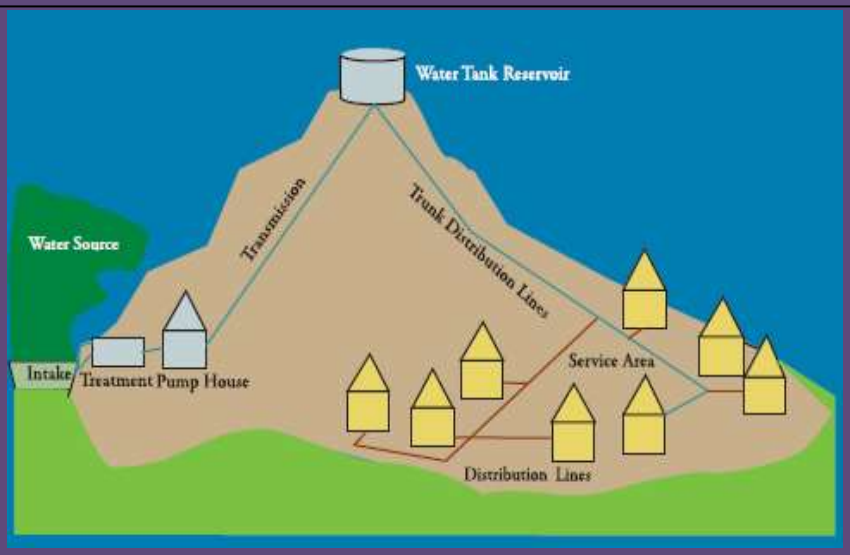
THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

MINISTRY OF WATER IRRIGATION AND EELECTRICITY

RURAL PIPED SYSTEM WATER SUPPLY OPERATION AND MAINTENANCE MANAGEMENT



Part A: Module C-Sessions A to G

A Trainer's Manual for Technical Operation and Maintenance Requirements For Rural Piped System

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October, 2015

PART - A: TECHNICAL OPERATION & MAINTENANCE MANAGMENT

MODULE NO.	SESSION	SESSION TITLE	ESTIMATED TIME (Hours)
MODULE – A	Session – A	Facilitator's Guide for Rural Water Supply Operation & Maintenance Management	4
	Session – B	Introduction to the training: objectives and expectations	2
	Session – C	Introduction of Rural Piped System and Pastoral areas Water Supply Technologies	2
MODULE – B	Session – A	Description of Water Sources for Water Supply	2
MODULE – C	Session - A	Introduction of Rural Piped System Operation and Maintenance	2
	Session - B	O&M Requirements for Water Sources to Water Supply	4
	Session - C	O&M Requirements for Intakes	4
	Session - D	O&M Requirements for Electro-Mechanical Equipment	32
	Session - E	O&M Requirements for Pipelines	8
	Session - F	O&M Requirements for Storage Tanks/Service Reservoir	4
	Session - G	O&M Requirements for Consumer Points	4
Sub Total for this Module			**58**
MODULE – D	Session -A	Spare Parts Supply and Management	36
	Session - B	Equipment and Tools Management	8
	Session - C	Asset Management	16
MODULE - E	Session – A	Water Audit and Leakage Detection	16
MODULE - F	Session – A	Water Quality Monitoring and Surveillance	24
MODULE - G	Session – A	O&M Requirements for Solar Energy	6
	Session –B	O&M Requirements for Wind Energy	4

MODULE - H	Session – A	O&M Requirements for Sand Dam	6
	Session – B	O&M Requirements for Haffir & Berkads	6
	Session – C	O&M Requirements for Rain Water Harvesting	4
		TOTAL	**202**

Total Training duration for Part – A is about 25 days.

MODULE - C: TECHNICAL O&M TRAINING MANUAL FOR RURAL PIPED SYSTEM

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Definition of Terms

Pump	A pump is a device, which raises or transfers liquids at the expense of power input or a unit that transfers the mechanical energy of a motor or an engine into potential and kinetic energy of a liquid.
Centrifugal Pumps	Centrifugal pumps are commonly used for low and high service to lift and transport water. The two essential parts of a centrifugal pump are rotating membrane with vanes and the impeller and surrounding case
Booster Pump	Booster pumps are pumps which take water from a supply main and discharge it at a higher pressure to another point in the same pipeline, and are also used to increase pipeline pressure in outlying areas when loss of head is too great along the line
Throttled operation	At times if motor is continuously overloaded, the delivery valve is throttled to increase head on the pump and reduce power drawn from motor. Such operation results in inefficient running as energy is wasted in throttling
Pressure gauge	is an instrument used to measure the pressure of the pipe system
Priming	is the process of filling the pump casing and suction line from external source or by pouring water.
History Sheet	History sheet of all pumps shall be maintained. The history sheet shall contain all important particulars, records of all maintenance, repairs, inspections and tests etc
Generators	Diesel generators are frequently used as a stationary power source. The main parts of the engine are the cylinders, pistons, valves and crankshaft. Air is compressed by a piston inside a cylinder and diesel fuel is injected into it by a high pressure pump, which results in an explosion that moves the piston. In turn, the piston turns a crankshaft
Preventive Maintenance	Refers to an activity that includes checking the status of water supply facilities components at regular fixed intervals
Rehabilitation	Is the correction of major defects and the replacement of equipment to enable the facility to function as originally intended.
Repair	It is the restoration of a defective component to return the facility to acceptable working condition. The cost of the repair should be borne by the community.
Rural Area	“Areas of population outside urban and peri-urban using point or surface water sources for which the community is responsible for the O&M”. in addition, low population densities characterize rural areas, with small houses isolated from each other.
Rural Piped System	It is a water supply system feeding various villages and small towns by gravity, pumping and a combination system through public taps and yard connections
Scheme (Water)	The entire facility (concrete works, pipes, pumps) established to extract water from a water source, and distribute it to (close to) people’s homes

Source (Water)	The natural water source only, i.e. spring, groundwater, river, etc
Transmission Line	is to deliver raw water from the source to the treatment plants, and transmit treated water from treatment plants to the storage reservoirs

Acronyms and Abbreviations

D.C	Direct Current
G.I	Galvanized Iron Pipe
HDPE	High Density Polyethylene Pipe
NGOs	Non Governmental Organizations
O&M	Operation and Maintenance
PM	Preventive Maintenance
POM	Preventive Operation and Maintenance
PVC	Polyvinyl Chloride Pipe
RPS	Rural Piped System
SR	Service Reservoir
WASH	Water Supply Sanitation and Hygiene
WASHCO	Water Supply Sanitation and Hygiene Committee

1 SESSION – A: INTRODUCTION TO RURAL PIPED SYSTEM OPERATION & MAINTENANCE

MODULE - C	TECHNICAL O&M MANAGEMENT REQUIREMENTS FOR RURAL PIPED SYSTEM
1.1. Session Outline	This session covers the following core topics: ▪ Introduction to RPS ▪ Feature of RPS in Ethiopia ▪ Configuration of Rural Pipes System in Ethiopia ▪ Classification of Maintenance ▪ Maintenance Planning Process ▪ Inputs, Spare parts and tools required for maintenance ▪ Technical Assistance Requirements
1.2. Objective	The Water Board, Water Administration office staff understands what rural piped system and O&M management means. At the end of the session, participants understand the concept of RPS configuration and different types of O&M, the process of maintenance planning, inputs, tools and spare parts requires.
Output	▪ An O and M schedule ▪ List of tools ▪ List of suppliers with contact details ▪ Contact numbers for individuals and organizations that can provide technical ▪ assistance or services for maintenance tasks or in case of unexpected breakdowns
Timing	Approximately 2 hours
Methodology	▪ Presentation, discussion and group exercises ▪ Demonstrate graphically different configuration of rural pipes system.
Materials	▪ Flip charts, markers, pens, even overhead projector
Session Guide and Content	
1.3. Introduction	Rural piped system is a water supply system which serves more than one rural village and small towns in combination from a single source or combination of sources; with gravity or pumping or combination system; with a distribution system that is managed by elected community representatives and operated by recruited scheme operators (local service providers – water administration office). Now days such system is well known and expanded in Ethiopia like Etosa, Bale Robe-Melliyu, Wulbareg, Dalocha, Etege Tayitu and so many.

1.4. Special Features of RPS in Ethiopia	Explain the RPS schemes in Ethiopian context that are distinguished through the following characteristics: ▪ One source supplies several rural villages and possibly one or more small towns, ▪ The source is located far away from the users and their villages, ▪ The systems have large installations such as head works, pumping stations, long transmission lines, service reservoir, distribution system, water points and connections, ▪ Users are organized to form an association and select representatives to ensure effective oversight of the scheme, The management of the scheme requires professional operator.
1.5. Configuration of Rural Piped System	Two different types of RPS configuration predominately exist. These are presented in Attachment 1.1 and 1.2. Attachment 1.1 is showing the water sources are mainly from the rural area, like that of Robe-Melliyu and Hetosa, which feeds the various villages and end to the urban areas. The other one is the sources belongs to urban area like dams and deep boreholes, which mainly feed to the urban community and extended to the various nearby villages as presented in attachment 1.2. The two systems are totally having different service delivery models. The former one is fully managed by community elected management bodies, while the later, delivery the service by urban water utility. This report focuses on the community managed rural piped system.
1.6. Classification of Maintenance	Discuss the two maintenance classification: 1) Scheduled (preventive Maintenance) and 2) Un-schedules (breakdown) Maintenance. **1.6.1. Scheduled (Preventive Maintenance)** It may be defined as the care and servicing by individuals involved with maintenance to keep equipment/facilities in satisfactory operational state by providing for systematic inspection, detection, and correction of incipient failures either prior to their occurrence or prior to their development into major failure. Explain why Preventive Operation & Maintenance is required? ▪ enhance capital equipment productive life, ▪ reduce critical equipment breakdowns, ▪ allow better planning and scheduling of needed maintenance work, ▪ minimize production losses due to equipment failures, and ▪ promote health and safety of maintenance personnel The most important principle to keep continuous management support is: *"If it is not going to save money, then don't do it!"* Discuss on the following elements of Preventive Operation and Maintenance (POM) as described in Table 1-1. What activities are done when we mean POM. **Table 1-1: Elements of Preventive O&M**

No	Elements	Description
1	Inspection	Periodically inspecting materials/items to determine their serviceability by comparing their physical, electrical, mechanical, etc., characteristics (as applicable) to expected standards
2	Servicing	Cleaning, lubricating, charging, preservation, etc., of items/materials periodically to prevent the occurrence of incipient failures
3	Calibration	Periodically determining the value of characteristics of an item by comparison to a standard; it consists of the comparison of two instruments, one of which is certified standard with known accuracy, to detect and adjust any discrepancy in the accuracy of the material/parameter being compared to the established standard value
4	Testing	Periodically testing or checking out to determine serviceability and detect electrical/mechanical-related degradation
5	Alignment	Making changes to an item's specified variable elements for the purpose of achieving optimum performance
6	Adjustment	Periodically adjusting specified variable elements of material for the purpose of achieving the optimum system performance
7	Replacement	Periodic replacement of limited-life items or the items experiencing time cycle or wear degradation, to maintain the specified system tolerance

Explain the following items that are necessary to be considered for effective POM program:

- accurate historical records of equipment,
- manufacturer's recommendations,
- skilled personnel,
- past data from similar equipment,
- service manuals,
- unique identification of all equipment,
- appropriate test instruments and tools,
- management support and user cooperation,
- failure information by problem/cause/action,
- consumables and replaceable components/parts, and
- Clearly written instructions with a checklist to be signed off.

An O and M schedule is based on the understanding that performance is measured by the quality of service being provided.

Indicators of performance include:

- frequency of disruptions to supply

- length of disruptions to supply
- quality of water provided
- Cost of water production versus payment charged and paid.

The training facilitator raises the issue and debate on the idea with the participants.

Preventing a problem is much cheaper than fixing a problem. Preventing a problem keeps the system working. If the objective of the system is to provide a reliable service, then it is unacceptable for the system to break down or stop working.

It is better to stop the system briefly for routine maintenance than to wait until it breaks down.

The O and M schedule provides information on **what** has to be done, **by whom** and **when**.

1. Developing an O and M schedule

To develop an O and M schedule, go through each component of the system and discuss the tasks to be done, filling in the table below as required.

Task	Responsibility	How Often

2. Developing monitoring tools

It makes no sense to develop the O and M Schedule without ensuring that the tasks have been done. The easiest way to make sure that the tasks are carried out is to require the person responsible to sign off on a form when the task is completed. This means that a form or forms should be designed to suit the O and M schedule – this will be scheme and component specific.

The example below provides an indication of a monitoring tool for routine monthly maintenance tasks.

Task	Frequency	Meskerem	Tikemet	Hidar	Tahissase
Change Oil					
Patrol pipeline					
Inspect reservoir					

1.6.2. Un-scheduled (Breakdown) Maintenance

Un-scheduled maintenance helps in preventing breakdown of equipment but totally avoiding is impractical. Some failures could not be identified easily but needs fault tracing and correction in other words trouble shooting.

Repairing the failed part cannot be a full solution to the problem as long as reasons of failure are not known. Knowing the exact problem will assist in preventing repetitive failures.

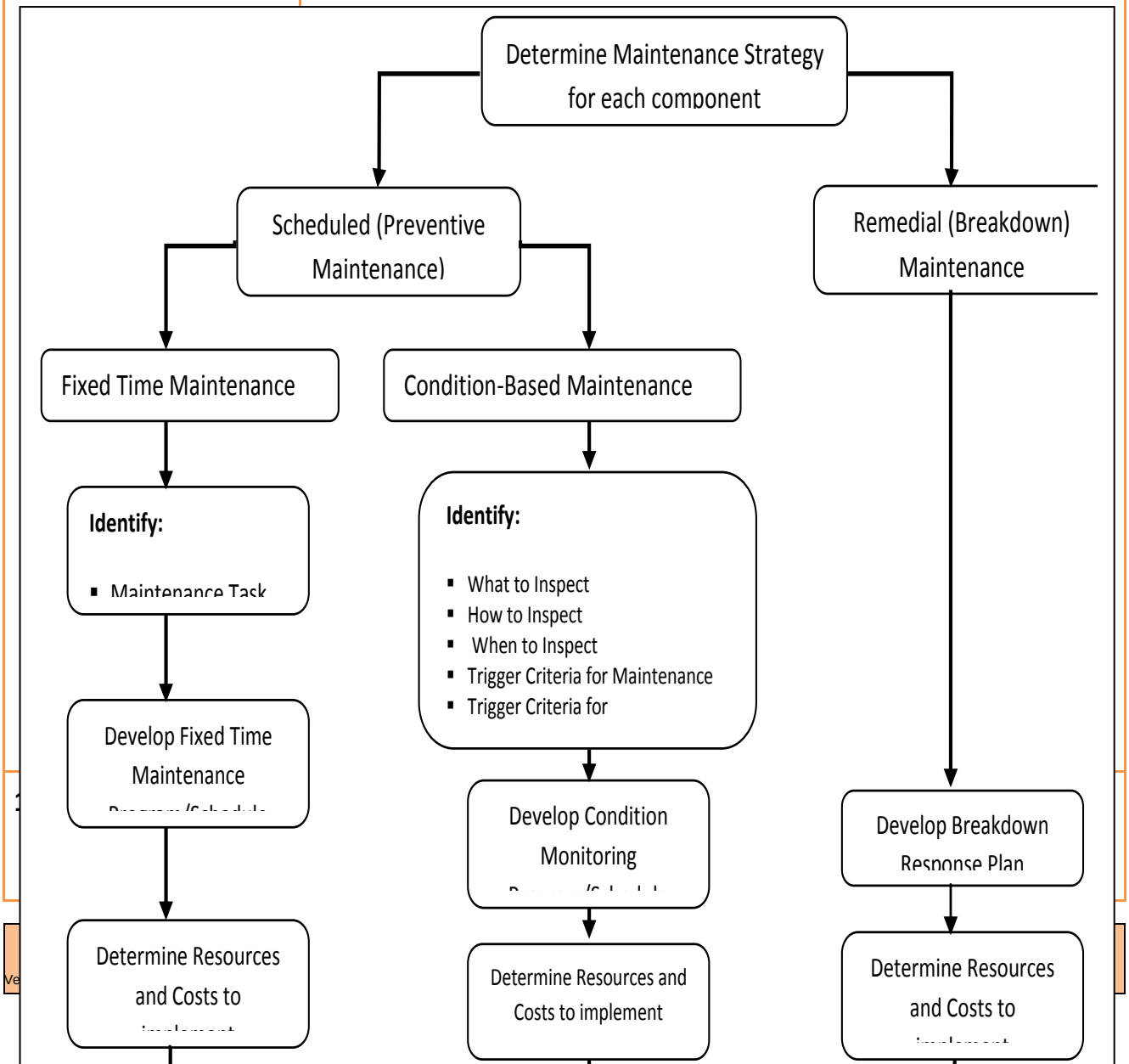
As in all repairs and maintenance activities, correct procedures must be followed in repairing break downs. These procedures must be followed in repairing break downs.

These procedures include testing by instruments, trouble shooting or any other means but the manufacturer maintenance manual is the best reference to follow correct repair procedures.

1.7. Maintenance Planning Process

Maintenance has to be planned as preventive maintenance and breakdown maintenance. The training facilitator explains the maintenance planning process with the help of Flow Chart in Figure 1.1 described the process of maintenance planning.

Figure 1-1: Maintenance Planning Process



assistance

various supplies to operate properly.

These may include:

- fuel
- lubricants – oils and grease
- chemicals
- electricity
- meters for new connections
- fittings for new connections
- Filters, etc.

Discuss the arrangements required to ensure that sufficient supplies are stockpiled and what measures need to be put in place to make sure that the availability of the supplies is not interrupted.

Issues include:

- stores – adequacy, access into, safety, security
- stores register
- Requisition forms.

2. Spare Parts and Materials

Discuss which spare parts are required for routine maintenance and to handle emergencies. Draw up a list of the spare parts that the project should have available at all times.

These may include:

- filters for oil, fuel and air
- washers
- materials for pipeline repairs – glue, piping, fittings
- taps and tap washers
- spare locks
- replacement meters
- valves
- painting materials, solvents
- Construction materials.

3. Supply Chain

It is unwise to consider what spare parts are required without considering where these components are sourced. It is helpful to draw up a list of suppliers and to decide what minimum quantity of the spare parts and materials should be kept in the store.

When this minimum amount is reached, then a requisition form should be prepared to start the process of procuring additional spare parts and materials.

Spare	Minimum required in Store	Name and contact of Supplier 1	Name and contact of Supplier 2	Expected cost per unit on delivery

4. TOOLS

Discuss the tools required by every member of O and M staff. Draw up a list. Tools can be kept in the store room or officially issued to the appropriate Water Administration Office/ WASHCO.

Sample Tool List

Tools	Purposes
1. Tool box	Storing tools
2. Wooden float 3. Steel float 4. Plastering trowel 5. Masonry trowel 6. Spirit level 7. Masonry hammer 8. Shovel	Masonry work
9. Steel brush 10. Die-stock 11. Joining compound 12. Pipe cutter 13. Chain spanner 14. Pipe wrenches 15. Pipe vice 16. Oil can	For GI (Galvanized Iron) pipework
17. Heating plate 18. Pocket-knife 19. File 20. Welding machine	For PVC and HDPE pipework
21. Measuring tape 22. Hacksaw 23. Pliers 24. Sisal fibre	Multi-purpose tasks

See Attachment 1-3: Essential tools for maintenance of water supply systems.

