.

Treated Water Tank

The Maintenance should be carried out for the following.

1) Metal Structures

- Check if the access hatch can open and shut freely. If any distortion is seen it should be rectified immediately.
- Check for any rust, remove if any and repaint.
- Check anchor bolts and ensure they are tight and secure.
- Check all ventilators and ensure proof netting is intact. If not replace immediately.
- Valves for outlet and scour pipes in valve chambers to be cleaned, greased and painted

2) Valve Chambers

- Ensure the insides of the chambers are clean and dry
- Keep grass clear from the inside and the corner of the Chambers

Backwash Water Tank and Backwash Pipeline

The maintenance of the rising/falling Pipeline and Gate Valves should be carried out as outlined below;

- Check that the Appurtenant Valves are in order.
- If any leakage/seepage is observed from the Valve, turn clockwise both the stud bold/nuts set on the packing gland.

  If the leakage cannot be stopped with additional slight turnings, refer to the Manufacturer's Manual.

- Any problem with the operation of the Ball Float Valve should be referred to the Manufacturer's Manual.

Washout Channels/Pipes

- Keep the pipes unblocked
- Check for any breakage or loosening of Concrete Works and report to Superintendent with assessment of the damage.
- Keep the Drains/ Manholes clear of grass growth, pest and rodents.
- Inspect points of discharge of Washout to the River for any erosion. Report to the Superintendent of any damage.

Access and Internal Roads at Treatment Works

All internal Roads within Chinga Water Treatment Works are precast inter-locking paving blocks measuring 200mm by 100mm by 50mm, with precast concrete paving slabs for pedestrians. Advantages include easy maintenance.

Maintenance of Pavement

Any section of the surface paved road which may have subsided especially after heavy rains should be remedied by trained Personnel or Specialist Contractor. Damage may also occur if excessive load is applied.

These repairs should be carried out as below.

Subsidence of Paving Blocks/ Slabs

Clean the affected section as well as the surrounding layer and fill the depression with washed bedding sand to appropriate level before hand-packing the blocks back. Fill the joints with washed sand and gently brush the sand into the joints.

Treated Water Transmission Main

The common problem with pipelines is leakage at the joints.

Line Patrol

Pipes

Patrolling is done as detailed in **Item 3.3.5.** Ensure adequate material and equipment is available for any type of repairs.

Gate Valves, Air Valves and Washout Valves

a) Air Valves

- Check that the Appurtenant Valves are in order.
- If any leakage/ seepage from the Air Valves is observed, take the following action.

- Shut the lever set just under the Air Valves.
- Loose bonnet bolt nuts set on the cover of the Air Valve and open the cover with care not to harm the O ring and gasket.
- Take the ball (float valve) out from the body taking great care not to scratch it.
- Clean the whole body, and take any foreign materials off from the body.
- Clean the conical valve seat set on the back of the cover with a pin to take off any foreign materials like sand.

- Check any depression marks caused by heavy traffic on the Pipeline.
- If the condition cannot be rectified immediately, report the condition to the Superintendent to obtain his instruction.

b) Washout Valves

The Valves are housed in closed Chambers. The Washout Valves are similar to other Valves structurally, except for their function. It is common for Valves at Washouts to have deposits of material like sand and gravel carried in the water. These can deposit in the seat of the gate and may prevent the Valve from closing fully. Thus water will leak out through the Washout Valve.

In such cases;

- If the Valves cannot be shut, open slightly the Washout Valve again for a while.

- It the water is still leaking, try to open and shut slightly for several times till it can shut.

  In such a case, the valve must not be forced shut with one's full strength.

- Report the condition to the superintendent if the valve did not fully shut even after trying to open and shut for several times as mentioned above. In such cases, the Superintendent can judge the best remedial action.

c) Valve Chambers

Every air relief Valve, Washout Valve and Line Valve is installed in a Chamber for conveniences of maintenance, except for small Valves.

- Check whether Valve Chambers are covered by soil. If so, remove the soil to expose the Chambers.

- Inspect whether the covers are depressed by the action of heavy traffic. Where depressed take urgent actions to repair them.

- If rust is observed, repaint the covers with an approved paint after removal of the rust.

- Remove all soil entering into the Chamber, when such condition is found.

- Check whether the cover-locks are operational, and the cover can be locked properly. If not, repair them urgently.

Storage Tanks

The Maintenance should be carried out for the following.

1) Metal Structures

- Check if the access hatch can open and shut freely. If any distortion is seen it should be rectified immediately.