5. Technical Assistance and Services

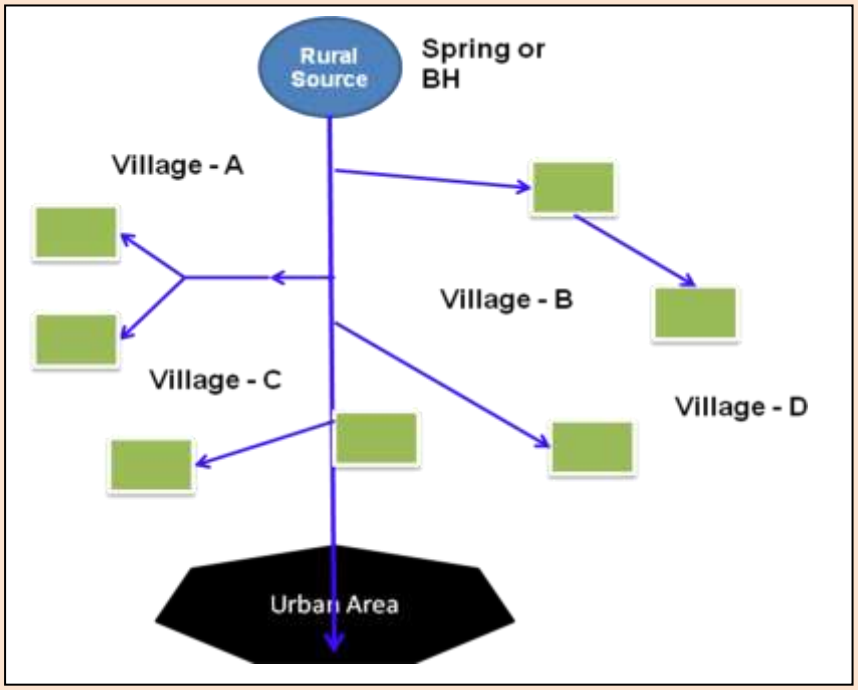
Discuss with the participants how and from whom additional technical assistance should be obtained (e.g., Woreda Water Office, Zone Water Office, Regional Water Bureau, NGOs operating in the vicinity, private company etc).

This information should be established before there is an emergency. Technical assistance includes the services that are sourced from time to time or those individuals or offices to be contacted in case of a system breakdown. Draw up a list similar to the one shown below.

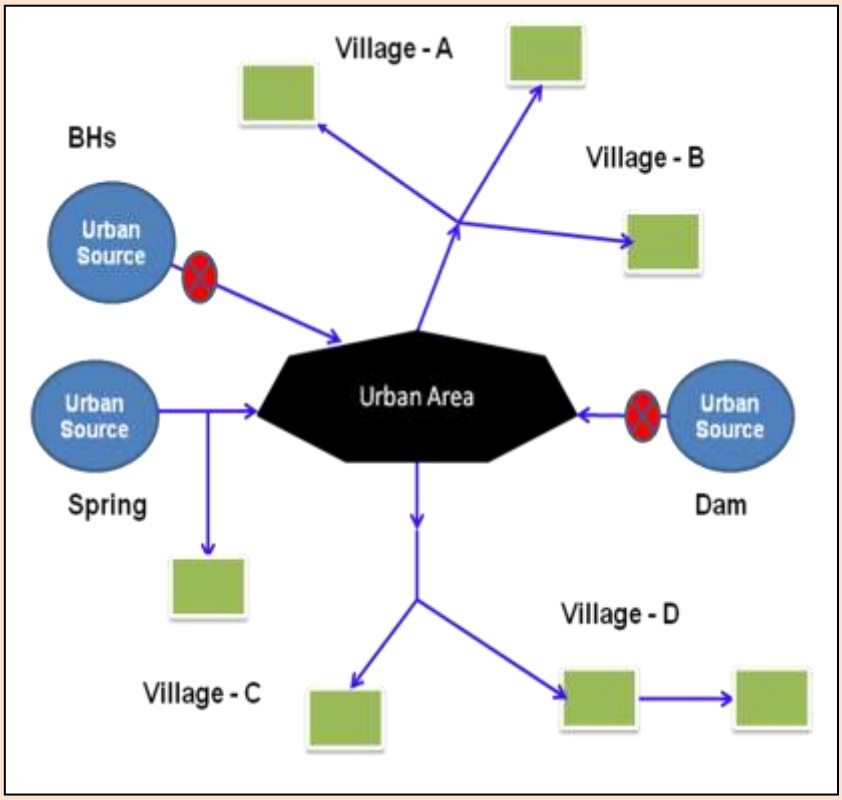
Component	Name of Technical assistant	Contact details	Back-up contact	Contact details for back-up
Pump Repair				
Generator Repair				
Electrician				
Water Quality				

Attachments

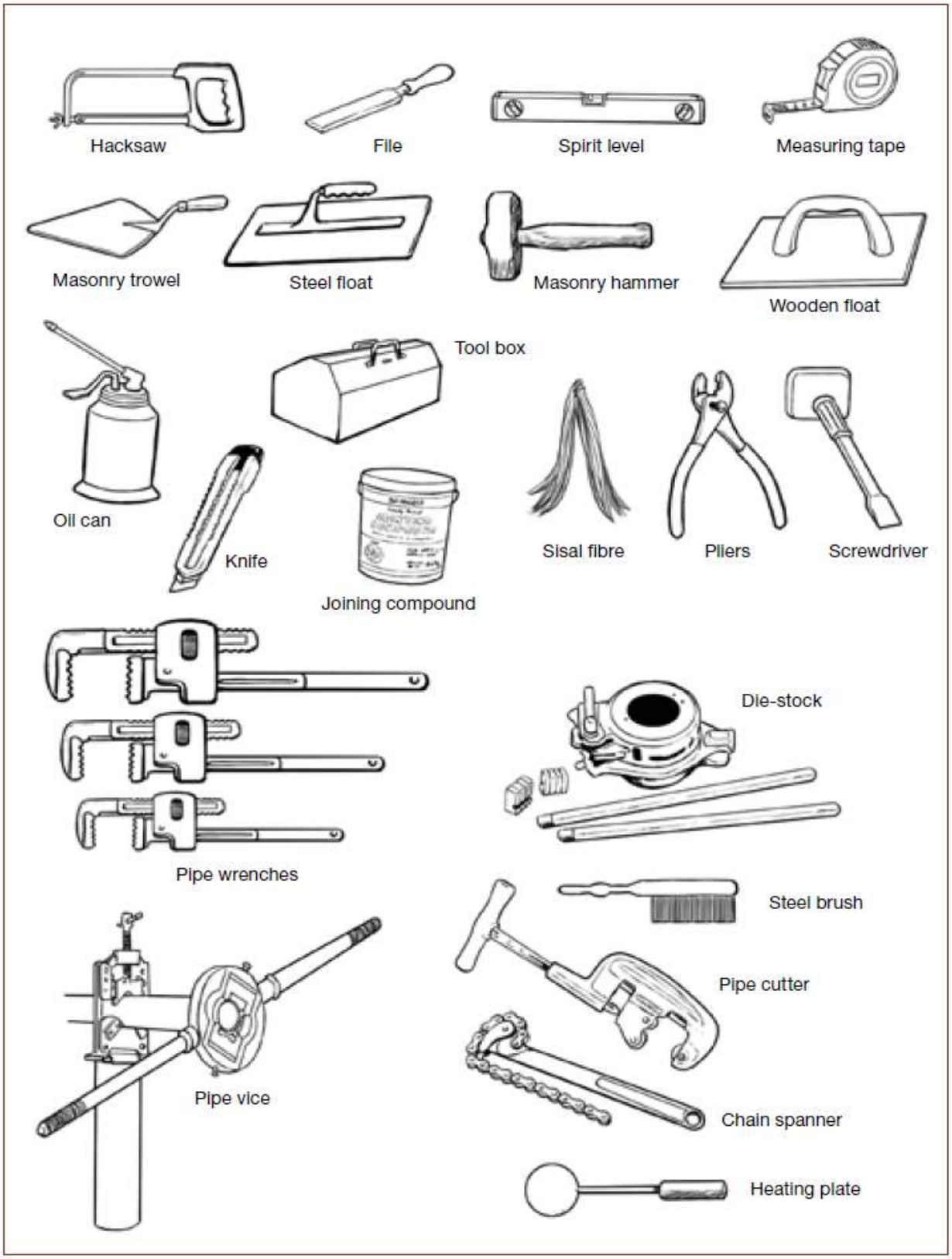
Attachment 1-1: Water sources from rural area RPS distribution



Attachment 1-2: Water sources from urban area RPS distribution



Attachment 1-3: Essential tools for maintenance of water supply systems



2 SESSION – B: TECHNICAL O&M REQUIREMENTS AT WATER SOURCES

Module – C	TECHNICAL O&M MANAGEMENT REQUIREMENTS FOR RURAL PIPED SYSTEM
2.1 Session – B1	**Boreholes with Submersible Pumps**
2.2 Session Outline	This session address the following core topics: ▪ Introduction ▪ Components of borehole ▪ Specific O&M Tasks at Borehole ▪ Troubleshooting for Borehole ▪ Tools, Spare parts and Technical assistance required
Appropriate Facilitator	Water Engineer or electromechanical engineer or technician with experience on operation and maintenance of boreholes and associated pumps.
2.3 Objectives of the Training	▪ Participants will be able to identify the different components of the borehole system including submersible pump ▪ Participants will have developed an Operation and Maintenance Plan for borehole and submersible pump.
Output	An Operation and Maintenance Plan
Timing	Session should take approximately 4 hours
Target Groups	The target groups for whom this training manual has developed for Water Administration Office for RPS and WASHCOs as well as Woreda Water Offices
Appropriate Venue	Any place where existing boreholes are available for practical demonstration.
Methodology	Brainstorming, Group Discussion/ presentation, Role Play, Question & answer and Site walk for demonstration
Training Materials	▪ Facilitator's and Participant's Manuals ▪ Flipchart, markers, flipchart stand and masking tape ▪ Computer, LCD Projector
Session Guide and Contents	
2.4 Introduction	Borehole systems typically include a number of different components. Most of these components are discussed individually under the sessions

on generators, tanks, public water point and pipelines. This session is intended to be an INTRODUCTION to Boreholes.

2.5 Step 1: System Overview

The first activity to be done by the facilitator will be in combination with a site walk, ask the participants to identify each component of their borehole system and discuss the purpose of the component. The following borehole components are typically found as indicated in Table 2-1:

Table 2-1: Typical Component of Borehole

Item	Purpose
Borehole	Protected hole which penetrates to the aquifer and which is filled by water from the aquifer.
Wellhead	Prevents surface water from seeping down the edge of the casing and entering the aquifer or borehole
Borehole casing	Casing prevents the hole from collapsing.
Screens	Perforated parts of the casing to allow water from the aquifer to enter the borehole.
Seal	Prevents seepage water from moving from higher aquifers or near surface to lower aquifers
Submersible electrical pump	Raise water from aquifer to tank. The pump is located in the hole and is protected by the borehole casing
Rising Main	Water is raised from the pump to the tank through the rising main
Dipper tube	Dipper tube allows the water level in the borehole to be measured
Meter	Measures volume of water extracted by the borehole from the aquifer
Pump House	Structure which usually contains the control panel. If the pump in use is an electrical submersible, then the pump house is also likely to contain the generator or the circuit board for the mains electricity power
Generator (Genset)	Provides electricity to run the pump. Generator may also be a standby for when mains power is not available. Generator is driven by a motor/engine which may be diesel powered
Control panel	The control panel is a set of electrical circuits whose purpose is to control the power to the pump.
Fuel Store	A well ventilated and secure store for fuel
Tank	Borehole water is typically raised to ground or elevated tank from which water is distributed to the

	consumer points
	The facilitator explains the borehole components with the aid of figure in attachment – 1 below.
2.6 Step 2: O & M tasks specific to Boreholes	Discuss the tasks relevant to the operations and maintenance of the system components. Note that specific sessions have been provided for generators, solar-voltaic powered systems, wind pumps, tanks, and public water points. **Box 2-1: Borehole O&M Tasks** Tasks may include: ▪ Check pump house and fuel store structures for defects and repair as required. ▪ Sweep and clean pump house; ▪ Read and record current to pump; ▪ Read and record voltage to pump; ▪ Read and record electricity meter reading (daily); ▪ Read and record water meter readings (daily); ▪ If no meter, measure discharge from borehole using either a bucket and stopwatch or recording the time to fill the storage tank (remember to close all outlets to the tank); ▪ Calculate the power production ratio on a monthly basis (m^3/Kw-hr). This is the water quantity produced by one KW-Hr. A reduction in the ratio indicates that the pump is not working efficiently or there is increasing resistance in the rising main; Use the format in Annex for practical demonstration; ▪ Once per year, take a 2 litre water sample (use a clean drinking water bottle) and send for chemical analysis. Changes to the water quality can provide early indication of borehole or aquifer problems;
2.7 Step 3: Trouble Shooting	Discuss the potential unexpected problems and what might be the cause and solution. In general, all remedial action should be taken by skilled and qualified staff. Use Table 2-2 below the solution for different causes of problems. **Table 2-2: Borehole Troubleshooting**

Problem	Probable cause	Possible solution
Pump fails to start	▪ Broken or loose electric connection ▪ Blown fuse- check the installation before replacing fuses ▪ Motor overload ▪ Low voltage ▪ Damaged supply cable insulation- check insulation resistance ▪ Cable- cable joint or motor windings may be wet or earthed ▪ Impeller plugged (Pump blocked with sand)	▪ Check power source ▪ Check switches ▪ Check fuses ▪ Call for Technical Assistance
No water from borehole	▪ No power to pump ▪ Pump is faulty and not working ▪ Pump not submerged (pump set too high or water level has fallen) ▪ Pump rotating in the wrong direction ▪ Leak(s) in riser pipe joints or corroded pipe ▪ Riser pipe joint threads corroded and disconnected ▪ Non-return valve in pump blocked or corroded ▪ Valves or discharge line blocked, damaged or not full open ▪ Worn pump due to pumping sand or other particles ▪ Strainer or impellers blocked with sand or chemical deposits ▪ Blocked or damaged borehole screen ▪ Pumping head too high for pump	▪ Check power source. Check switches ▪ Check fuses ▪ Check depth of water in borehole ▪ Call for Technical Assistance
Pump turns on and off frequently	▪ Excessive drawdown. ▪ Capacity of pump exceeds borehole yield so water level drops below level of pump	Call Technical Assistance to investigate in detail. This may require test pumping, monitoring water level in borehole, changing pump, or lowering pump in

			borehole
	Pump overload switch trips out	▪ Current overload/motor temperature sensor- possible causes: blockage, insufficient flow of water over motor, overload due to mechanical problems, low voltage ▪ Under-voltage- Low voltage on supply system ▪ Incorrect oil level in dashpot operated overloads ▪ Low-level cut-out – excessive drawdown ▪ Incorrectly set overloads- check settings.	Call Technical Assistance
	Borehole delivering less water than expected	▪ Screens are blocked Leaks in riser pipe	Call Technical Assistance to determine whether plunging borehole will result in improved yield. Remove riser pipe and repair/replace
	Persistent case of sediments in borehole water (i.e. not immediately after borehole development)	▪ Sediments are passing through the screens	Depending on the nature of the sediments, the sediments may be damaging to the pump. Check water quality
	Water quality is too saline	▪ Water in the aquifer is saline	This is a feature of the aquifer and only surface treatment of the water (through reverse osmosis) can be used to make water potable
2.8 Step - 4: Spares, Tools, & Technical Assistance	▪ See Modules related to pumps, tanks, pipelines and public water points. Technical Assistance – technical assistance should be sought from a hydro-geologist (available hydro-geologists at Zone or Region Water Bureau) in the event of down borehole problems. A specialised or electrician is required for generator or electric problems and a specialised mechanic is required for problems with the motor/engine to the generator. Borehole rehabilitation requires high skill personnel at Regional and Zones. The O&M for borehole rehabilitation is found in the main manual.		
Review Question	▪ What is a borehole or deep well?		

- What does the borehole requires for rehabilitation do?
- What is a submersible pump? How it works?

Attachments

Attachment 2-1: Typical Component of Borehole

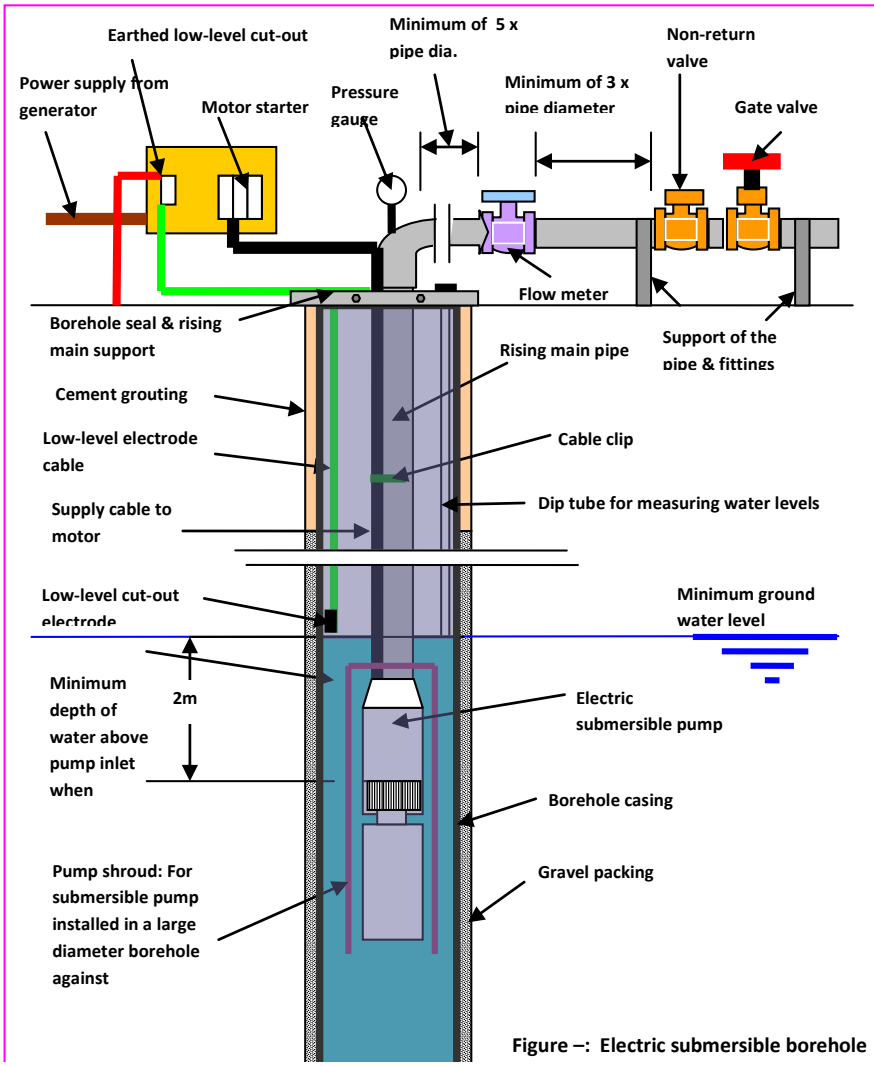
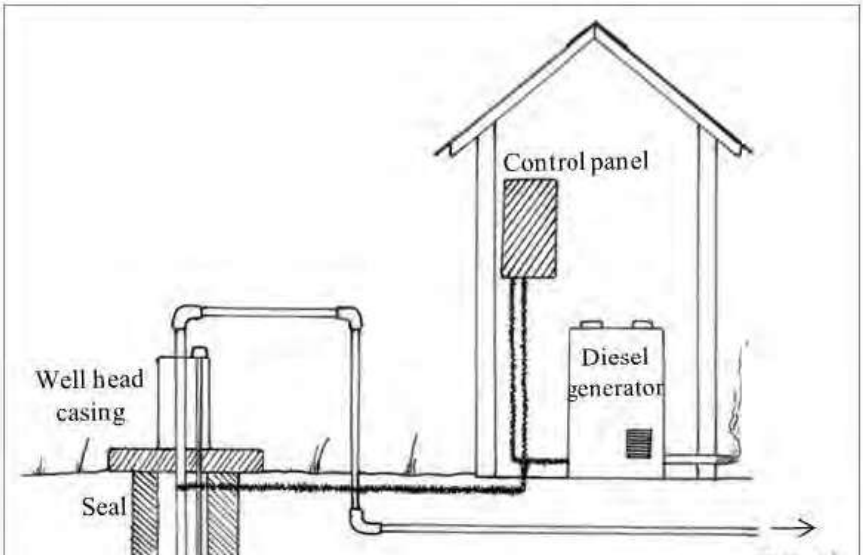
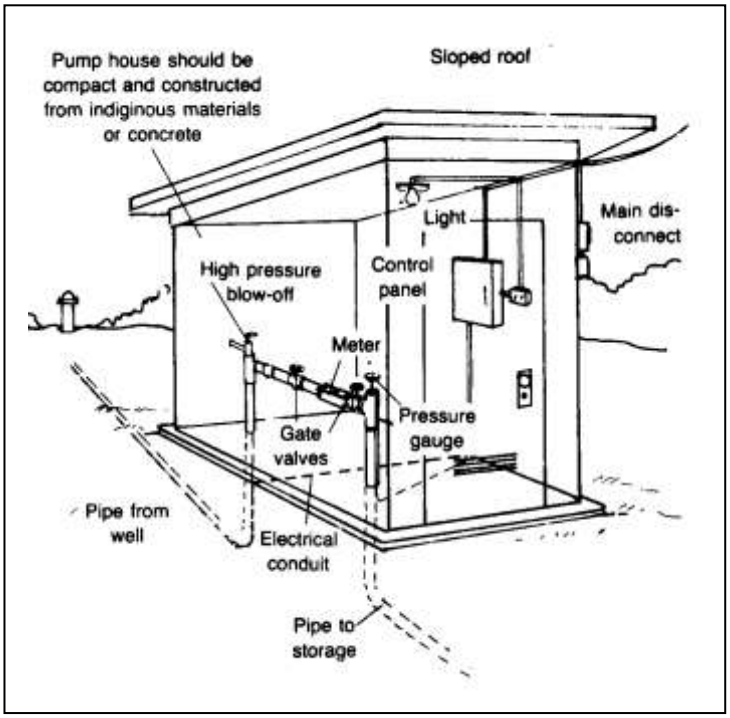


Figure –: Electric submersible borehole

Attachment 2-2: Typical Borehole Water Supply System





Typical Submersible Pump

3 SESSION – C: TECHNICAL O&M REQUIREMENTS AT INTAKES

MODULE – C	TECHNICAL O&M MANAGEMENT REQUIREMENTS FOR RURAL PIPED SYSTEM
3.1 Session – B2	**O&M Requirements for Intakes**
3.2 Session Outline	This session cover the following core topics: ▪ Introduction to different water source intakes ▪ Identification of different intake systems ▪ Specific O&M Tasks for Intakes ▪ Troubleshooting for different Intakes ▪ Preventive Maintenance Checklist ▪ Spare parts, Tools and Technical Assistance Requirements
Appropriate Facilitator background	Technician familiar with the maintenance tasks associated with intakes
3.3 Objectives	At the end of the session, the participants will be able to: ▪ Identify the main components of an intake ▪ Describe the functions of the key components ▪ Carry out intake maintenance
Output	An O & M Schedule
Timing	Session should take approximately 4 hours excluding the site walk
Target group	Maintenance staff, operator and caretaker of the WASH committee members
Appropriate Venue	At the water supply intake
Methodology	This is intended to be a PRACTICAL session. The components will be taught by demonstration on the system itself. The PowerPoint presentation or flip chart can be used to illustrate details if necessary. Reinforce the learning by allowing participants to handle components and describe their functions to each other.
Materials	▪ Valve key/wheel ▪ pipe wrench ▪ Tools – shovel, rake ▪ Facilitator's and Participant's Manuals ▪ Flipchart, markers, flipchart stand and masking tape ▪ Computer, LCD Projector

Session Guide and Contents

3.4 Introduction

This session covers intakes in general. There are many kinds of intakes and the facilitator should keep the discussion focused on the intake of the water supply system in question. Different kinds of intakes include:

- River intakes
- Spring intakes
- Lake intake
- Infiltration gallery

3.5 Step –1: System Identification

1. Catchment Area Maintenance

Discuss why vegetation is important to the catchment area:

- Vegetation holds soil in place and so reduces erosion/siltation
- Vegetation slows down runoff and helps water to soak into soil

Inspect the catchment area for signs of harmful activities (charcoal burning, over-grazing, de-forestation, etc). Refer Water Safety Plan Manual for detail.

- Discuss how the catchment area could be improved;
- Discuss which other institutions should be alerted in regard to catchment degradation and lobbied for collective action.

Note: Water point that rely on a catchment that extends beyond the boundary of the community will need to recognise that catchment conservation activities require a multi-stakeholder approach and should link up or form a Zonal or Woreda offices to develop a platform for collective action on catchment conservation.

2. Intake Components

Table 2-1 below explains the components of intake and the Facilitator explain to the participants the function of each component.

Table 3-1: Typical Intake Components

Component	Function
Catchment Area	Surface area where water flows towards the source
Source	Where the water originates – e.g. spring, river
Intake	The structure to abstract the water from the source
Intake chamber	Collects water from the source
Valve chamber	Protects the control valve
Weir (river intake)	Wall that regulates the level of the river
Infiltration	Perforated pipe and filter material that enables water

gallery	to enter pipe and be channelled to the sump
Sump	Collection chamber from which water is drawn
Screen/ strainer	Sieves objects entering the pipeline
Washout	Pipe and valve that is opened to allow cleaning of the chamber
Perimeter Fence	Boundary to stop livestock & children from entering source area
Compensation pipe	Pipe at the bottom of the intake weir to allow for downstream flow regardless of level of water above weir

Refer attachment for explaining the components of different type of intakes.

3.6 Step – 2: Intake Specific O & M tasks

Discuss the tasks relevant to the operations and maintenance of the system components. These may include:

- Patrol catchment area for damage/harmful activities;
- Report catchment degradation to Woreda Water Office;
- Patrol perimeter fence and repair;
- Clear weir wall and screens of any debris;
- Check walls or supports for any damage, undercutting, bypassing and repair;
- Any gate or sluice should be examined every month to ensure that they are in working order.
- After flood flows the banks and bed of the river adjacent to the intakes should be examined for signs of erosion. Any scouring or erosion should be repaired immediately.
- Open washout on weir wall and remove accumulated silt;
- Open washouts to clear out silt from chambers;
- Clear screen of any material and replace if damaged;
- Disinfect spring box if someone has entered;
- Read master meter.

3.6.1 Spring Intake

3.6.1.1 Components of Spring Chamber

In most cases the water sources for water supply for rural community is spring, so that the facilitator first explains the various component of the spring chamber as described in Figure 3.1 and 3.2.

Figure 3-1: Schematic Section of Spring Development with Spring Box

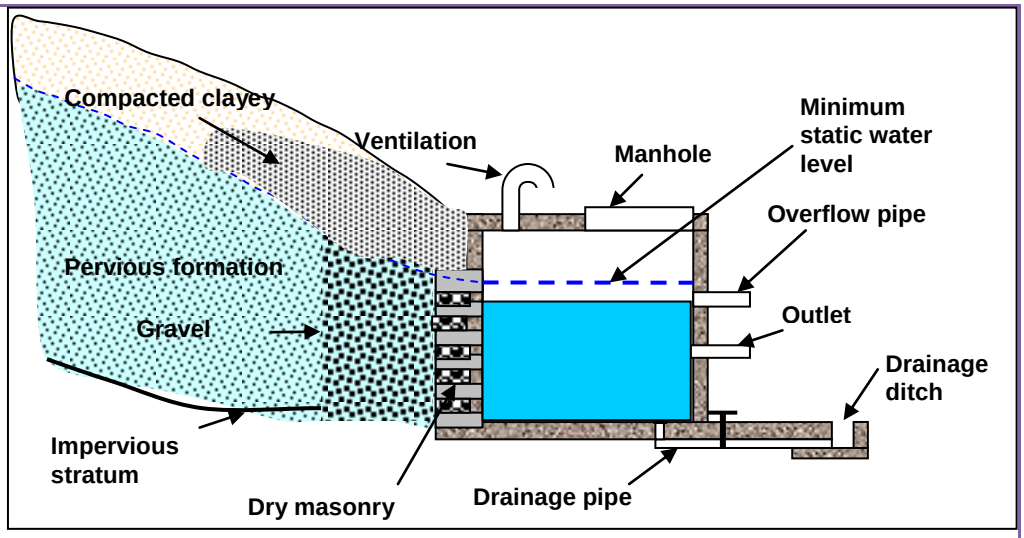
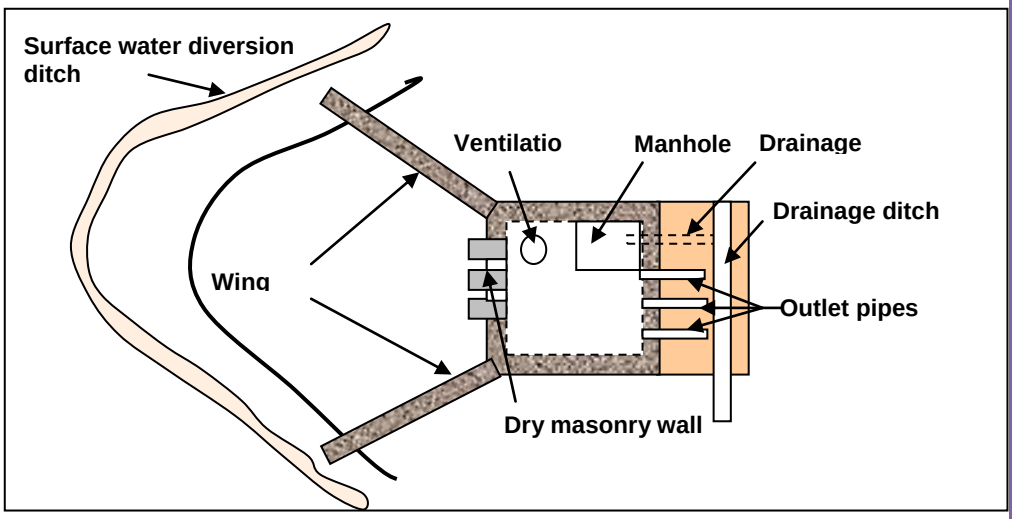


Figure 3-2: Schematic Plan of Spring Development with Spring Box



3.6.1.2 O&M Task at Spring Chamber

The following tasks are needed to be carried out as routine activities by WASHCO or Water Administration to use the spring for long time without depleting and contaminating.

- The spring should be protected from surface water pollution by constructing a deep diverting ditch,
- The spring and collecting basin should have a water tight top, preferably concrete,
- Access and inspection manholes, when provided, should be tightly fitted and kept locked,
- Drainage ditches intended to keep surface water away from the spring should always be clear,
- When there is a distinctive wet and dry season the ditches should be cleared of any rubbish or vegetation before the first rains are due. Any overflow channel should also be cleared eliminate to the possibility of water backing-up.
- The collecting chamber should be inspected at least once a month to check whether cleaning is necessary. Depending upon the origin of the spring and the collecting chamber constriction it will be necessary to empty and clean out the chamber at regular intervals. The walls

should then be scrubbed down with a solution of bleaching powder giving chlorine strength of at least 50 ppm,

- A vegetation should be kept clear of the spring,
- Stock should be kept at a distance by means of a fence or wall. The fence and the wall shall be kept in good repair,
- Periodic bacteriological examination should be conducted and the water disinfected,
- Water should be withdrawn only through a pipe by natural flow or by pumping; dipping or bailing should be prevented.

Routine Inspection to be carried out:

- Check the general condition. Are there cracks in the concrete or signs of leaks?
- Is there wet ground around the spring box? This may indicate a leak.
- Is water flowing out of the overflow pipe? If so this may indicate a blocked outlet pipe.
- Is there stagnant water around the spring box? If so proper drainage must be provided,
- Is the spring box having algae? If so clean and disinfect the spring box
- Is the spring box properly protected from external pollutants? If so properly protect the spring box.
- Open the manhole cover and look inside. Does it look clean and in good condition? Is there anything in there such as leaves, sticks or other vegetation?

The Facilitator should summarize the O&M tasks schedule, materials and equipment requires as indicated in Table 3-2.

Table 3-2: Summary of O&M Tasks for Spring Protection

Activity	How Often	Who by	Materials & Spare Parts	Tools & Equipment
Clean Spring surroundings	Weekly	Community		Broom, bucket, hoe, machete
Repair fence and clean surface drains	Monthly	Caretakers & Community (as necessary)	Wood, rope, wire	Machete, axe, knife, hoe, spade, pickaxe
Repair pipes and taps	As needed	Water Supply Service Office/Caretaker	Spare pipes, valves, joints, taps, washers, cement, sand, gravel	Bucket, trowel, spanner (wrench), flat spanners
Check water quantity	Monthly	Water Supply Service Office		Bucket, watch
Check water turbidity	After each heavy rain or flood	Water Supply Service Office/Caretaker		

Check water quality	Annually or after repair	Zone &/or Woreda	Laboratory supplies	Laboratory
Wash and disinfect spring	Annually or after repair	Water Supply Service Office/Caretaker	Chlorine	Bucket, wrench, brush
Repair faucets	When the need arises	Water Supply Service Office/Caretaker	Spare faucet and thread.	Wrench
Repair cracks	When the need arises	Water Supply Service Office/Caretaker	Cement, sand gravel	Bucket, trowel, hoe, spade, wheel barrow

3.6.1.3 Troubleshooting for Spring Intake

Explain the causes and the solution for unexpected problem at spring intakes as presented in Table 3.3.

Table 3-3: Troubleshooting for Spring Intake

No.	Problem	Probable Cause	Possible Solution
1	Leaking gate valve	Worn out valve	Replace stuffing box packing in gate valve or replace entire valve
2	No/ little water flowing into intake chamber	Inlet pipe blocked	Inspect source and unblock pipe
3	Overflow from intake chamber	▪ Gate valve blocked Blockage in pipeline (e.g. airlock) ▪ Damaged strainer Clogged strainer	▪ Remove and clear valve (replace if necessary) ▪ Check/open nearest air ▪ Valve Replace strainer ▪ Clean strainer
4	Dirty water	Silt in chamber	Clean out chamber

3.6.2 River and Lake Intakes

The facilitator should first describe the various river intake components as presented in Table 3-1 above.

3.6.2.1 Troubleshooting for River Intake

Table 3.4 present the problems, potential causes and solutions for the river intake with weir wall or sump. The facilitator explains the troubleshooting using Table 3.4 below.

Table 3-4: Troubleshooting for River Intake with Weir or Sump

No.	Problem	Probable Cause	Possible Solution
1	No/ little water flowing into intake chamber or sump	Screens on inlet chamber clogged	Clean screens
2	Erosion around side of weir wall	Insufficient height of wing and cut off walls	Construct or raise wing and cut off walls to

		to prevent flow around the weir	prevent flow around weir
3	Undercutting of weir wall on downstream toe or undercutting of sump	Excessively turbulent flow over weir wall and insufficient width of downstream apron	Provide protected apron (Concrete, grouted rip rap, etc) at toe of weir wall or around base of sump.
4	Dirty water	▪ Excessive sediments upstream of weir wall ▪ Silt in intake chamber or sump	▪ Clean out sediments from area immediately ▪ upstream of weir ▪ Clean out chamber Protect catchment from severe erosion.

3.6.3 Impounding Reservoirs

A dam impounding water is another type of source where operational staff can also undertake the activities, which is strictly maintenance type of work.

All matter likely to affect the quality of the water should be cleared form the reservoir site, particularly vegetation that on decay might cause unpleasant tastes and odours in the water.

The catchments area should be kept free from cattle and should be guarded also against trespassers who might cause any pollution.

Discuss the components of embankment dam.

Table 3-5: Components of Impounding Reservoir

No.	Items	Purposes
1	Catchment Area	Area above the source where rain falls and the runoff comes from
2	Source	Where water is taken from, e.g. river or stream
3	Inlet channel	A channel that conveys water from the source and puts it into the dam
4	Pan Embankment	Wall of excavated material
5	Dam Embankment	Wall that is built and compacted to hold the water
6	Storage area	The volume that is filled with water
7	Spillway sill	Wall in the spillway to control top water level
8	Spillway channel	Channel to safely discharge excess water to water course or away from the dam/pan

9	Outlet/draw-off	Pipe-work to take water out of the dam
10	Perimeter fence	Constructed to prevent livestock, wild animals and children from entering the dam/pan area and contaminating the water

3.6.3.1 Catchment Area Maintenance

Where does the silt come from? Which part of the catchment contributes the most silt and why? Are soil erosion features (e.g. gullies), exposed roots of bushes and trees, etc) visible?

Inspect the catchment area for signs of harmful activities (charcoal burning, over-grazing etc). The catchment area could be improved through proper watershed management such as terracing, check dam, gabion, a forestation, etc activities over the catchment area. Such issues well discussed in Water Supply Safety Plan of the point source manual.

3.6.3.2 O&M tasks for Catchment area

- Patrol perimeter fence and repair,
- Clear bush from and repair inlet channel (an eroded inlet channel can become the main watercourse),
- Inspect and de-silt silt trap(s) and inlet channels
- De-silt pan before top water level reaches embankment (Note: inlet channel needs to be blocked during de-silting)
- Clear bush from spillway
- Check spillway sill for damage and repair as necessary
- Check spillway channel for signs of erosion and take steps to prevent erosion by improving grass cover, stone pitching, spreading flow in the channel by building horizontal sill(s)
- Check dam embankment for cracks and erosion and repair
- Check dam embankment for tree or bush growth and remove, improve grass cover on embankment
- Check downstream side and toe of dam wall for leaks.
- Open and close all outlet valves once a month
- Monitor leakage from dam
- Check for rodents nesting in embankment and remove
- Read meter to monitor abstraction from dam
- Read staff gauge to establish water level.

3.6.3.3 Trouble shooting for Impounding Reservoir

The following are potential unexpected problems and what might be the cause and solutions for impounding reservoir.

Table 3-6: Trouble Shooting for Impounding Reservoir

No.	Problem	Probable cause	Possible solution
1	Leakage along toe of dam wall	Poor design and construction	Monitor leakage
2	Water does not last long	Reservoir area has accumulated a	Remove silt from reservoir area Reduce erosion in

	after end of rains	significant amount of silt, Erosion of catchment area, Excessive seepage due to pervious soil in reservoir area	catchment area. Apply and mix in clay, preferably bentonite clay to impoundment area
3	No water from outlet	Outlet pipe blocked	Clear blockage at mouth of draw off pipe. ; Protect pipe by placing ballast surround to mouth of draw off pipe; Note a blocked pipe through a dam can be very difficult to unblock. Do NOT remove the pipe
4	Polluted water	Livestock in dam/pan Contamination from catchment area	Fence pan/dam Control access; discourage open defecation in the catchment
5	Excessive weed growth	High nutrient concentration in water	Address source of nutrients, possibly by controlling access to dam/pan or catchment area by livestock

3.7 Preventive Maintenance Checklist

The following PM checklists are based on the information obtained from the existing manufacturer's operation and maintenance manuals. It provides instructions for inspecting, cleaning, lubricating and adjusting equipment used in different water supply systems.