- Check for any rust, remove if any and repaint.

- Check anchor bolts and ensure they are tight and secure.

- Check all ventilators and ensure proof netting is intact. If not replace immediately.
- Valves for Inlet, Outlet and Scour Pipes in Valve Chambers to be cleaned, greased and painted.

- Check that the Ball Float Valve is functioning.

2) Valve Chambers

- Ensure the insides of the Chambers are clean and dry

- Keep grass clear from the inside and the corner of the Chambers

LABORATORY WORK PLAN

The laboratory is key to the assessment of water quality and ensuring that the desired standards for safe water are met. There are three water parameters that are crucial in meeting these standards, namely turbidity, pH and residual chlorine levels. These parametes are closely monitored for as long as the treatment process continues as their fluctuations usually indicate a problem in the water treatment cycle. Aside from the monitoring of water parameters, there are also other important tests carried out that help in understanding and troubleshooting problems that affect water quality such as bacteriological tests, water hardness tests, chlorine demand tests, among others.

1. **Routine monitoring of pH, Turbidity and Residual chlorine**

Raw water coming in from the intake is untreated and thus its safety for consumption is not guaranteed. A sample of the raw water is taken and its level of clarity, that is turbidity, is measured using a colorimeter and the value recorded. Its pH is then measured using a pH probe connected to a pH meter and the values recorded. These values are crucial in determining the amount of aluminium sulphate to be used in water treatment. This is done on a daily basis.

After the treatment process and the raw water has been disinfected, it is then sampled at the sample collection point at the treatment works and its pH, turbidity and residual chlorine levels measured using their respective instruments. Monitoring of these parameters is done at an hourly interval to ensure that the treatment process is effective. The level of residual chlorine in the treated water is directly proportional to the level of water quality. Acceptable ranges of residual chlorine are between 0.5-1.5 miligrams per litre; the maximum allowable unit for turbidity is 5 nephelometric units(N.T.U) while pH should lie between 6.5-7.5.

2. Consumer point sampling and testing

The laboratory technician takes samples of consumer water along the distribution lines and checks for pH, turbidity and residual chlorine levels. He/she may also assess the cleanliness of distribution tanks to recommend for their cleaning and sludge removal. The field sampling is carried out at least on a weekly basis and the data recorded to form part of the water quality report. In addition, he/she may take samples from the raw water supply and consumer points for analysis by regulating bodies or external laboratories that capture parameters that cannot be analysed by the main laboratory or he/she could submit samples for the purpose of comparison to gain insight.

Samples brought in from the field are also incubated to test for the presence of pathogens.

3. Jar tests and chlorine demand tests

Jar tests are carried out to determine the amount of aluminium sulphate to be used in treating water. It also determines the dosage to be used for optimum coagulation and flocculation, sidestepping the dosing by trial and error. Optimum results are dependent upon the flow of raw water into the treatment works. It checks for the rate at which coagulation and flocculation happens at different raw water samples containing different concentrations of standard aluminium sulphate. The sample with the better floc formation and colour removal gives the aluminium sulphate dose for optimum coagulation. This test is carried out on a weekly basis.

Chlorine demand test gives the amount of calcium hypochlorite to be used for effective disinfection of treated water. A sample of the calcium hypochlorite to be used is dissolved in 500ml of filtered water and then diluted as per calculations done to reach the targeted concentration that will produce the desired results. The diluted sample is then divided into two for observation under light and dark conditions. Residual chlorine levels are tested on the sample at an hourly interval, monitoring the rate of change. The calcium hypochlorite sample that gives the most consistent result after 24 hours of observation is then recommended for use. The amount to be used is then determined by the chlorine demand obtained from the test added to the total residual chlorine.

This test is done to compare the effectiveness of calcium hypochlorite from different manufacturers.

4. Bacteriological tests

To ascertain that disinfection has been successful, treated water samples can be subjected to two main tests that check the presence of bacteria. These include membrane filtration tests and pathoscreen tests.

Pathoscreening is relatively cheaper and faster of the two, albeit less sensitive in distinguishing the type of bacteria. A sample of water is collected using a sampling bottle that has been autoclaved or properly sterilized by some other means. A culture medium is then added to the sample bottle and incubated in an incubator for 24 hours. A negative sample will retain the colour of the culture medium while a positive sample will give a black precipitate. This test is carried out on field samples and in-site samples as well.

Membrane filtration tests are more sensitive to the type of bacteria that grow on samples and also enable the counting of individual colonies. It involves passing a sample of water through a film having microscopic pores. This film is then placed on an adsorbent containing M-Coliblue medium that provides nutrients to the bacteria, specifically coliform bacteria and excluding others. The sample is then placed in a sterilized petri dish and incubated for 24 hours. Formation of colonies indicates a positive sample while a negative sample will have no bacterial growth as confirmed by a control sample.

5. **Sewage sample testing**

Two parameters are crucial in determining the effectiveness of sewage treatment: chemical oxygen demand and biochemical oxygen demand. Chemical oxygen demand measures the total oxygen required to chemically oxidize both biodegradable and nonbiodegradable organic matter in wastewater. It usually uses potassium dichromate to break down organic matter and takes about three hours to complete.

Biochemical oxygen demand measures the amount of oxygen required by microorganisms to break down organic matter in wastewater under aerobic conditions over a period of 5 days. It shows the biodegradable organic pollution in water but does not account for non-biodegradable pollutants.

A ratio of biochemical oxygen demand to chemical oxygen demand helps determine the biodegradability of wastewater. These tests are conducted at least once every two weeks.

WORK PLAN FOR WATER TREATMENT OPERATIONS

1. **Water abstraction from Intake:**

   At the raw water reservoir, approximately 13,000 cubic metres of water is abstracted by means of gravitational force. To separate physical matter from entering the intake pipes, screens are placed at the intake chambers. These screens are serviced at a weekly basis or as per the need arises, due to unexpected rainfall tthat may cause deposition of more objects than the screen can handle.

   Additionally, flushing of washouts along the intake lines and the servicing of air valves is done to ensure smooth flow of water from the source. This is also done by the water production technician who maintains the status of the screens.

2. **Water treatment processes:**

Water from the intake pipes is directed to a collection point, where its level can be monitored to check fluctuations across time. To ensure distribution of clean and safe water, a series of techniques are employed to separate the physical, chemical and microbial agents present in the water.

- **Elimination of physical media:** As water flows from the collection weir to the sedimentation tanks, aluminium sulphate is added to enhance coagulation and flocculation of particles. Coagulation helps in the precipitation of colloids and suspended matter which further aids in improving the clarity of water. Flocculation causes suspended particles to coalesce and can be filtered easily.
- **Elimination of chemical agents:** Addition of aluminium sulphate also aids in the precipitation of ions that cause water hardness by forming complex ions that are insoluble in water and can be filtered. Sodium carbonate is added to buffer the pH level of water and ensures that aluminium sulphate works effectively.
- **Elimination of pathogens and other microbes:** This is done by the addition of calcium hypochlorite which kills bacteria and other microbes and thus ensuring water is safe for consumption.

After the addition of aluminium sulphate, the water is directed to sedimentation tanks, where the water remains undisturbed to allow for the sinking of silt and other dense materials that are present in water. This also gives time for the aluminium sulphate to work effectively to lower the turbidity of the raw water. Some of the operations done here include:

- **Scrubbing the walls of the inlet weir:** This is done to remove the mosses that grow at the point of contact between the water and the well.
- **Washing of troughs at the sedimentation tanks:** The floccules and lighter sediments tend to cling to the troughs that collect surface water from the sedimentation tanks, tainting the colour of the troughs. Therefore, the troughs should be scrubbed as soon as their colour starts to darken, which can vary, depending on the turbidity of the incoming water.
- **Cleaning of the sedimentation tanks:** The denser matter that sinks at the bottom of these tanks should be removed to ensure that the water maintains its low levels of turbidity. This should be done at least after a fortnight, depending on the turbidity of the raw water.

The top part of the water in the sedimentation tanks is collected and directed to the filter galleries where further elimination of physical material takes place. Due to the nature of the filter packaging, the filter wells gradually fill up with water as time passes, and the rate of filtration slows down. To overcome this, a backwash system is used to eliminate matter that sticks in between the filter packaging. The backwashing of the filters is done as soon as the operator notices that the water in the filter well has risen to approximately three quarters of the total volume of the well. A properly backwashed filter ensures smooth flow of water through the packaging and into the channels that direct the filtered water to the collection tank. The water level of the backwash tank should be monitored to ensure that there is sufficient water available for a backwash operation. If not, then the operator is to turn on the backwash pump to fill the backwash tank with water accordingly.