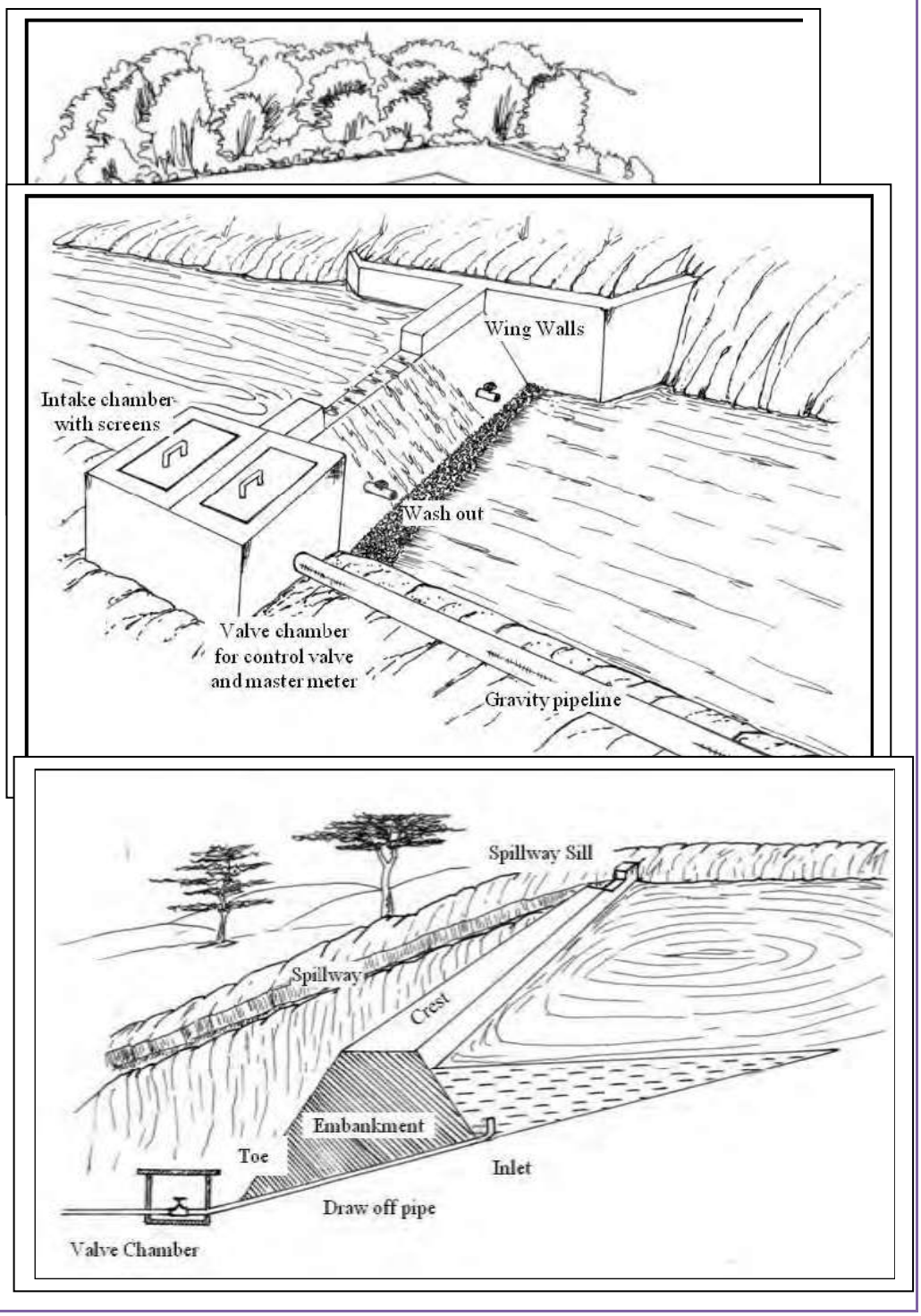
Table 3-7: Preventive Maintenance Checklist for Water Sources Facilities

No.	PM Checklists	D	W	M	Q	S	A
1	**Boreholes**						
1.1	Record time and rate of pumping						●
1.2	Measure water levels and draw down and keep record			●			
1.3	Take water samples for chemical analysis				●		
1.4	Make sure that concrete apron around the well is water tight. Make the necessary minor repairs.				●		
1.5	Clean well, screen and gravel packing, when required (by qualified personnel only)						●
1.6	Keep a running tabulation of pumping	●					
1.7	Test yield of borehole						●
2	**Springs**						
2.1	Inspect sanitation conditions		●				

2.2	Check concrete structure for cracks		●				
2.3	Check the manhole cover is well secured and tight		●				
2.4	Check concrete structure and steel parts repair if required					●	
2.5	Clean sediment and disinfect spring box					●	
2.6	Check that spring is suitably protected from surface water pollution				●		
2.7	Take water samples for analysis						●
3	**Lake and River Intakes**						
3.1	Check the Water Quantity and Quality Regularly	●					
3.2	Check the depth of the Lake and estimate the amount of silt flowing in			●			
3.3	Examine intake opening and screen, cleam vegetation and remove silt, leaves and debris			●			
4	**Dams and Impounding Reservoirs**						
4.1	Inspect spill way clean as necessary		●				
4.2	Inspect concrete and masonry dam for leakage and make repairs			●			
4.3	Inspect slopes and repair and erosion				●		
4.4	Inspect water shed and clean as necessary				●		
4.5	Inspect for algae and aquatic weeds and take measures as necessary					●	
4.6	Inspect sediment flowing into the water storage and take necessary measures				●		
4.7	Take water samples and send for analysis				●		
4.8	Inspect fences, and repair					●	

Attachment

Attachment 3-1: Typical Spring Intake



Workout exercises how to record the condition of spring chamber on monthly check sheet.

Monthly Check sheet for spring Type-1

Site Name:	Technician/Plumber Name

Date	Facility	Work Condition			Crack Yes/No	Leak/Broken Yes/No	Wet Ground Yes/No	Clean in/outside Yes/No	Drainage Ok Yes/No	Overflow Ok Yes/No	Pipe Ok Yes/No	Valve Ok Yes/No	Remark
		Check	In case of "Non-Functioning										
			When Stop	When Repair									
	Spring Box	Functioning/ Non---functioning											
	Tap	Functioning/ Non---functioning											
	Spring Box	Functioning/ Non---functioning											
	Tap	Functioning/ Non---functioning											
	Spring Box	Functioning/ Non---functioning											
	Tap	Functioning/ Non---functioning											
	Spring Box	Functioning/ Non---functioning											
	Tap	Functioning/ Non---functioning											

Monthly Check sheet for spring Type-2

Site Name:	Technician/Plumber Name

Date	Facility	Work Condition			Crack Yes/No	Leak/Broken Yes/No	Wet Ground Yes/No	Clean in/outside Yes/No	Drainage Ok Yes/No	Overflow Ok Yes/No	Pipe Ok Yes/No	Valve Ok Yes/No	Remark
		Check	In case of “Non-Functioning										
			When Stop	When Repair									
	Spring Box	Functioning/Non---											
	Tapstand-No.1	Functioning/Non---											
	Tapstand-No.2	Functioning/Non---											
	Spring Box	Functioning/Non---											
	Tapstand-No.1	Functioning/Non---											
	Tapstand-No.2	Functioning/Non---											
	Spring Box	Functioning/Non---											
	Tapstand-No.1	Functioning/Non---											
	Tapstand-No.2	Functioning/Non---											

Daily Water Production Record

Month: _____ Name of Operator: _____

Year: _____ Borehole/Spring No. _____

Day	Meter reading		Water Production (m3/day)	Day	Meter reading		Water Production (m3/day)
	Start	End			Start	End	
1				16			
2				17			
3				18			
4				19			
5				20			
6				21			
7				22			
8				23			
9				24			
10				25			
11				26			
12				27			
13				28			
14				29			
15				30			
Total Water Production (m^3/month)							

Checked by: _____

Signature: _____

Date: _____

Daily Water Distribution Record

Month: _____ Name of Operator: _____

Year: _____ Reservoir Name: _____

This data measured at the outlet of the reservoir

Day	Meter reading		Water Distributed (m3/day)	Day	Meter reading		Water Distributed (m3/day)
	Start	End			Start	End	
1				16			
2				17			
3				18			
4				19			
5				20			
6				21			
7				22			
8				23			
9				24			
10				25			
11				26			
12				27			
13				28			
14				29			
15				30			
Total Water Distributed (m^3/month)							

Checked by: _____

Signature: _____

Date: _____

4 SESSION – D: O&M REQUIRMENT FOR ELECTRO – MECHANICAL EQUIPMENT

MODULE – C	TECHNICAL OPERATION AND MAINTENANCE REQUIREMENTS FOR RURAL PIPED SYSTEM
4.1 Session Outline	This session covers the following core topics: ▪ Introduction to Electro-mechanical Equipment ▪ Identification of different components at pumping station ▪ Defining some important terms ▪ Types of Pumps and Generators ▪ Brands of Pumps and Generators exist in Ethiopia ▪ Important consideration in operation of E-M Equipment ▪ Preventative Maintenance requirements for E-M Equipment ▪ O&M tasks for driving Equipment ▪ Facilities required for maintenance and repair works ▪ Troubleshooting for E-M Equipment ▪ Safety Rule
Appropriate Facilitator	Appropriate trainer for this session shall be Electro-mechanical Engineer with a very good theoretical and practical background and experience.
4.2 Objective	At the end of this session training participants will be able to: ▪ Understand different components of pumping station and equipment; ▪ Acquire knowledge on pump operation and maintenance as well as preventive maintenance ▪ Understand different type of pumps ▪ Identify the roll of pump and generator
Outputs	Familiarization with those instruments and equipment
Timing	Approximately 32 hours
Target Group	Mechanics and Technicians
Methodology	▪ Observation of components ▪ Conducting practical training ▪ Group work ▪ Short presentations/question and answer
Materials	▪ Manuals ▪ Practical demonstration of components;

	▪ Flip Charts and marker pens; ▪ Dented parts etc
Session Guide and Contents	
4.3 Introduction	Pumping equipment and pumping station are very important components in water supply system. Pumping machinery is subjected to wear, tear, erosion and corrosion due to their nature of functioning and therefore is vulnerable for failures. Generally, more number of failures or interruptions in water supply is attributed to pumping equipment than any other component. Therefore, correct operation and timely maintenance and upkeep of pumping stations and pumping machinery are of vital importance to ensure uninterrupted water supply. Sudden failures can be avoided by timely inspection, follow up actions on observations of inspection and planned periodical maintenance. Downtime can be reduced by maintaining inventory of fast moving spare parts. Efficiency of pumping machinery reduces due to normal wear and tear. Timely action for restoration of efficiency can keep energy bill within reasonable optimum limit. Proper record keeping is also very important. Obviously due attention needs to be paid to all such aspects for efficient and reliable functioning of pumping machinery. This session discusses procedures for operation and maintenance and addresses pertinent issues involved in O&M of pumping equipment. This part of the manual deals with the operation and maintenance requirements for pumping equipment, driving equipment, pumping station and ancillary equipment.
4.4 Component in Pumping Station	Components in pumping station are divided in to three groups: 1) Pumping Equipment, 2) Ancillary Equipment and 3) Pumping station. The Facilitator explains these three component as: **4.4.1 Pumping Equipment** These are: ▪ Pumps and other mechanical equipment, i.e. valves, pipe work, vacuum pumps ▪ Motors, switchgears, cable, transformer and other electrical accessories. **When do use pumps?** i) When water must be raised from one level to another, ii) When the pressure in the main must be increased, iii) When the elevation of the source is such that water will not flow by gravity into the tank. **4.4.2 Ancillary Equipment** These are equipment to use for installation, dismantling, flow control and generation etc. ▪ Lifting equipment, ▪ Water hammer control device, ▪ Flow meter,

- Diesel generating set,

4.4.3 Pumping Station

- Sump/intake/well/borehole,
- Pump house,
- Screen,
- Gate/Valve

4.5 Definition

The facilitator explains important definition of pump terms as:

No.	Term	Definition
1	Submersible Pump	For deep-well applications, centrifugal pumps are housed with the electric engine in a single unit that is designed to be submerged. Usually, a multiple-stage pump is used. The multiple-stage pump is placed above a motor and under a check valve that leads to the rising main.
2	Horizontal Centrifugal Pumps	Horizontal Centrifugal pumps are that the pump is drive by a horizontal shaft and commonly used for low and high service to lift and transport water. The two essential parts of a centrifugal pump are rotating membrane with vanes and the impeller and surrounding case.
3	Horizontal Centrifugal Pumps	All the definitions used above for horizontal centrifugal pumps are relevant to pumps operating vertically. The pump is driven by a vertical shaft, which is usually coupled, to a driving unit above floor level. Pumps commonly used in such installations are: ▪ Vertical enclosed- shaft pump ▪ Vertical opened-shaft pump The suction pipe is usually connected to a wet well (wet pit) structure, which means that the location of the pump is almost lower than wet well water level and suction pressure is positive.
4	Booster Pump	Booster pumps are pumps which take water from a supply main and discharge it at a higher pressure to another point in the same pipeline, and are also used to increase pipeline pressure in outlying areas when loss of head is too great along the line. They may operate in conjunction with filling of elevated storage tanks. For a very long pipeline or for large elevation difference between the entry and exit points,

			the pumping head is excessive and pipes withstanding such a high pressure may not be available, or the provision of high-pressure pipes may be uneconomical. In such a case, instead of providing a single pumping station, it is desirable to provide a number of pumping stations.

4.6 Types of Pump

Explain the types of pumps used for water supply system with practical demonstration including their difference and similarity.

The types of the pumps mainly are:

1. Centrifugal pumps
2. Vertical turbine pumps
   - Oil lubricated
   - Self water (pumped water) lubricated
   - Clear water lubricated
3. Submersible pumps
   - Vertical borewell type pump-motor set
   - Monobloc open well type pump-motor set
4. Jet pumps
5. Reciprocating pumps

Submersible Pumps

Surface water pumps mainly consist of:

(i) Horizontal centrifugal pumps

(ii) Vertical centrifugal pumps

(iii) Vertical submersible motor pumps

4.6.1 Potential Problems

4.6.1.1 Submersible Pumps

The facilitator explains the potential problems that could be happen at submersible pump. Identifying the problems helps to indicate the solution

1. sand or other particles may enter the pump and cause abrasion damage,
2. the rising main may corrode due to poor water quality,
3. the pipeline system can be damaged by the severe pressure surges that result when the pump is started or stopped abruptly,
4. The main limitations of a submersible centrifugal pump are its price, the need to maintain a reliable supply of electricity or fuel, and the high level of technology involved.

4.7 Brands of Pumps and Generators

The training facilitator should brief the available brands of pumps and Generators mostly used for water supply system in Ethiopia.

under operation in Ethiopia

4.7.1 Submersible Pumps

The following submersible brand pumps are available in the Country. Each of these pumps has merit and demerit based on the specification. Discuss with the participants.

Lowara	**CMS**	**Frankline**
Grundfos	Stac	TATA
Caprari	Pleuger	

4.7.2 Surface Pumps

The following surface pumps are existing in Ethiopia which are used by many water utilities.

KSB	Cimonath	Hydraulic Ram
Caprari	CMS	TATA
Rovatti		

4.7.3 Engine and Alternators (generators)

The following generators brands are existing in Ethiopia which is used by many water utilities.

Engine	**Alternator**
Lister	Lister
Deutz	Mecc alte
Sun	Marelli
Lombardini	Linz
Daewoo	
Johndeer	
Perkins	
Fiat	
Sleunz	
Kelesker	

4.8 Important Points in Pump Operation

The training facilitator should describe to the trainee operators very important points to be considered during the operation of pump to minimize risk and breakdown. Explain using the graph for pump characteristic curve.

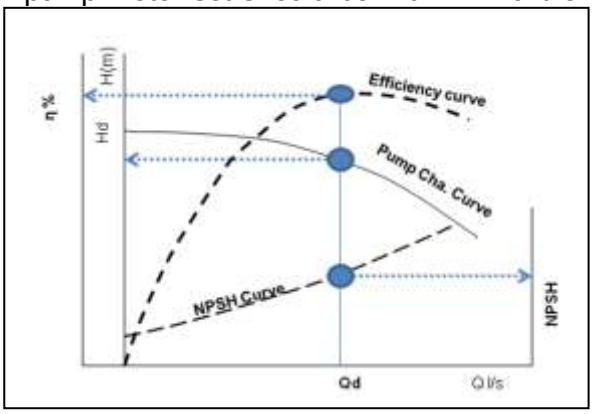
a) Dry running of the pumps should be avoided,

b) Centrifugal pumps have to be primed before starting,

c) Pumps should be operated only within the recommended range on the head-discharge characteristics of the pump,

- If pump is operated at point away from duty point, the pump efficiency normally reduces.
- Operation near the shut off should be avoided, as the operation near the shut off causes substantial recirculation within the pump, resulting in overheating of water in the casing and consequently, in overheating of the pump.

d) Voltage during operation of pump-motor set should be within + 10% of rated voltage. Similarly current should be below the rated current as per name plate on the motor.



e) Whether the delivery valve should be opened or closed at the time of starting should be decided by examining shape of the power-discharge characteristic of the pump.

Pump of low and medium specific speeds draw lesser power at shut off head and power required increases from shut off to normal operating point. Hence in order to reduce starting load on motor, a pump of low or medium specific speed is started against closed delivery valve.

Normally the pumps used in water supply schemes are of low and medium specific speeds. Hence, such pumps need to be started against closed delivery valve.

The pumps of high specific speed draw more power at shut off. Such pumps should be started with the delivery valve open.

f) The delivery valve should be operated gradually to avoid sudden change in flow velocity which can cause water hammer pressures.

It is also necessary to control opening of delivery valve during pipeline - filling period so that the head on the pump is within its operating range to avoid operation on low head and consequent overloading. This is particularly important during charging of the pumping main initially or after shutdown. As head increases the valve shall be gradually opened.

g) When the pumps are to be **operated in parallel**, the pumps should be started and stopped with a time lag between two pumps to restrict change of flow velocity to minimum and to restrict the dip in voltage in incoming feeder. The time lag should be adequate to allow to stabilize the head on the pump, as indicated by a pressure gauge.

h) When the pumps are to be **operated in series**, they should be started and stopped sequentially, but with minimum time lag. Any pump, next in sequence should be started immediately after the delivery valve of the previous pump is even partly opened.

Due care should be taken to keep the air vent of the pump next in sequence open, before starting that pump.

i) The stuffing box should let a drip of leakage to ensure that no air is passing into the pump and that the packing is getting adequate water for cooling and lubrication. When the stuffing box is grease sealed, adequate refill of the grease should be maintained.

j) The running of the duty pumps and the standby should be scheduled so that no pump remains idle for long period and all pumps are in ready-to run condition. Similarly unequal running should be ensured so that all pumps do not wear equally and become due for overhaul simultaneously.

k) If any undue vibration or noise is noticed, the pump should be stopped immediately and cause for vibration or noise be checked and rectified.

l) Bypass valves of all reflux valve, sluice valve and butterfly valve shall be kept in closed position during normal operation of the pumps.

Frequent starting and stopping should be avoided as each start causes overloading of motor, starter, contactor and contacts. Though overloading lasts for a few seconds, it reduces life of the equipment.

4.8.1 Inspection before starting up of pumps

The facilitator expalin what checks should be carried out before staring up the pumps by the operators in regular manner.

Box 4-1: Things to be checked when staring the pump operation

Following points should be checked before starting the pump.

- Power is available in all 3 phases,
- Trip circuit for relays is in healthy state
- Check voltage in all 3 phases,
- The voltage in all phases should be almost same and within + 10% of rated voltage, as per permissible voltage variation,
- Check functioning of lubrication system specifically for oil lubricated and clear water lubricated VT pumps and oil lubricated bearings,
- Check stuffing box to ensure that it is packed properly,
- Check and ensure that the pump is free to rotate,
- Check over current setting if the pump is not operated for a week or longer period,
- Before starting it shall be ensured that the water level in the sump/intake is above low water level and inflow from the source or preceding pumping station is adequate.