3. **Operations at the Treatment Works:**

The water production technician (W.P.T) at the treatment works is expected to do the following:

- Chemical application: The W.P.T applies the chemicals used in water treatment process as calculated by the laboratory analyst/technician to produce the desired results at both the treatment works level and at consumer point.
- Monitoring the raw water levels to ensure continuous supply of sufficient water for customers. He/she may adjust the levels coming in as per the demand of water or as directed by water distribution officials or the water production officer.
- Servicing of screens and strainers
- Washing of sedimentation tanks and troughs
- Backwashing of filters
- Monitoring of the flow of electricity to ensure that there is sufficient power for water production purposes as well as security and lighting purposes.
- Facilities and compound maintenance: The W.P.T should regularly clean the offices, laboratory and other amenities that are used on a daily basis to ensure they are well kept and maintained. Additionally, the areas immediately surrounding these facilities should be assessed and proper action taken, like trimming of fences and grass lawns, application of herbicides to control weeds and other plants growing on surfaces like walls and pavements.
- Maintenance of records used in assessing the quantity of chemicals used as well as the water parameters measured throughout the day.
- Maintenance of equipment at the treatment works to ensure smooth operation and longevity of the machines used as well as minimizing accidents that may result from the use of broken tools and machines.

- Monitoring clean water level in the storage tank to ensure that sufficient water is available for supply to customers.

Standard Operating Procedures for Technical Department.

SOP for Meter Replacement

Purpose

Water meters may show inaccurate readings due to age, wear and tear, obstruction and physical defects. A meter shall be deemed to be inaccurate and due for repair or replacement, if any error shown is 5% or greater. This SOP describes the steps to be followed by the company in repairing water meters.

Responsibility/Accountability

The Non-Revenue Water Technicians are responsible for assessing the condition of the meter and forwards it to the Non-Revenue Water Assistant for test and repair.

Procedure

1. The Meter Reader reports any malfunctioning meter through the designated communication platforms.
2. The Non-Revenue Water (NRW) Technician visits the property to assess the reported meter.
    - If the meter is repairable, the Technician carries out the necessary repairs, seals the meter, and restores it to service.
    - If the meter is beyond repair, the Technician recommends replacement to the Non-Revenue Water Assistant.
3. The Non-Revenue Water Assistant submits a request for a replacement meter.
4. The Non-Revenue Water Officer and the Technical Services Manager review and approve the meter replacement request.
5. Upon approval, the Store Clerk issues a replacement meter to the NRW Technician for installation.
6. The NRW Technician replaces the faulty meter, seals the new meter, and records both the old and new meter details in the official Meter Replacement Form.
7. The completed Meter Replacement Form is signed by the Non-Revenue Water Assistant and the Non-Revenue Water Officer.
8. The Technician returns the old meter to the Store Clerk, who acknowledges receipt by signing the Meter Replacement Form.
9. The Technician files the completed and signed Meter Replacement Form in the official replacement records.

SOP for Meter Testing

Purpose

Meter testing is applicable, when a Meter Reader finds a meter that is not reading properly, an inconsistent consumption pattern as recorded over 6 consecutive readings, a customer reports an inconsistency or when a meter has been in use for 5 years. A meter shall be deemed inaccurate if

the error is greater than 5%. This SOP describes the steps to be followed to carry out a water meter test.

Responsibility/Accountability

The Technical Services Manager is responsible for water meters testing.

Procedure

1. The Non-Revenue Water (NRW) Officer initiates the meter testing process by completing a Meter Testing Form and forwarding it to the Technical Services Manager for authorization.

2. Upon authorization, a Technician designated by the Technical Services Manager conducts the meter test on-site using a Portable Meter Testing Kit.

3. During the test, the Technician connects the Portable Meter Testing Kit in series with the meter under inspection and compares the readings of the two meters to determine accuracy.

    - Based on the test results, the meter may be:
    - Reinstated,
    - Repaired, or
    - Removed for replacement.

4. The Testing Technician completes and signs the Meter Testing Form, and submits it to the Technical Services Manager for approval.

5. The Technical Services Manager reviews the form, approves it, and forwards a copy to the Commercial Manager for implementation of the recommendations.

SOP for Pipe Laying

Purpose

Pipe laying requires quality workmanship especially in trenching, bedding, leveling and jointing. This SOP describes the steps to be followed by the technical Staff in pipe laying.

Responsibility/Accountability

The Technical Manager is responsible for pipe laying.

Procedure

The authorized Technician:

1. Conduct a preparatory site visit.
2. Ensure the site is cleared to provide adequate working space.
3. Reconfirm pipeline alignment by taking measurements to validate the distances indicated in the design.
4. Mark the trench width, taking into account working space requirements inside and outside the trench.
5. Excavate the trench to the specified depth and width in accordance with the approved measurements.
6. Clean the pipe ends and fittings to remove dirt and debris.
7. Level the trench using suitable bedding material to provide uniform support for the pipeline.
8. Connect the pipes with the appropriate fittings:
   - **Welded joints** – performed inside the trench.
   - **Fusion joints** – carried out outside the trench, then laid inside.
   - **Push joints** – may be executed either inside or outside the trench.
9. Backfill the trench gradually, ensuring the joints remain exposed for inspection.
10. Pressurize the system and inspect all joints for leaks. Once confirmed leak-free, cover the joints with soil.
11. Conduct a pipeline pressure test and, upon successful completion, prepare a formal test report.

SOP for Disconnecting Customer Connections from the Main

Purpose

This SOP describes the steps to be followed by the technical Staff in disconnection of dormant connection from the main.

Responsibility/Accountability

The non-revenue water Officer is responsible for disconnection of dormant connection from the main.

Procedure

Disconnecting Customer Connections from the Main

1. The Non-Revenue Water (NRW) Officer prepares and submits the list of accounts to be disconnected from the main.

2. The NRW Technician verifies that all customer records, including account details and disconnection reasons, are properly documented.
3. Where applicable, the NRW Technician issues an official disconnection notice to the customer in line with company policy and regulatory requirements.
4. The NRW Technician conducts a site visit to locate the exact point of connection between the customer's service line and the main.
5. The NRW Technician reconfirms the service line to ensure the correct customer connection is identified and to avoid accidental disconnection.
6. The NRW Technician excavates the area around the service pipe connection point on the main.
7. The NRW Technician carefully exposes both the main and the customer service pipe without causing damage to surrounding infrastructure.
8. The NRW Technician shuts off supply to the service line, where possible, using appropriate valves.
9. The NRW Technician cuts and disconnects the service pipe from the main using approved tools and methods.
10. The NRW Technician seals or plugs the tapping point on the main to prevent leakages and water loss.
11. The NRW Technician backfills and compacts the excavation to restore the site to its original condition.
12. The NRW Technician updates the customer's account records in the billing system to reflect the disconnection.
13. The NRW Technician documents the disconnection process with photographs and GPS coordinates using Kobo Collect, and prepares a field report for submission to the relevant departments.

SOP for Leak Detection and Repair

Purpose

This SOP describes the steps to be taken by the Company to reduce water leakage. It outlines the procedure to be deployed by the staff to detect and repair leaks within the transmission lines, distribution lines and in the customer service lines.

Responsibility/Accountability

The Non-Revenue Water Officer is responsible for leak detection and repair.

Procedure

Procedure for Leak Detection

1. The Technical Manager establishes and maintains mechanisms to encourage the general public to report water leaks (e.g., hotlines, mobile applications, reporting desks).
2. The Operations and Maintenance Officer form a Leak Detection Team comprising Technicians and the Non-Revenue Water (NRW) Assistant.
3. The Operations and Maintenance Officer verify reported leaks (from the public, customers, or media) by deploying the Leak Detection Team to the site.
4. The Operations and Maintenance Officer monitors bulk meter readings in areas with suspected leaks and assigns the Leak Detection Team to investigate and confirm the anomalies.

5. The Leak Detection Team carries out inspections and, where applicable, detects underground leaks using appropriate detection methods and equipment.

Procedures for Leak Repair

A. Pipes up to 80 mm

The **Technician**:

1. Visits the site and, with the assistance of artisans, exposes the leaking pipe.
2. Assesses the leak and, upon approval of the Technical Manager, requisitions the required materials.
3. Repairs the leak and flushes the pipeline.
4. Documents the repair using **Kobo Collect**.

B. Pipes between 80 mm and 200 mm

The **Technician**:

1. Visits the site and, with the assistance of artisans, exposes the leaking pipe.
2. Assesses the leak and, upon approval of the Technical Manager, requisitions the required materials
3. Isolates the faulty section of the pipeline and drains it.
4. Repairs the leak and flushes the pipeline.
5. Ensures that water service is restored.
6. Documents the repair using **Kobo Collect**.