4.8.2 Inspection REQUIREMENTS during staring and Operation of Pumps

The operators should inspect the pumps during starting and operation in regular manner.

The following procedures shall be explained to the trainees for starting and operation of different types of pumps are described below:

4.8.2.1 Centrifugal Pump (low and medium specific speed)

i) To start a centrifugal pump, the suction pipes and the pump should be fully primed irrespective of the fact whether the pump is with positive (flooded) suction or suction lift.

- The centrifugal pump with positive suction can be primed by opening valve on suction side and letting out air from the casing by opening air vent.
- Centrifugal pump on suction lift necessitates close attention to prime the pump fully.
  - To achieve this, the suction pipe and the pump casing must be filled with water and entire air in suction piping and the pump must be removed. If vacuum pump is provided, the pump can be primed by operating vacuum pump till steady stream of water is let out from delivery of vacuum pump. In absence of vacuum pump, priming can be done by pouring water in casing and evacuating air through air vent or by admitting water from pumping main by opening bypass of reflux valve and delivery valve. Check all joints in the suction pipe and fittings.

ii) Close the delivery valve and then loosen slightly.

iii) Switch on the motor, check that direction of rotation is correct. If the pump does not rotate, it should be switched off immediately.

iv) Check vacuum gauge, if the pump operates on suction lift. If the pointer on gauge gradually rises and becomes steady the priming is proper.

v) Pressure gauge should be observed after starting the pump. If the pump is working correctly, the delivery pressure gauge should rise steadily to shut off head.

vi) When the motor attains steady speed and pressure gauge becomes steady, the delivery valve should be gradually opened in steps to ensure that the head does not drop below recommended limit. (In the absence of recommendations, the limit shall be about 85% of duty head for centrifugal pump).

vii) Check that ammeter reading is less than rated motor current.

viii) Check for undue vibration and noise.

ix) When in operation for about 10-15 minutes, check the bearing temperature, stuffing box packing, and leakage through mechanical seal and observe vibrations, if any.

x) Voltage should be checked every half an hour and should be within limit.

4.8.2.2 Vertical Turbine Pump (of low and medium specific speed)

i) Close delivery valve, and then loosen slightly.

ii) If pump is oil-lubricated, check the oil in the oil tank and open the cock to ensure that oil is flowing at the rate of 2-4 drops per minute.

- If the pump is self water-lubricated and length of column assembly is long (15m or above), external water shall be admitted to wet and lubricate the line shaft bearings before starting the pump.
- If the pump is external clear water lubricated, the clear water lubricating pump should be started before starting main pump.

iii) Open the air vent in discharge/delivery pipe.

iv) Switch on the motor and check correctness of direction of rotation. If the pump does not rotate, it should be switched off immediately.

v) Check that oil is flowing into the pump through the sight glass tube. The number of drops/min. should be as per manufacturer's recommendations (normally 2-4 drops/minute).

- For clear water lubricated pump, check that lubricating clear water is passing into the column assembly.

vi) Check pressure gauge reading to ensure that pump has built up the required shut off head.

vii) When the motor attains steady speed and pressure gauge becomes steady, the delivery valve should be gradually opened in steps to ensure that the head does not drop below recommended limit. (In absence of recommendation, the limit shall about 75% of duty head for VT & submersible pump).

viii) If steady water stream is let out through air vent, close the air vent.

ix) Check that ammeter reading is less than rated motor current.

x) Check for undue vibration and noise.

xi) When in operation for about 10-15 minutes, check bearing temperature, stuffing box packing and observe vibration if any.

xii) Voltage should be checked every half an hour and should be within limit.

4.8.2.3 Submersible Pumps

Starting of a submersible pump is similar to vertical turbine pump except that steps- ii, v, and xi are not applicable and since motor is not visible, correctness of direction of rotation is judged from pressure gauge reading which should indicate correct shut off head.

4.8.2.4 Jet Pump

The procedure for starting jet pumps is similar to centrifugal pump except that priming by vacuum pump is not possible. Priming needs to be done by filling the pump casing and suction line from external source or by pouring water.

4.8.2.5 Vacuum Pump

The procedure for starting vacuum pump is similar to centrifugal pump except that priming is not necessary and valves on both suction & delivery side of vacuum pump should be fully open.

4.8.2.6 Reciprocating Pump

The steps stipulated for centrifugal pump are equally applicable for reciprocating pump. However exceptions as follows are applicable.

- The pump should be started against partially open delivery valve.
- The pump should never be started or operated against closed delivery valve.

4.8.3 Inspection Requirement during stopping of pumps

The training facilitator explains the steps to be followed for stopping a pump of low and medium specific speed as follows in normal and power failure/tripping conditions.

4.8.3.1 At Normal Condition

Box 4-2: Things to be checked when stopping the pump operation

i) Close the delivery valve gradually (sudden or fast closing should not be resorted to, which can give rise to water hammer pressures).
ii) Switch off the motor.
iii) Open the air vent in case of V.T. and submersible pump.
iv) Stop lubricating oil or clear water supply in case of oil lubricated or clear water lubricated VT pump as applicable.

4

Explanation note to the Training Facilitator

If power supply to the pumping station fails or trips, actions stated below should be immediately taken to ensure that the pumps do not restart automatically on resumption of power supply. Though no-volt release or under volt relay is provided in starter and breaker, possibility of its malfunctioning and failure to open the circuit cannot be ruled out.

In such eventuality, if the pumps start automatically on resumption of power supply, there will be sudden increase in flow velocity in the pumping main causing sudden rise in pressure due to water hammer which may prove disastrous to the pumping main.

Secondly, due to sudden acceleration of flow in the pumping main from no-flow situation, acceleration head will be very high and the pumps shall operate near shut off region during acceleration period which may last for few minutes for long pumping main and cause overheating of the pump. Restarting of all pumps simultaneously shall also cause overloading of electrical system.

Hence, precautions are necessary to prevent auto-restarting on resumption on power. Following procedure in Box 4-3 should be followed.

Box 4-3: Things to be checked when stopping the pump after power failure/tripping

i) Close all delivery valves on delivery piping of pumps if necessary, manually as actuators cannot be operated due to non-availability of power.

ii) Check and ensure that all breakers and starters are in open condition i.e. **off**-position.

iii) All switches and breakers shall be operated to open i.e. **off-**position.

iv) Open air vent in case of V.T. or submersible pump and close lubricating oil or clear water supply in case of oil lubricated or clear water lubricated V.T. pump.

v) Information about power failure should be given to all concerned, particularly to upstream pumping station to stop pumping so as to prevent overflow.

4.9 Preventive Maintenance of Pumping Equipment

4.9.1 General

This section describes what preventive maintenance for pumps is and the prevailing effects for unsuccessful preventive maintenance like:

Lack of preventive and timely maintenance or poor maintenance can cause undue wear and tear of fast moving parts, and premature failure of the equipment.

The shortcomings in maintenance can also result in increase in hydraulic and power losses and low efficiency. Inefficient running of the pump increases burden of power cost. Importance of preventive maintenance, therefore, need not be overstressed.

Appropriate maintenance schedule and procedure need to be prescribed for all:

- electrical and mechanical equipment based on manufacturers' recommendations,
- characteristics of the equipment,
- Site and environment conditions i.e. temperature, humidity, dust condition, etc.

The preventive maintenance schedule shall detail the maintenance to be carried out at regular intervals i.e. daily, monthly, quarterly, half yearly, annually etc. or operation hours. The schedule shall also include inspections, services and tests to be performed at appropriate interval or periodicity.

General guidelines for maintenance schedules for pumps and associated electrical and mechanical equipment are enlisted below. The guidelines should not be considered as total, full-fledged and comprehensive as characteristics of equipment and site conditions differ from place to place.

4.9.2 Maintenance Schedule for Pumps

Discuss pump maintenance to be carried out on daily, weekly, monthly quarterly and annually. After identifying the pump maintenance schedule from the participants, the training facilitator, explain the schedule as described below.

4.9.2.1 Daily Maintenance

Operator should perform the following every day in regular manner.

- Clean the pump, motor and other accessories,
- Check coupling bushes/rubber spider,
- Check stuffing box, gland etc.

4.9.2.2 Routine observations of irregularities

The pump operator should be watchful and should take appropriate action on any irregularity noticed in the operation of the pumps. Particular attention should be paid to following irregularities:

1. Changes in sound of running pump and motor,
2. Abrupt changes in bearing temperature,
3. Oil leakage from bearings,
4. Leakage from stuffing box or mechanical seal,
5. Changes in voltage,
6. Changes in current,
7. Changes in vacuum gauge and pressure gauge readings,
8. Sparks or leakage current in motor, starter, switch-gears, cable etc,
9. Overheating of motor, starter, switch gear, cable etc.

a) Record of operations and observations

A log book should be maintained to record the hourly observations, which should cover the following items:

1. Timings when the pumps are started, operated and stopped during 24 hours,
2. Voltage in all three phases,
3. Current drawn by each pump-motor set and total current drawn at the installation,
4. Frequency (50Hz),
5. Readings of vacuum and pressure gauges,
6. Motor winding temperature,
7. Bearing temperature for pump and motor,
8. Water level in intake/sump,
9. Flow meter reading,
10. Daily PF over 24 hours duration,
11. Any specific problem or event in the pumping installation or pumping system e.g. burst in pipeline, tripping or fault, power failure.

4.9.2.3 Monthly Maintenance

1. Check free movement of the gland of the stuffing box; check gland packing and replace if necessary,
2. Clean and apply oil to the gland bolts,

3. Inspect the mechanical seal for wear and replacement if necessary,
4. Check condition of bearing oil and replace or top up if necessary.

4.9.2.4 Quarterly Maintenance

1. Check alignment of the pump and the drive. The pump and motor shall be decoupled while correcting alignment, and both pump and motor shafts shall be pushed to either side to eliminate effect of end play in bearings,
2. Clean oil lubricated bearings and replenish with fresh oil. If bearings are grease lubricated, the condition of the grease should be checked and replaced/replenished to the correct quantity. An anti-friction bearing should have its housing so packed with grease that the void space in the bearing housing should be between one third and half. A fully packed housing will overheat the bearing and will result in reduction of life of the bearing,
3. Tighten the foundation bolts and holding down bolts of pump and motor mounting on base plate or frame,
4. Check vibration level with instruments if available; otherwise by observation,
5. Clean flow indicator, other instruments and appurtenances in the pump house.

4.9.2.5 Annual Inspection and Maintenance

A very thorough, critical inspection and maintenance should be performed once in a year. Following items should be specifically attended:

1. Clean and flush bearings with kerosene and examine for flaws developed, if any, e.g. corrosion, wear and scratches. Check end play. Immediately after cleaning, the bearings should be coated with oil or grease to prevent ingress of dirt or moisture.
2. Clean bearing housing and examine for flaws, e.g. wear, grooving etc. Change oil or grease in bearing housing.
3. Examine shaft sleeves for wear or scour and necessary rectification. If shaft sleeves are not used, shaft at gland packing should be examined for wear.
4. Check stuffing box, glands, lantern ring, mechanical seal and rectify if necessary.
5. Check clearances in wearing ring.

   Clearances at the wearing rings should be within the limits recommended by the manufacturer. Excessive clearance reduces discharge and efficiency of the pump. If the wear is only on one side, it is indicative of misalignment. The misalignment should be set right, and the causes of misalignment should be investigated.
6. Check impeller hubs and vane tips for any pitting or erosion,
7. Check interior of volute, casing and diffuser for pitting, erosion, and rough surface,
8. All vital instruments i.e. pressure gauge, vacuum gauge, ammeter,

voltmeter, wattmeters, frequency meter, tachometer, flowmeter etc. shall be calibrated,

9. Conduct performance test of the pump for discharge, head and efficiency,
10. Measures for preventing ingress of flood water shall be examined. Ingress of flood water in sump, well, borehole shall be strictly prevented. Seal cap shall be provided above borehole.
11. Check vibration level.

4.9.2.6 Overhaul/Service of Pump

It is difficult to specify the periodicity or interval for overhaul in the form of period of service in months/years or operation hours, as deterioration of pump depends on nature of service, type of installation i.e. wet pit or dry pit, quality of water handled, quality of material of construction, maintenance, experience with particular make & type of pump etc.

However generally, following operational hours may be taken as broad guidelines for overhauling.

- Submersible pump – 5,000 – 6,000 hours
- Vertical turbine pump – 12,000 hours
- Centrifugal pump – 15,000 hours

4.9.2.7 History Sheet

History sheet of all pumps shall be maintained. The history sheet shall contain all important particulars, records of all maintenance, repairs, inspections and tests etc.

It shall generally include the following:

1. Details of the pump, rating, model, characteristic curves, performance test report etc,
2. Addresses of manufacturer & dealer with phone & fax number and e-mail addresses,
3. Date of installation and commissioning,
4. Brief details and observations of monthly, quarterly and annual maintenance and inspections,
5. Details of breakdown, repairs with fault diagnosis, replacement of major components i.e. impeller, shaft, bearings, wearing rings,
6. Results of annual performance test including discharge and efficiency,
7. Yearly operation hours of the pumps,
8. Brief findings of energy audit.

4.9.3 Maintenance Schedule for Motors

Like the maintenance schedule for pumps, the same applied for motors as describe below. First the training facilitator differentiate the pump and motor and then explain the maintenance requirements on daily, weekly, monthly and annual basis.

4.9.3.1 Daily Maintenance

The following activities presented in Box-4.4 below shall be carried out as a daily maintenance of pumping motor:

Box 4-4: Daily Maintenance Tasks for Motor

1. Clean external surface of motor,
2. Examine earth connections and motor leads,
3. Check temperature of motor and check whether overheated. The permissible maximum temperature is above the level which can be comfortably felt by hand. Hence temperature observation should be taken with RTD or thermometer. (Note: In order to avoid opening up motors, a good practice is to observe the stator temperature under normal working conditions. Any increase not accounted for, by seasonal increase in ambient temperature, should be suspected).
4. In case of oil ring lubricated bearing:
   - ☞ Examine bearings to check whether oil rings are working,
   - ☞ Note bearing temperature,
   - ☞ Add oil if necessary.
5. Check for any abnormal bearing noise,

4.9.3.2 Monthly Maintenance

Discuss the following monthly maintenance to be carried out.

Box 4-5: Monthly Maintenance Tasks for Motor

1. Check belt tension. In case where this is excessive it should immediately be reduced,
2. Blow dust from the motor,
3. Examine oil in oil lubricated bearing for contamination by dust, grit, etc. (this can be judged from the colour of the oil),
4. Check functioning and connections of anti-condensation heater (space heater).
5. Check insulation resistance by mongering

4.9.3.3 Quarterly Maintenance

Discuss the following quarterly maintenance to be carried out for motor of the pump.

Box 4-6: Quarterly Maintenance Tasks for Motor

1. Clean oil lubricated bearings and replenishes fresh oil. If bearings are grease lubricated, the condition of the grease should be checked and replaced/replenished to correct quantity.

   An anti-friction bearing should have its housing so packed with grease that the void space in the bearing housing should be between one third and half. A fully packed housing will overheat the bearing and will result in reduction of life of the bearing.
2. Wipe brush holders and check contact faces of brushes of slip-ring motors. If contact face is not smooth or is irregular, file it for proper and full contact over slip rings.
3. Check insulation resistance of the motor.
4. Check tightness of cable gland, lug and connecting bolts.
5. Check and tighten foundation bolts and holding down bolts between motor and frame.
6. Check vibration level with instrument if available; otherwise by observation.

4.9.3.4 Half Yearly Maintenance

Discuss the following semi annually maintenance to be carried out for motor of the pump.

Box 4-7: Haft Yearly Maintenance Tasks for Motor

1. Clean winding of motor, bake and varnish if necessary.
2. In case of slip ring motors, check slip-rings for grooving or unusual wear, and polish

4.9.3.5 Annual Inspection and Maintenance

Discuss the following annual maintenance to be carried out for motor of the pump.

Box 4-8: Annual Inspection and Maintenance Tasks for Motor

1. Clean and flush bearings with kerosene and examine for flaws developed, if any, e.g. wear and scratches. Check end-play. Immediately after cleaning, the bearings should be coated with oil or grease to prevent ingress of dirt or moisture,
2. Clean bearing housing and examine for flaws, e.g. wear, grooving etc. Change oil or grease in bearing housing.
3. Blow out dust from windings of motors thoroughly with clean dry air. Make sure that the pressure is not so high as to damage the insulation.
4. Clean and varnish dirty and oily windings. Re-varnish motors subjected to severe operating and environmental conditions e.g., operation in dust-laden environment, polluted atmosphere etc.
5. Check condition of stator, stamping, insulation, terminal box, fan etc.
6. Check insulation resistance to earth and between phases of motors windings, control gear and wiring.
7. Check air gaps.
8. Check resistance of earth connections.

4.9.3.6 History Sheet

Similar to history sheet of pump, history sheet of motor should be maintained. The history sheet should contain all important particulars, records of periodical maintenance, repairs, inspections and tests. The training facilitator explains the following points.

1. Details of motor, rating, model, class of duty, class of insulation, efficiency curve, type test result and type test certificate etc.
2. Date of installation and commissioning.
3. Addresses of manufacturer & dealer with phone & fax number and e-mail addresses.
4. Brief details of monthly, quarterly, half yearly and annual maintenance and observations of inspections about insulation level, air gap etc.
5. Details of breakdown, repairs with fault diagnosis.
6. Running hours at the time of major repairs.

4.9.4 Maintenance Schedule for Valves at Pumping Station

The following five types of valves in pumping installation exist, these are:

1. Foot valve,
2. Sluice valve,
3. Knife gate valve,
4. Non-Return (Reflux) valve, and
5. Butterfly valve.

Maintenance of valves at pumping station is presented in Table 4.1

Table 4-1: Maintenance of Valves at Pumping Stations

Type of Valves	Maintenance Tasks
Foot Valve	☞ Clean foot valve once in 1-3 months depending on ingress of floating matters, ☞ Clean flap of the foot valve once in 2 months to ensure leak proof operation, ☞ Inspect the valve thoroughly once in a year. Check for leakage through foot valve after priming and observing level in volute casing.
Sluice and Knife Gate Valves	☞ Check gland packing of the valve at least once in a month. It should be ensured that pickings' inside the stuffing box are in good trim and impregnated with grease. ☞ It may be necessary to change the packing as often as necessary to ensure that the leakage is within limit. ☞ Grease should be applied to reduction gears and grease lubricated thrust bearing once in three months.

	☞ Check tight closure of the valve once in 3 months. ☞ A valve normally kept open or closed should be operated once every three months to full travel of gate and any jamming developed due to long disuse shall be freed. ☞ Inspect the valve thoroughly for flaws in guide channel, guide lugs, spindle, spindle nut, stuffing box etc. once in a year. ☞ Important **DON'T** for valve is that it should never be operated with oversize hand wheel or cap or spanner as this practice may result in rounding of square top and hand wheel or cap or spanner may eventually slip. ☞ An important **DON'T** for valve is that it should never be operated under throttled i.e. partially open condition, since such operation may result in undue chatter, wear and failure of valve spindle.
Non-Return (Reflux) Valve	☞ Check proper operation of hinged door and tight closure under no-flow condition once in 3 months. ☞ The valve shall be thoroughly inspected annually. Particular attention should be paid to hinges and pins and soundness of hinged door. ☞ Condition of dampening arrangement should be thoroughly examined once in year and necessary maintenance and rectification as per manufactures' instructions shall be carried out. ☞ In case of dampening arrangement, check for oil leakage and replace oil once in a year.
Butterfly Valve	☞ Check seal ring and tight shut-off once in 3 months. ☞ Lubricate gearing arrangement and bearing once in 3 months. ☞ Inspect the valve thoroughly including complete operations once in a year. ☞ Change oil or grease in gearing arrangement once in a year.
General	☞ Operate bypass valve wherever provided once in 3 months. ☞ Flange adapter/dismantling joint provided with valve shall be loosened and retightened once in 6 months to avoid sticking.

4.9.4.1 Annual Inspection and Maintenance

1. Examine all components and wiring thoroughly and rectify as necessary.
2. Change oil or grease in gear box and thrust bearing.

3. Check condition of gears & replace gears if teeth are worn out.

4.9.5 Maintenance Schedule for L.T. Starters, Breakers and Panel

Note: Circuit diagram of starter/breaker should be posted on door of switch gear and additional copy should be kept on record. Table 4.2 below is presented the maintenance tasks for Starter, breaker and panel in the pumping station.

Table 4-2: Maintenance Activities of L.T Starter, Breaker and Panel

Maintenance Duration	Activities
Daily	☞ Clean the external surface. ☞ Check for any spark or leakage current. ☞ Check for overheating
Monthly	☞ Blow the dust and clean internal components in the panel, breaker and starter. ☞ Check and tighten all connections of cable, wires, jumpers and bus-bars. All carbon deposits shall be cleaned. ☞ Check relay setting
Quarterly	☞ Check all connections as per circuit diagram. ☞ Check fixed and moving contacts and clean with smooth polish paper, if necessary. ☞ Check oil level and condition of oil in oil tank. Replace the oil if carbon deposit in suspension is observed or colour is black. ☞ Check insulation resistance. ☞ Check condition of insulators.
Yearly	☞ Check and carry out servicing of all components, thoroughly clean and reassemble. ☞ Calibrate voltmeter, ammeter, frequency meter etc.

4.9.6 Maintenance Schedule for Lifting Equipment

Relevant points in the maintenance schedule for lifting equipments, depending on the type of lifting equipment i.e. chain pulley block, monorail (travelling trolley and chain pulley block), manually operated overhead crane and electrically operated travelling crane is presented in Table 4.3 below.

Table 4-3: Maintenance Activities of Lifting Equipment

Maintenance Duration	Activities
Quarterly	☞ Check oil level in gear box and top up if required. ☞ Check for undue noise and vibration.

	☞ Lubricate bearings and gear trains as applicable. ☞ Check insulation resistance of motors
Haft Yearly	☞ Clean limit switches. ☞ Clean all electrical contacts
Yearly	☞ Change oil in gear box. ☞ Conduct load test of crane for rated load or at least for maximum load required to be handled. All fast moving components which are likely to wear should be thoroughly inspected once in a year and if necessary shall be replaced.

4.9.7 Maintenance Schedule for Water Hammer Control Devices

Maintenance requirements of water hammer devices depend on type of water hammer control device, nature of its functioning, water quality etc.

The training facilitator explains the different types of water hammer control devices used in water pumping installations as follows:

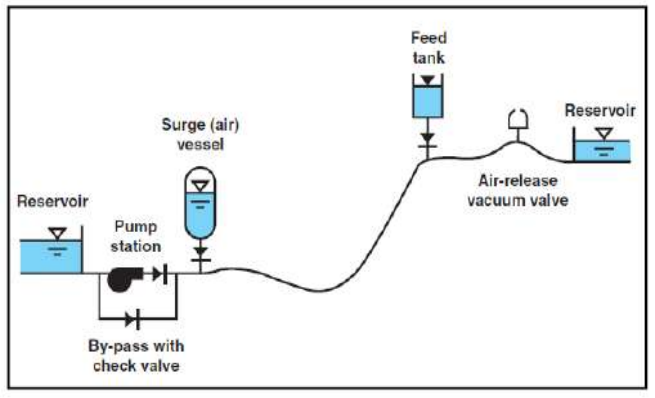
- Surge tank
- One-way surge tank
- Air vessel (air chamber)
- Zero velocity valve and air cushion valve.
- Surge anticipation valve (surge suppressor)
- Pressure relief valve.

Discuss the general guidelines for maintenance of different types of water hammer control devices as follows:

4.9.7.1 Surge Tank

The following maintenance activities shall be carried out at surge tank in the transmission line.

- **Quarterly:** Water level gauge or sight tube provided shall be inspected, any jam rectified, all cocks and sight tube flushed and cleaned.
- **Yearly:** The tank shall be drained and cleaned once in a year or earlier if frequency of ingress of foreign matter is high.
- **Valve maintenance:** Maintenance of butterfly valve, sluice valve and reflux valve shall be attended as specified for valves on pump delivery in section above,



- **Painting:** Painting of tanks shall be carried out once in 2 years.

4.9.7.2 Air Vessel

Air vessel maintenance in the transmission line is presented in Table 4.4.

Table 4-4: Maintenance Activities of Lifting Equipment

Maintenance Duration	Activities
Daily	☞ Check air-water interface level in sight glass tube. ☞ The air water level should be within range marked by upper and lower levels and shall be preferably at middle. ☞ Check pressure in air receiver at interval of every 2 hours.
Quarterly	☞ Sight glass tube and cock shall be flushed. ☞ All wiring connections shall be checked and properly reconnected. ☞ Contacts of level control system and pressure switches in air supply system shall be cleaned.
Yearly	☞ The air vessel and air receiver shall be drained, cleaned and dried. ☞ Internal surface shall be examined for any corrosion etc. and any such spot cleaned by rough polish paper and spot-painted. ☞ Probe heads of level control system shall be thoroughly checked and cleaned.

4.9.7.3 Zero velocity valve and air cushion valve

Foreign matters entangled in valve shall be removed by opening all hand holes and internal components of the valves including ports, disk, stem, springs, passages, seat faces etc. should be thoroughly cleaned and checked once in 6 months for raw water and once in a year for clear water application.

4.9.7.4 Surge anticipation valve (surge suppressor)

Pilot valves and tubes shall be flushed and cleaned every month

4.9.7.5 Pressure relief valve

The spring shall be checked and freed from jam every month.

4.9.8 Maintenance Schedule for Air Compressor

a) Daily :

- ☞ Clean external surface.
- ☞ Check oil level and top up if necessary.

b) Monthly :

- ☞ Clean oil filter
- ☞ Clean air filter

c) Quarterly :

- ☞ Check condition of oil and change if dirty.
- ☞ Check grease in bearing housing and replenish/change if

necessary.

- ☞ Check condition of oil in air filter and change if dirty.

d) Half yearly :

- ☞ Change oil.
- ☞ Change oil filter element.
- ☞ Thoroughly clean air filter.
- ☞ Clean bearing and bearing housing and change grease/oil.

e) Yearly :

Thoroughly check all components, piping valve etc. and rectify if necessary.

4.10 Maintenance of Pumping Station

Maintenance of pumping station such as screens, gate, sump / intake / well and pump house including civil works as described below:

4.10.1 Screens

1. Screen should be cleaned at a frequency depending on ingress load of floating matters. The frequency in monsoon season shall be more than that in fair season. However, cleaning frequency should be at least once in a week, or, if head loss in screen exceeds 0.20 m.
2. Care should be taken to remove and dump the screening far away from the pump house.
3. Lubricate wheels and axle of wheel burrows.
4. The screen, catch tray and screen handling arrangement shall be thoroughly inspected once in six months and any item broken, eroded, corroded shall be rectified.

4.10.2 Sluice Gate

a) Monthly :

- ☞ The sluice gate normally remains in open position and closed only when inflow is to be stopped. Since floating matters may adhere to the gate and may accumulate in the seat, it should be operated once in a month. In order to ensure that gate remains free for operation.

b) Yearly :

- ☞ The gate should be thoroughly inspected once in a year preferably after wet season and components found worn out shall be replaced. Particular attention shall be paid to the seats of the frame and gate.
- ☞ The gate should be closed to check the leakages. For this purpose, the sump/intake shall be partly dewatered so that differential head is created on the gate and leakage test at site can be performed.

4.10.3 Sump/Intake Well

- ☞ All foreign floating matters in the sump/intake shall be manually removed at least once in a month and shall be disposed off away from pump house,
- ☞ De-silting of intake/sump shall be carried out once in year preferably

after wet season. Care should be taken to dump the removed silt away from pump house.

- ☞ It is generally observed that reptiles like snakes, fish, etc. enter intake particularly in wet season. The intake should be disinfected.
- ☞ The sump/intake should be fully dewatered and inspected once in a year.
- ☞ It is advisable to undertake leakage test of sump once in a year. For this purpose, the sump shall be filled to FSL and drop in water level for reasonably long duration (2-3 hours) should be observed. If leakage is beyond limit, rectification work shall be taken.

4.10.4 Pump House

- ☞ The pump house should be cleaned daily. Good housekeeping and cleanliness are necessary for pleasant environment,
- ☞ Entire pump house, superstructure and sub-structure shall be adequately illuminated and well ventilated. Poor lighting, stale air etc. create unpleasant environment and have an adverse effect on will of the staff to work,
- ☞ Wooden flooring and masonry stone grating wherever damaged should be repaired on priority,
- ☞ It is observed that at many places, roof leaks badly and at times the leakage water drips on the panel/motor which is dangerous and can cause short circuit and electric accidents. All such leakages should be rectified on priority.
- ☞ All facilities in sub-structure i.e. stair case, floors, walkways etc. should be cleaned daily.
- ☞ Painting of civil works should be carried out at least once in two years.

4.11 Driving Equipment

4.11.1 Diesel/Gasoline Engines/Alternators

Diesel-powered generators are used in many boreholes and water intakes to drive electrical pumps. There is a wide variety of makes, although Lister-Peter and Perkins are common.

The principles of the O and M tasks required are similar, regardless of the make or model. Specific requirements for each make and model should be obtained from the manufacturer's Operators Manual for each engine.

Gasoline engines can be used for direct connection to centrifugal pumps operating at a moderate heads, but need a reducing gear to low pumping heads.

4.11.1.1 Identification of parts of a Diesel Powered System

Identify the different parts of the pumping system and explain the purpose of each part.

Table 4-5: Different parts of Generator Engine and its purposes

Component	Purpose
Pump House	Keeps the engine and its control panel safe from unauthorized access

Fuel store	Keeps the fuel safe from uncontrolled access
Diesel engine	Turns on the alternator
Alternator	Generates electricity
Control panel	Controls the current to the pump and protects the pump from periods of high currents
Electrical pump (e.g., submersible pump in bottom of borehole)	Pumps water to the tank
Master meter	Measures water from the borehole

Now focus on a diesel-powered engine and explain the names and purpose of its different components.

4.11.1.2 Start Up Procedure

a) Before starting up diesel generator, the followings have to be checked:

The training facilitator explains what checks should be carried out before starting up of diesel generators using Table 4-6.

Table 4-6: Pre-Start Check and Service of Generator Engine

No.	Description	Checking
1	Oil	Check the different types of oil, coolant and fuel levels. The oil level may be checked with the engine running or stopped. The recommended method of checking is while the engine is not running. Badly contaminated or deteriorated oil shall be replaced immediately regardless of the replacement interval, and the oil level has to be maintained between the lower and upper marks of the oil dip stick.
2	Radiator	Check the coolant level on the control board meter. If additional water is needed, remove fill cap and add as necessary. In addition to this, always check randomly radiator core, mountings, hose, steam-relief tube and valve are in good condition, correctly assembled, securely mounted and do not leak.
3	Fuel Tank	Fuel can be added to the tank by removing the fill cap on top of the fuel tank. After completion of refuelling, be sure to tighten the fuel tank cap to protect against vandalism.
4	Batteries	Check electrolyte level in each battery cell and maintain the level to the bottom of the fill openings with distilled water. Clean the top of the batteries with a clean cloth.

		Keep the terminals clean and coated with petroleum jelly. Check the indicating meter located on the control board, it is always expected to indicate at least nominal battery rating unless and otherwise the meter is faulty.
5	Instruments and Gauges	Check the following meters at frequent intervals under the full range of engine speeds for correct readings, if unusual readings are observed stop the equipment immediately and report to the supervisor. ▪ Ammeters ▪ Voltmeters ▪ Speedo-meter ▪ Temperature gauge
6	Accessories	Check accessories such as fuel pump, carburettor, generator, regulator, starter, fan belt and water pump for loose connections or mountings.

b) Start engine, make the following checks:

The training facilitator explains what checks have to be carried out during the start of the diesel engine as described in Box 4 – 9.

Box 4-9: Checking during starting of Generator Engine

- Observe engine warm up.
- Check that the starter has adequate cranking speed and engages
  and disengages properly without unusual noise.
- Do not place engine under load before reaching normal operation condition.
- Check oil pressure and all other instruments (Tachometer, Voltmeter, Temperature gauge).

c) During Operation of the engine

During operation, operators must correct simple defects only and if the defects are beyond their capacity the defects are to be reported to the supervisor. Box 4 - 10 describes the checking's to be carried out during the engine in operation.

Box 4-10: Checking during operation of Generator Engine

- Check clutch (if applicable).
- Check engine controls and watch for poor engine performance such as the lack of usual power, misfiring, unusual noise, stalling, overheating, or excessive exhaust smoke. Check that engine responds satisfactorily to the controls and the controls are correctly adjusted.
- Check leaks.
- Check accessories and belts.
- Check alternator meter for correct operating current and voltage. Adjust if required.

d) After operation, make the following checks:

Box 4-11 lists checking requirements after operation of diesel engine. The training facilitator explains these requirements.

Box 4-11: Checking after operation of Generator Engine

- Check any irregularities noticed previously.
- Check fuel, oil and water.
- Check instruments.
- Check battery.
- Check accessories and belts.
- Check fuel filters.
- Check for leaks.

4.11.1.3 Switching Off Procedure

1. Turn engine off,
2. Record end time on Log Chart,
3. Check for any oil leaks.

4.11.2 Schedule of Preventative Maintenance for Diesel Engines

In almost all cases, diesel engine prime movers are designed as standby units, these must be given proper care to prolong their life and for their efficient operation. In the absence of the equipment operating manual, listed below are suggested preventive maintenance practices.

Table 4-7: Schedule of PM for Diesel Engines

O&M Duration	Activities
Daily Operation/ every 8 hours (to be carried out by Operator)	☞ Check fuel and engine oil levels, top up if necessary ☞ Check water level in radiator & top up if necessary and secure the cap ☞ Check tension of alternator drive belt, check battery condition/water level ☞ Check the lubricating oil pressure at the gauge ☞ Check for loose nuts and bolts, check and correct any leaks or engine damage ☞ In very dusty conditions clean air cleaner element, drain and clean dust bowl ☞ Check exhaust pipe ☞ Check foundation bolts
Every 100 hours or 3 months (to be carried out by skilled mechanics)	☞ As for daily services. ☞ Renew engine lubricating oil ☞ Renew engine oil filter ☞ Drain water from fuel filter and pre-filter ☞ Check the condition of the battery fitted ☞ When moderately dusty, empty bowl and clean or replace the air cleaner element ☞ Clean the compressor air filter ☞ Check and adjust idle speed
Every 200 – 250 hours or 6 months (To be carried out by skilled mechanics)	☞ As for previous servicing ☞ Change the engine oil and oil filter element ☞ Clean fuel strainer, fuel tank breather. Renew fuel filter canister ☞ Clean battery terminals
Every 400 hours or 12 months (To be carried out by skilled mechanics)	☞ As for previous servicing ☞ Replace air cleaner element ☞ Renew fuel filter element ☞ Check concentration of coolant ☞ Check the battery charging system. Check alternator drive belt for wear, Check ☞ wiring harness & connections and tighten if required ☞ Check injectors for performance
After 600 hrs or 18 months (to be carried by skilled	☞ As for 200 hour servicing and maintenance ☞ Renew coolant ☞ Renew alternator drive belt

mechanics)	☞ Tighten cylinder head ☞ Check and adjust valve clearances ☞ Check electrical system ☞ Check all nuts and bolts for tightness ☞ Check engine mountings

4.11.3 Troubleshooting for Generator

Discuss the potential unexpected problems, what might be the causes, and some possible solutions for diesel engine.

Table 4-8: Troubleshooting for Diesel Engines

No.	Problems	Possible Cause	Remedy
1	WILL NOT START (i) Engine does not turn)	Battery is flat or has failed	(a) Check the liquid level; fill if necessary. (b) Recharge the battery and check that all cells are working. (c) Replace the battery if it has failed.
		Starter circuit faulty	(a) Check, clean and refit the battery connections. (b) Check the circuit relay and starter solenoid.
		Starter faulty	(a) Replace the motor. (b) Check that the starter is engaging; attempt to turn the engine by hand.
		Lubricating oil to thick	Replace with the correct grade of oil.
		Engine or alternator jammed	Inspect and remove any obstruction.
	(ii) Engine turns but does not fire	(a) No fuel atomizers (b) Air in fuel system (c) Dirty fuel or water in the fuel (d) Faulty lift pump (e) Faulty injection pump (f) Injection timing wrong	(a) Check there is fuel available in the tank. (b) Check that all fuel valves are open. (c) Bleed the fuel system. (d) Clean or replace the fuel filter. (e) Check the fuel lift pump. (f) Check the fuel injection pump. (g) Reset the injection pump timing.
	(iii) Engine fires but fails to start	(a) Limited fuel supply (b) Faulty lift pump (c) Faulty injection pump	(g) Bleed the fuel system and check it thoroughly for evidence of dirt or water.

		(d) Fuel filter blocked (e) Air filter blocked (f) Worn or dirty injectors	(h) Service the fuel lift pump. (i) Service the injection pump. (j) Clean or replace the fuel filter. (k) Clean or replace the air filter. (l) Service or change injectors.
2	Starts but misfires	(a) limited fuel supply (b) Faulty lift pump (c) Faulty injection pump (d) Fuel filter blocked (e) Worn or dirty injectors (f) Loose or broken pipes (g) Incorrect valve clearances	(a) Bleed the fuel system and check it thoroughly for evidence of dirt or water. (b) Service the fuel lift pump. (c) Service the injection pump. (d) Clean or replace the fuel filter. (e) Service or change the injectors. (f) Tighten or replace the pipes. (g) Reset the valve clearances.
3	Starts but loses power	(a) All possible causes shown under 2 above (b) Air filter blocked (c) Faulty cylinder head or inlet manifold joints (d) Damaged or dirty turbocharger	Attention as shown in (a) to (g) above (under item 2 above). (i) Clean or replace the air filter. (j) Replace the gasket. (k) Clean or replace the filter.
4	Excessive fuel consumption	(a) Faulty injection pump (b) Worn or dirty injections (c) Incorrect valve clearance (d) Fuel pump timing incorrect (e) Incorrect fuel (f) Excessive engine wear	(a) Service the fuel injection pump. (b) Service or change the injectors. (c) Reset the valve clearance. (d) Reset the fuel pump timing. (e) Check the fuel specification. (f) Overhaul the engine.
5	Black exhaust smoke	(a) Faulty injection pump (b) Worn or dirty injectors (c) Air filter is blocked (d) Fuel pump timing	(a) Service the fuel injection pump. (b) Service or change the injectors. (c) Clean or replace the air filter. (d) Reset the fuel pump

		incorrect (e) Incorrect fuel (f) (Damaged or dirty turbocharger (g) Excessive load (h) Long running time on light load	timing. (e) Check the fuel specification. (f) Clean or replace the turbocharger. (g) Reduce the load as necessary. (h) Run on full load for a one-hour period.
6	Blue/white exhaust smoke	(a) Engine misfiring (b) Excessive engine wear	(a) See remedy under item 2 above. (b) Overhaul the engine.
7	Low lubricating oil pressure	(a) Low oil level in sump (b) Oil pressure gauge faulty (c) Oil filter blocked (d) Faulty relief valve (e) Oil pump worn (f) Excessive oil temp	(a) Add lubricating oil to normal level (b) Replace the oil pressure gauge. (c) Clean or replace the oil filter. (d) Clean or replace the relief valve. (e) Replace the oil pump. (f) See the problem outlined in item 8 below.
8	High Engine temp	(a) Low level of coolant (b) Faulty thermostat (c) Fan belt slipping (d) Radiator matrix blocked (e) Blockage in cooling system (f) Low level of lubricating oil (g) Fuel injection pump's timing is incorrect (h) Cylinder head gasket failed	(a) Refill the radiator and check for any leaks. (b) Check and replace the thermostat if necessary. (c) Adjust the tension of the fan belt. (d) Clean out the radiator thoroughly. (e) Drain the system, flush it out and refill. (f) Refill the lubricating oil to the correct level. (g) Reset the timing of the fuel injection pump. (h) Remove the cylinder head and replace the gasket.