C. Pipes greater than 200 mm

The **Technician**:

1. Visits the site and, with the assistance of artisans, exposes the leaking pipe.
2. Assesses the leak and, upon approval of the Technical Manager, requisitions the required materials
3. If the pipeline is a rising main, ensures that pump shutdown procedures are followed by the Pump Operator.
4. Isolates the faulty section and drains the main pipeline.
5. Repairs the leak, flushes the pipeline, and disinfects the section in accordance with applicable standard procedures.
6. Coordinates with the Pump Operator to restart the pump according to standard start-up procedures.
7. Ensures that water service is restored.
8. Documents the repair using **Kobo Collect**.

SOP for Maintenance of Customer Service Line

Purpose

The objective of maintaining a customer's service line is to repair leaks, replace old pipes and fittings and improve water flow so that customers get reliable water supply. The customer service line is the entire pipeline from the distribution main line to the meter and from the meter into the property. This SOP describes the steps to be taken by the utility to maintain customer water service line.

Responsibility/Accountability

The Operations and Maintenance Officer is responsible for maintenance of customer water service line.

Procedure

1. The Customer Care Section receives information on malfunctioning of a customer service line from the public, Meter Readers, zones-in-charge and Leak Detection Team.
2. The Technician visits the site, assesses the customer service line problem and gets consent using the Customer Service Line Maintenance from the customer to rectify the situation.
3. The Operations and Maintenance Officer prepare the cost estimates.
4. The Technical Manager approves the cost estimates and issues an invoice to the customer.
5. The Operations and Maintenance Officer instruct the Technician to prepare a job card for resolving the problem.
6. The Technical Manager approves the requisitioned materials from stores
7. The Technician repairs the service line, tests and restores the service.

SOP for Pipes and Fittings Inspection

Purpose

Pipes and fittings are one of the most important supplies to the water utilities. Substantial amount of money is used in their procurement. It is a prerequisite that correct specifications are drawn and materials supplied meet the requirements. The adage that what you see is what you get applies, unless you inspect diligently what you receive in your stores.

Responsibility/Accountability

The Technical Manager is responsible for inspecting and ascertaining the quality of the supplied pipes and fittings vis-a-vis the specifications.

Procedure

1. The public procurement guidelines stipulate that all receivables into the stores should be inspected before being accepted.
2. Once the pipes and fittings are brought to the stores, the inspection team is appointed by the Chief Executive and called in by the Store's Officer.
3. The Inspection Team, comprising members from the technical department knowledgeable about pipes and fittings, checks the supplies against the requisition and the specifications.
4. The Inspection Team signs the Inspection Acceptance Form T10, in case pipes and fittings are acceptable in quality and quantity or rejects them in part or in full.
5. Accepted pipes and fittings are received into the stores and a Goods Received Note (GRN) is issued by the Store's Attendant.
6. The User Department is informed by the Store's Officer of the availability of their requisitioned pipes and fittings in stores.
7. This procedure is applicable to all other materials received in the stores.

SOP for Handling Meter Tempering

Purpose

This SOP describes an internal control mechanism to systematically improve the identification of meters that have been tampered with and to rectify the situation.

Responsibility/Accountability

It is the responsibility of the Commercial Manager to monitor, control and make follow up on utility water losses associated with meter tampering.

Procedure

1. Identifies meters that have been tampered with in accordance with utility policy.
2. Obtains and document evidence of tampering with the meter by recording a video or taking picture using a phone.
3. Computes compensation amount based on utility policy.
4. Presents compensation claim for payment to the customer, responsible for the meter tampering.
5. In case the compensation is not paid, seek court redress through a utility legal officer.

SOP for Material Requisition

Purpose

This SOP describes an internal control mechanism for materials from the company stores that are used by the technical departments in accordance with the annual plan and budget.

Responsibility/Accountability

It is the responsibility of the Procurement Officer to ensure that appropriate requisitioning process are used, when requesting materials and that the store inventories are managed adequately.

Procedure

1. The user department fills a pre-numbered purchase requisition form.
2. The user department submits the purchase requisition to the procurement unit for procurement purposes.
3. The stores officer receives required materials into the stores from the supplier after inspection and approval of the deliveries.
4. The stores officer informs the user department on receiving the materials from the suppliers.
5. The user department completes the pre-numbered material requisitioning and issuing and submits it to stores.
6. The stores officer issues the materials to the user department.
7. The user department signs the issue note and collects materials from the stores.
8. The user department uses the materials and maintains own consumption register for auditing purposes.