4.11.4 D.C Battery

Explain the following maintenance schedule that shall be applicable for D.C. Batteries on differ time table:

i. ***Daily:*** Check voltage and specific gravity of the batteries and battery supply for the tripping circuit.

ii. ***Monthly:*** Check the battery charging & fuses and clean contact faces.

Apply petroleum jelly or grease to battery terminals.

iii. ***Quarterly:*** Check to ensure that battery is not overcharged/under charged.

iv. ***Yearly:*** Check rectifier, diode, rheostat motor thoroughly.

4.12 Facilities for Maintenance and Repairs

The following facilities should be provided for maintenance, inspection and repairs in the pumping installation:

- Adequate stock of consumables and lubricants,
- Adequate stock of spare parts,
- Tools and testing instruments,
- Lifting equipment,
- Ventilated and illuminated adequate space for repairs.

4.12.1 Consumables and Lubricants

Adequate stock of gland packing, belts, gaskets, lubricating oil, greases, transformer oil, insulation tape, sealing compound, emery paste etc. shall be maintained.

Quantity shall be decided depending on consumption and period required to procure and replenish the stock.

4.12.2 Spare parts

Adequate stock of spare parts should be maintained to avoid downtime due to non-availability of spares.

Generally, spares required for one-two years maintenance as per list below shall be kept in stock.

The list should not be considered as full-fledged and comprehensive and should be updated and revised in light of manufacturers' recommendations and previous history of repairs undertaken.

Table 4-9: Lists of Spare parts need to be stock for O&M of Pumps and Generators

No.	Spare part Items	No.	Spare part Items
1	Set of wearing rings	12	Lantern ring
2	Shaft sleeves	13	Coupling for line shaft
3	Bearings	14	Slip ring unit
4	Gland packing's and gaskets	15	Carbon brushes
5	Coupling bushes and bolts	16	Fixed and moving contacts
6	Line shaft bearings and spiders	17	Lugs
7	Line shaft	18	Gland for cable termination
8	Pump shaft	19	Fluorescent tubes and lamps
9	Shaft enclosing tube	20	Fuses
10	Tube tensioning plate	21	Impeller

11	Gland nut	22	Rotating assembly of pump (for large pumping installation)

4.12.3 Tools and Testing Instruments

The pumping installation should be equipped with all necessary tools, testing instruments and special tools required for repairs and testing. Their quantity and special tools depend on size and importance of installation.

Generally the following tools and testing instruments shall be provided:

Table 4-10: Lists of Tools and testing Instruments required for O&M

No.	Lists of Tools	No.	Spare part Items
1	Double ended spanner set and ring spanner set	11	Bearing puller
2	Box spanner set	12	Torque wrench
3	Hammers (of various sizes and functions)	13	Clamps for column pipes, tube and line shaft
4	Screw driver set	14	Specials tools such as grinder, blower, drilling machine
5	Chisel	15	Tap and die set
6	Nose pliers, cutting pliers	16	Bench vice
7	Flies of various sizes and smooth/rough surfaces	178	Special tools for breakers
8	Adjustable spanner	18	Fluorescent tubes and lamps
9	Pipe wrenches	19	Crimpling tool
10	Heating stove for heating sleeves	20	Rotating assembly of pump (for large pumping installation)
No.	**Lists of Tools**	**No.**	**Spare part Items**
1	Insulation tester	1	Earth resistance tester
2	Tongue tester	2	Wattmeter, CT and PT
3	AVO meter	3	Dial gauge
4	Test lamp	4	Tachometer

4.12.4 Safety Rule

Discuss the safety rules with the participants.

i) Safety rules: general

1. Keep a fire extinguisher or a bucket of sand close at hand to deal with fire.
2. Smoking is not allowed in the pump house or fuel store.
3. Wear protective clothing that fits well: no loose clothes that can get caught in the moving parts of the engine.
4. Never put cleaning rags or other loose items in your pockets when you are in the pump house. They can get caught in the moving

parts.

5. Wear good protective shoes.
6. Keep the floors of the pump house and store clean and dry, so that you will not slip or fall.

ii) Safety rules: fuel and lubricants

1. Keep spare fuel and lubricants in a secure, ventilated store.
2. Do not smoke in the fuel store or while refueling is being carried out. Ensure the area is clear of any spectators or smokers.
3. Use a pump or tap to take diesel out of a drum. Transferring diesel fuel by sucking it up with a hose is not good for your health.
4. NEVER put fuel or oil into the engine while it is running.
5. Do not use kerosene as a fuel. It reduces the life of the engine and the fuel pump.

iii) Safety rules: during operations

1. Keep spectators out of the pump house while the engine is operating.
2. Open the windows and ensure that the pump house is well ventilated.
3. Do not open the radiator cap.
4. Do not top up the radiator by pouring cold coolant into a hot engine as this may cause the cylinder head to crack.
5. Keep your fingers away from moving parts of the engine.
6. NEVER put fuel or oil into the engine while it is running.
7. Never clean the engine when it is running.
8. Do not operate the engine if the safety guard has been removed.
9. Only one person should control the engine.

iv) Safety rules: during maintenance work

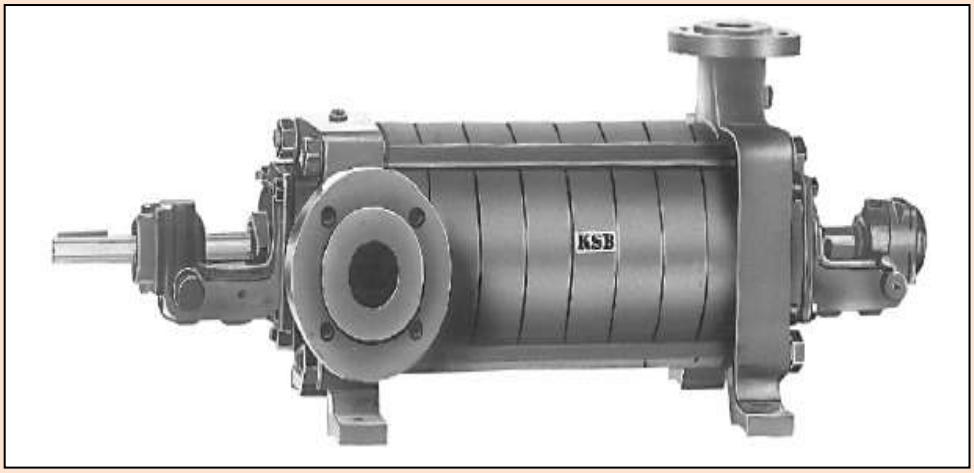
1. Do not make any adjustments that you do not understand.
2. Maintenance operations must be carried out on a cold engine.
3. Maintenance operations must be carried out under sufficient lighting.
4. Do not overfill the engine oil in the sump; this may cause the engine to give off smoke.
5. Do not use salt water or any other coolant which can cause corrosion in the closed cooling unit.
6. Disconnect the battery terminals before a repair is made to the electrical system.
7. If you are working with chemicals, such as solvents, cleaners, chlorine etc., be careful. Read the instructions on the container and follow them closely. Some chemicals give out fumes that are poisonous if inhaled. Some of them will burn your skin.

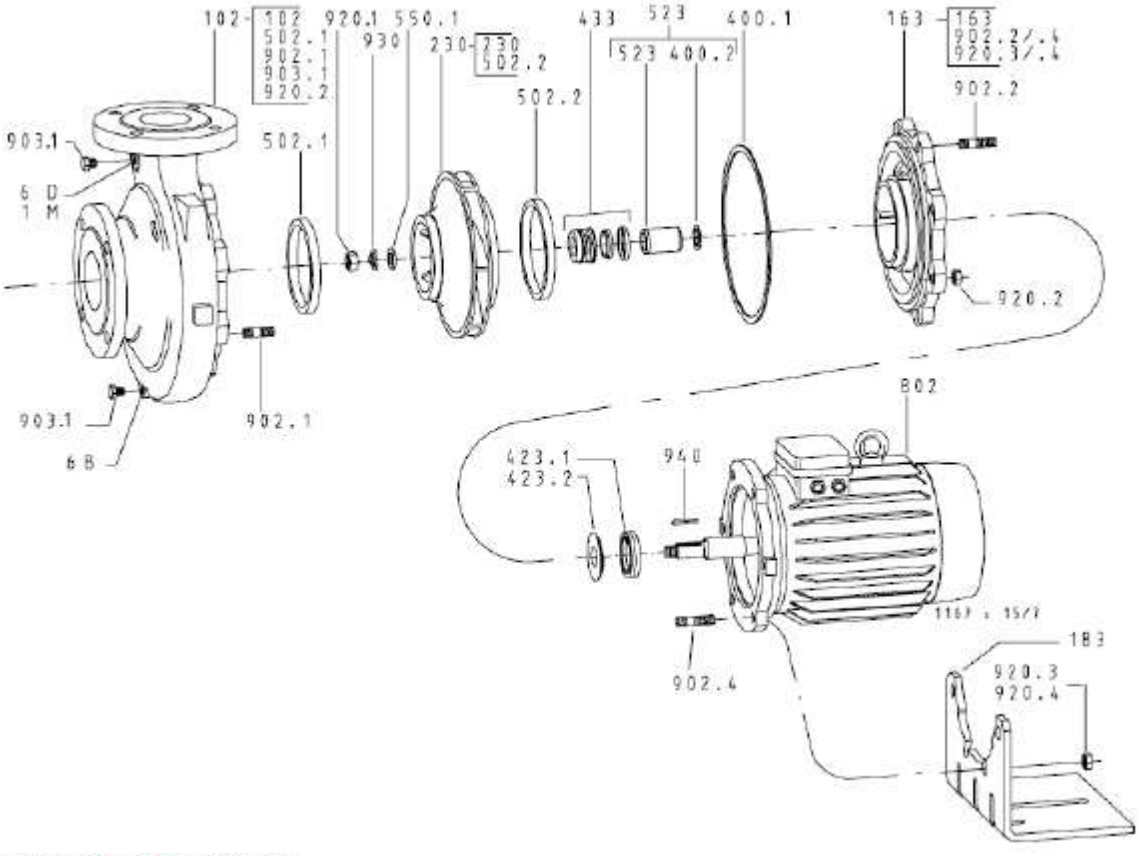
Attachments	Attachment 4-1: Typical Surface Pumps Attachment 4-2: Engine Log Attachment 4-3: Engine Service Form

Attachment 4-4: Diagram of the Lister TS3 diesel engine

Attachment 4-2: Typical Surface Pumps

1. KSB Surface Multi stage Centrifugal Pump

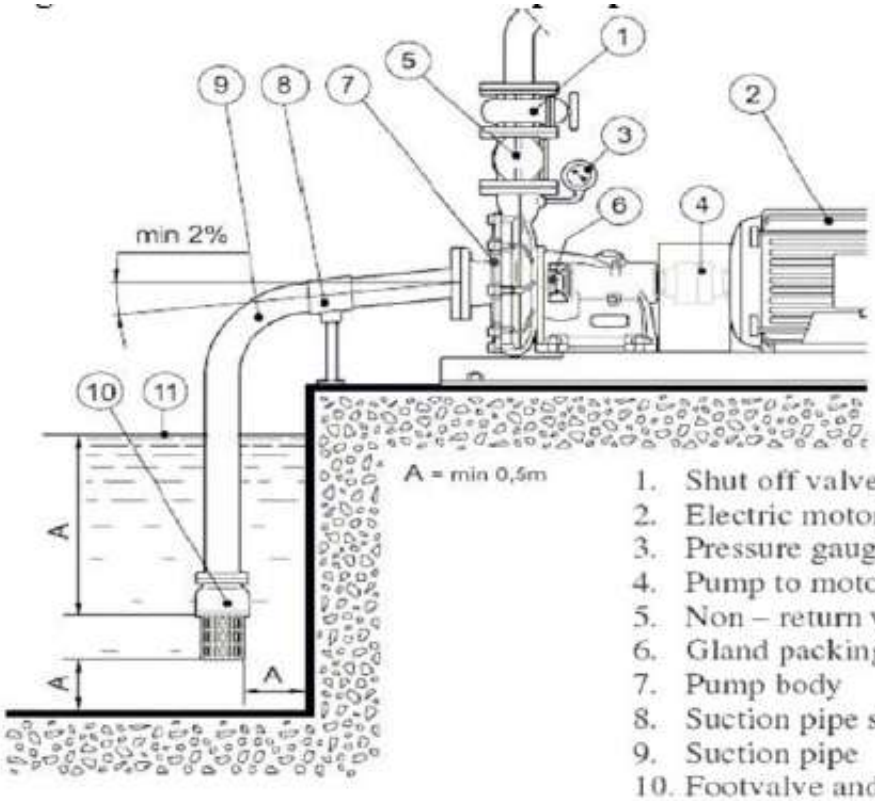




Supplied in packaging units only

Part No.	Description	Part No.	Description	Auxiliary connections	
102	Volute casing	523	Shaft sleeve	1M	Pressure gauge
163	Discharge cover	550.1 [1]	Disc	6B	Casing drain
183 [2]	Support foot	802	Motor for close coupling	6 D	Priming and venting
230	Impeller	902.1/.2/.4 [2]	Stud		
400.1/.2	Gasket	903.1	Screwed plug		
412.1	O-ring	920.1-.3	Hex. nut		
423.1/.2	Labyrinth seal	920.4 [2]	Hex. nut		
433	Mechanical seal	930	Spring washer		
502.1/.2	Casing wear ring	940	Key		

2. Rovatti Surface Single Stage Centrifugal Pump



1. Shut off valve
2. Electric motor
3. Pressure gauge
4. Pump to motor coupling
5. Non – return valve
6. Gland packing
7. Pump body
8. Suction pipe support
9. Suction pipe
10. Footvalve and strainer
11. Water level

Note distance A > 0.5 m.

3. Different Model of Groundfos Submersible Pump

Attachment 4-3: Engine Log

ame of Water Supply		Engine Type		Northing
ub-Location		GPS	Easting	
ocation				
ivision				
istrict				

	At Start		During Operations		At End					
ate	Fuel Added (Litres)	Start Time	Voltage (Volts)	Current (Amps)	Time	Kw-Hrs (Meter reading)	Water pumped (Meter reading)	Comments Repairs Problems	Initials of Operator	

Attachment 4-4: Engine Service Form

Engine Make:.....Model:.....

Date of Service:.....Name of Mechanic:.....Tel:.....

Hours at Current Service:.....Hours at next Service:.....

CATEGORY	ITEM	CHECKED (Tick if checked)	WORK DONE	COMMENTS
LUBRICATION	Engine Oil			
	Oil Filter			
	Greasing			
FUEL SYSTEM	Fuel Filter			
	Injector/Fuel Pump (leakages)			
	Tank			
	Fuel Lines (cracks, leaks)			
ENGINE	Belts			
	Air Filter			
	Plugs/Injectors			
ELECTRICALS	Battery			

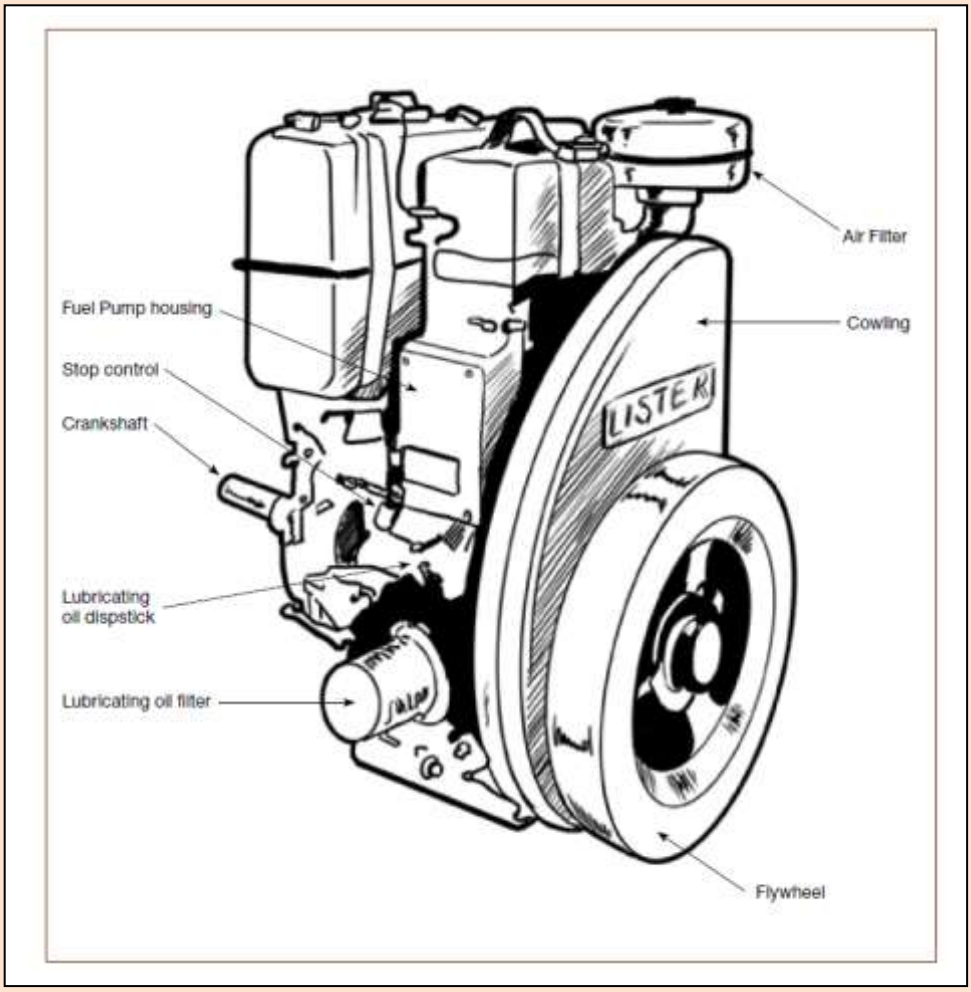
Comments.....

.....

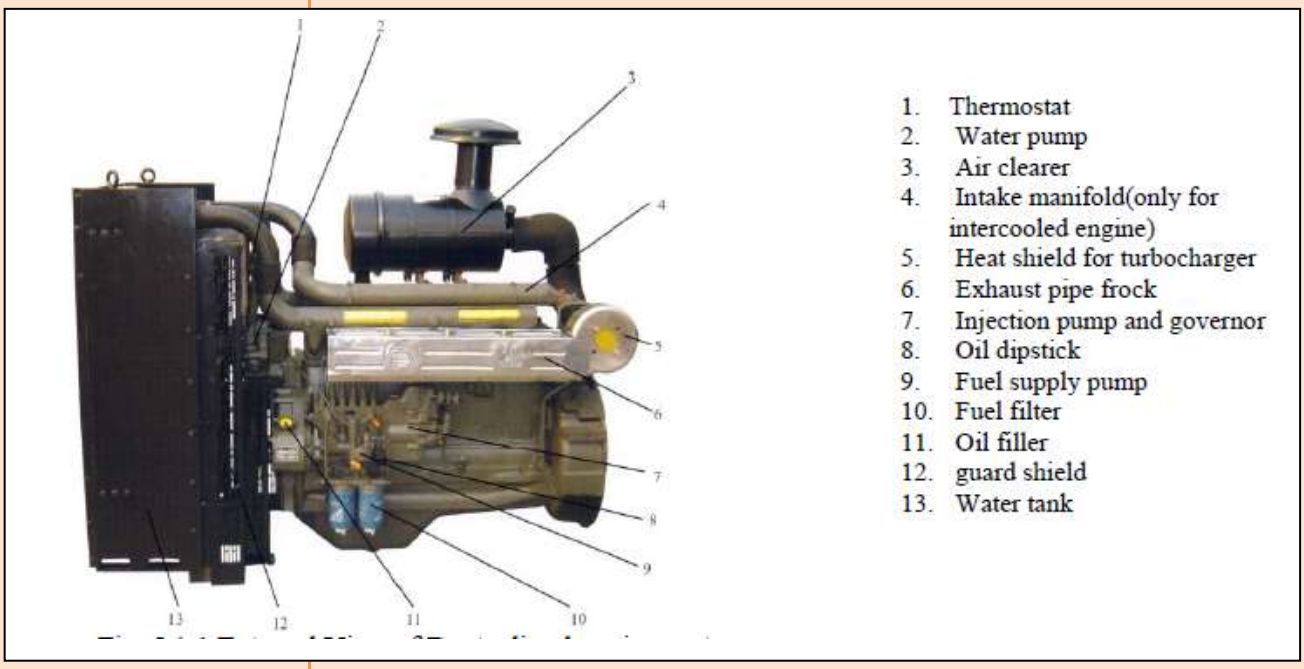
Signature:.....

Signed by (Name):.....

Attachment 4-5: Diagram of the Lister TS3 diesel engine



Attachment 4-6: Diagram of the Deutz diesel engine



5 SESSION – E: TRANSMISSION & DISTRIBUTION PIPELINES

Module - C	TECHNICAL OPERATION & MAINTENACE REQUIREMENTS FOR RURAL PIPED SYSTEM
5.1 Session Outline	This session covers the following main topics: ▪ Introduction of pipelines ▪ Description of different water supply system ▪ Identification of pipeline system ▪ O&M Tasks for pipelines and appurtenants ▪ Troubleshooting for pipelines and appurtenants ▪ Service line Repairs
Appropriate Facilitators background	This session of the training should be given by experienced Engineer.
5.2 Objective	At the end of the session, the participants will be able to: ▪ identify the main components of a pipelines, ▪ describe the functions of the key components ▪ carry out pipeline operation and maintenance
Output	▪ An O and M schedule
Training timing for this session	8 hours
Methodology	This is intended to be a practical session. The components will be taught by demonstration of the system itself, not using drawings or descriptions. The flip chart can be used to illustrate details if necessary. Reinforce the learning by allowing participants to handle the parts and describe their functions to each other.
Materials	▪ Valve key/wheel, pipe wrench, tools, tap, gate valve, non-return valve
Session Guide and Content	
5.3 Introduction	Transmission pipeline is conveying raw water from the source to the treatment plants, and transmit treated water from treatment plants to the storage reservoirs. If the raw water source is groundwater, it conveys from borehole to the service reservoir, in most cases it located at local hill. Transmission through pipes can be either by gravity flow or by pumping system. Distribution pipelines are conveying potable water from service reservoir to the point of consumers via gravity or pumping system, the former is predominant in Ethiopia. The line mainly branched in the case of RPS, seldom looped system whenever deliver to towns.

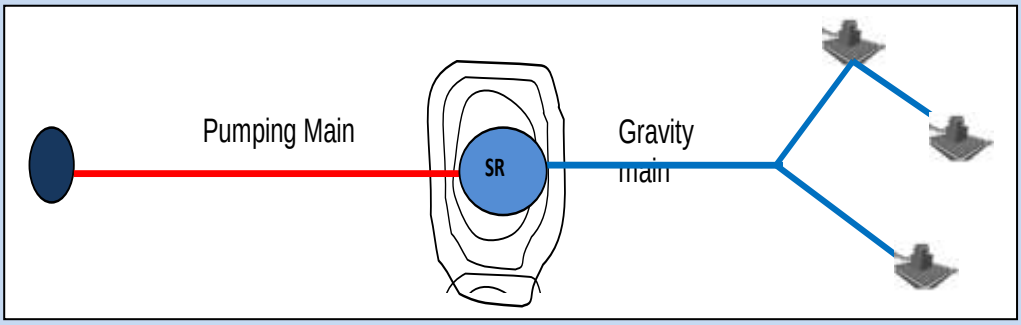
	This training session is dealing with the operation and maintenance requirements for transmission line, service reservoir, distribution system, public water point, service line and appurtenants in the system.
5.4 System Description	The training facilitator discusses the different types of water supply systems and asks the participants which system belongs to their areas. There are 5 different water supply system predominantly exist in Ethiopia as described below.

5.4.1 Option-1: Pumping System from Single Borehole

In this system water is conveyed from borehole through submersible pump to service reservoir located relatively at higher altitude via pumping main pipeline.

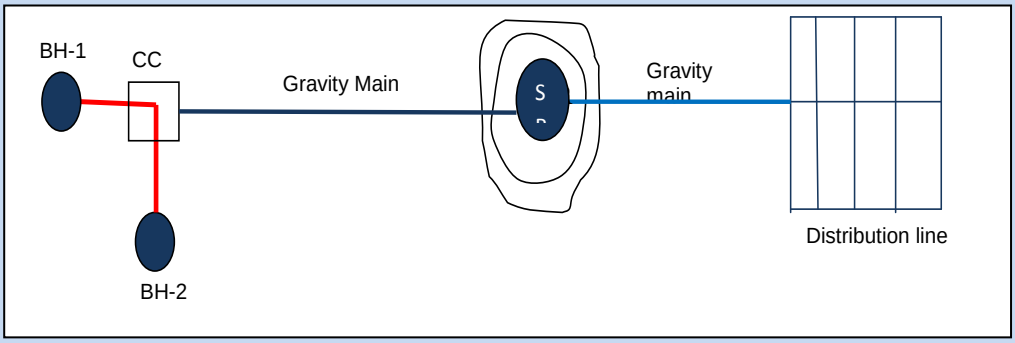
From the service reservoir, water is distributed to the consumer by gravity system. This system is the most applicable method in Ethiopia in provision of water supply.

Along the pipeline, various valves and fitted such as gate valve, non-return valve, pressure gauge, water meter, air release valve, washout valve, pressure sustain valve etc fitted on the system.



5.4.2 Option-2: Pumping -Gravity System from Multiple Boreholes

If multiple boreholes are involved, the system incorporate collection chamber and booster pump. If the consumer's location is at higher altitude compare to the location of the collection chamber.

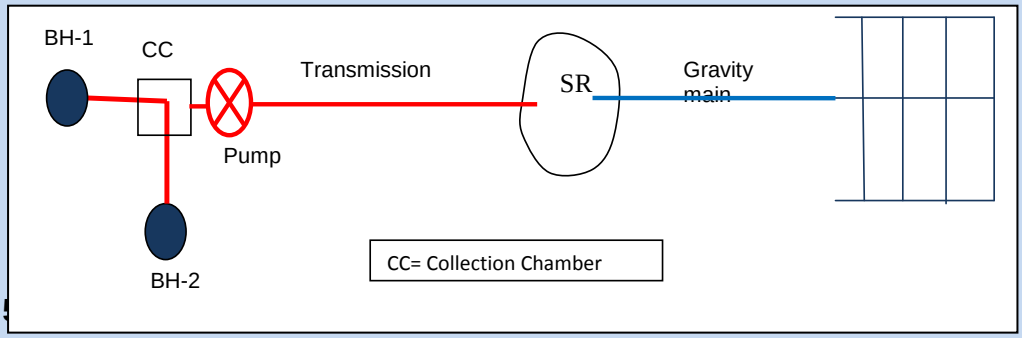


This option is seldom encountered that the location of the well fields are at high altitude and placing the collection chamber at higher elevation to facilitate gravity water supply system to service reservoir, and then to distribution system. Such arrangement is cheaper than the option-3 below.

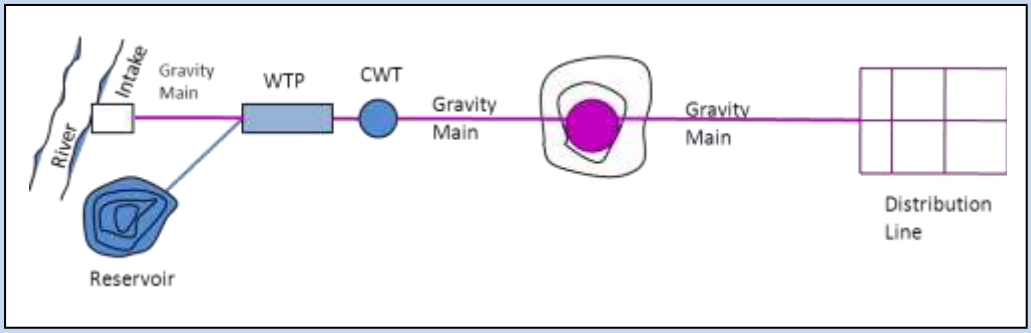
In some cases, option-2 modified due to the topographic situation and incorporated boost pump to boost the water to the service reservoirs as presented in the sketch presented as option-3 below.

5.4.3 Option-3: Pumping-Pumping-Gravity System from Multiple Boreholes

Option-3 is more prevalent system in the Country from multiple groundwater sources.



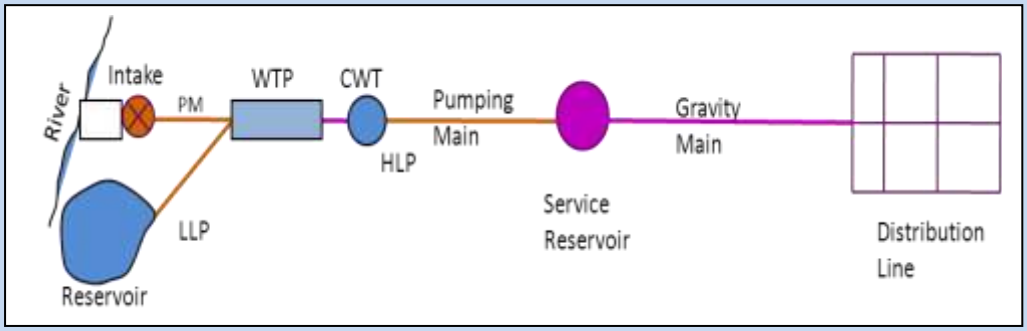
This option is ranked the 4th from the above 3 options, due to that this requires treatment plant facilitates. This kind of arrangement may be adopted for urban water supply provision where the demand is high and the availability of surface water sources nearby.



5.4.5 Option-5: Pumping system from River and Reservoir sources

This kind of pumping system arrangement up to service reservoir is exist in Ethiopia urban water supply. This system is the most expensive than the other 4 options.

Such configuration is preferred if groundwater scarce and surface water is available in nearby area.



5.5 System Identification

5.5.1 Gravity or pumped system

Using the diagrams in Attachment 1 and 2, discuss the basic arrangement of the system:

- Is it a gravity or pumped system? (Note that many pumped systems also have a gravity component.)
- Which parts of the pipeline are under pressure?
- How much pressure? (Make an estimate if there are no pipeline profile drawings that show the pressure in different parts of the system.)
- How is the pressure controlled?
- What happens on a pumped scheme if there is a burst pipe? How about on a gravity system?
- Where is storage tanks positioned within a system?

5.5.2 Pipeline components

Identify and demonstrate the functions of the different components of pipeline as described in Table 5-1.:

Table 5-1: Pipeline components and their functions

No.	Component	Function
1	Source	Where the water originates (e.g. Groundwater, river, lake, pond etc)
2	Intake	The structure to abstract the water from the source
3	Pumping main or gravity main line	The pipeline that conveys water to the storage tank(s)
4	Distribution lines	Pipeline branches from the main line or from the storage tank to the individual connections or public water points
5	Storage tanks/Service Reservoir	Constructed o store water to supply peak demand as well as to facilitate gravity flow
6	Break-Pressure Tank	Decreases water pressure in the pipeline – brings pressure to atmospheric pressure by constructed the tank or install pressure reducing valve.
7	Pipe supports	Support the pipeline above ground; limit damage to pipeline during floods and excess pressure
8	Pipe markers	Mark the route of a buried pipeline
9	Control valves	Open or close the pipeline
10	Air valves	Release air from the high points in the pipeline
11	Washouts	Opened to clean out silt, sand and mud at low points in the pipeline

12	Meters	Master meter to measure abstraction; individual or public water points meters to measure water consumed
13	Water Points	Public tap stands, cattle troughs and house connections

5.5.3 Valves

Note: Many valves do not work properly. This is frequently due to improper use or incorrect selection of the valve. Explain the differences between gate valves, non-return valves, washouts, air valves and stopcocks or taps, as outlined below:

Box 5-1: Function of different Valves

1. Gate valves are designed to be fully open or fully closed.
2. Gate valves allow us to start or stop the flow of water in a pipe.
3. Gate valves should be opened or closed slowly to reduce the chance of hammer pressures.
4. Non-return valves control flow so that it goes in one direction only.
5. Air valves are placed at high points along a pipeline to release trapped air.
6. Washouts are placed at low points along a pipeline to drain the pipeline at a controlled point and to flush out any silt that has accumulated in the pipeline.
7. Stopcocks or taps can be used like a gate valve or to regulate flow.
8. Taps are most appropriate at consumer points because they are designed.

to be open and closed many times a day.

5.6 Specific Pipeline O&M Tasks

Ask participants what problems might occur if maintenance of the pipeline is not carried out properly. Identify components that require maintenance.

Typical maintenance tasks include:

- Repairing erosion around pipes and pipe supports.
- Repairing leaking or damaged pipes.
- Repairing damaged valve chambers.
- Checking for blocked or leaking air valves once a month.
- Opening washout valves once a month to clear silt (more often during periods of rain). Washouts should be opened and left open for a sufficient length of time to get water flowing fast to flush out all the silt. Check to see that all silt has been removed (look at color of the water).
- Clearing any bush or shrubs along the pipeline route and keeping the pipe markers in a good condition.
- Explain the importance of regular pipeline patrols. Ask how these

patrols could be made easier.

A detailed session to demonstrate pipe repair may be necessary if the maintenance staff are not competent with the kind of repairs that are frequently needed. There are various ways of repairing pipe leakages, depending on the kind of pipe and materials available.

Allow the operator or plumber to demonstrate the repair technique (see Attachment 5-3 to 5.5):

- Repair of PVC pipes by heating pipe end to make a socket (OK for low pressure pipes).
- Repair of PVC pipes using a socket with rubber
- Repair of PVC pipes using a glued socket
- Repair of PE pipes using ready-made sockets
- Repair of GI pipes involving threading the pipe ends and inserting a union/joint fitting and replacement pipe length.

Discuss tasks to be considered during the preparation of an O and M schedule including:

- patrolling pipeline route identifying leaks, illegal connections, exposed pipe, damage to pipe cover, pipe markers or pipe supports
- opening washouts to clear out silt
- checking air valves to ensure all air has been released
- checking ball cocks and main valves
- reading the master meter
- reading individual or kiosk meters
- Checking that consumption is in accordance with agreed uses.

5.6.1 Preparation for Repairs

Ask the participants what should be prepared before departing to the site for repair works and discuss on the following issues to be taken in to considerations.

1. Post the phone numbers of key maintenance personnel conspicuously in the pumping station or office,
2. Keep the following items available and ready for use at all times: valve keys, hand tools, digging tools, pavement breakers, trench-shoring material, a portable centrifugal pump, floodlights, an emergency chlorinator, and calcium hypochlorite,
3. Keep a stock of split-sleeve and mechanical-joint repair fittings in sizes that fit critical mains,
4. Keep an inventory of the type of equipment that is available at these sources whether for borrowing or renting. The contact details of the persons in charge of the equipment at these sources should also be posted conspicuously at the pumping station.

After a pipe break is located, determine which valve is to be closed to isolate the section where the break has occurred and should be notified about the break.

After the closure of the valve the dewatering/mud pumps are used to drain the pipe break points. The sides of trenches have to be properly protected before

the workers enter the pit.

The damaged pipe is removed, and the accumulated silt is removed from inside the pipe and the damaged pipe is replaced and the line is disinfected before bringing into use.

A report shall be prepared following every pipe break about the cause of such break, the resources required for rectification and the time and cost required for repairing etc. so that the WAO/operators/plumbers can follow up with measures for avoiding such breaks and also modify their plan to address such breaks in future.

5.6.1.1 Repairing Pipe Leaks

The repair job then consists of sealing the leaks and/or replacing the defective pipe section.

Explain different methods of fixing leaks as described below:

a) Using Epoxy (for Small Leaks)

1. Dry the surface of the area to be repaired,
2. File the surface to make it rough, and slightly enlarge the crack or hole,
3. Apply the epoxy, forcing some of it into the crack or hole to produce a seal,
4. Normally, the epoxy will set in 2 to 4 hours before the pipe can be disinfected and put back into service, However, be sure to check the directions for use of the epoxy as some types may require more or less time.

b) Using Sleeve Type Coupling /Repair Clamps

1. Put a split sleeve/repair clamp around the leak opening.

c) Using Strips from the Inner Tube (“Interior”) of a Rubber Tire

1. In emergency work when no other repair materials are available, cut a discarded inner tube of a rubber tire into strips and wind the strong, flexible rubber strips tightly around the pipe to cover the leak and its surrounding surfaces.
2. If the leak is small hole, insert wood temporary until the main repair start.

d) After the Leak is Repaired

1. Open the control valve to allow water to flow into the repaired section,
2. Observe carefully to verify if the leak is completely sealed,
3. After sealing, backfill the excavation and restore the surface to its former condition,
4. Apply the disinfection procedures.

5.6.1.2 Replacing Damaged Sections of Pipelines

When the damage in a certain section of a water main is extensive, repair may involve cutting off and replacing the damaged section. The procedures for repairs are as follows:

a) For Galvanized Iron (G.I.) Pipes

Attachment 5-3 shows the procedures of galvanizing Iron pipe repairs. Please refer it for detailed explanation.

Box 5-2: Repair procedures of galvanized Iron Pipes

1. Isolate the defective section by closing appropriate control valves;
2. Excavate the water main;
3. Determine the exact location of the leak;
4. Cut the defective portion of the water main;
5. If a nipple of appropriate length is not available, prepare a substitute nipple using a short pipe of the same kind, diameter and length as the cut off defective pipe;
6. Thread the ends of pipe to be joined;
7. Install G.I. coupling and union parts;
8. Assemble them as shown in Attachment 5.3;
9. Open the control valve to allow water to flow into the repaired section. Observe carefully if the repaired section is not leaking;
10. If there is no more leak, backfill the excavation and restore the surface to its former condition;
11. Disinfect the repaired section.

b) For Polyvinyl Chloride (PVC) Pipes

Explain the detailed procedures for repairing uPVC pipeline as described in Box 5-3 and attachment 5.4.

Box 5-3: Repair procedures of uPVC Pipes

1. Isolate the defective section by closing the appropriate control valves.
2. Excavate the water main;
3. Pinpoint the leak;
4. Measure and cut the defective portion of the pipeline. The length of the pipe cut should have an equivalent commercially available threaded nipple;
5. Install the PVC socket and adaptor union;
6. Join the two cut portions of the water main with the nipple in between (In case PVC threaded nipple is not available, use the equivalent G.I. threaded nipple);
7. Open the control valve to allow water to flow into the repaired section and observe if it is not leaking;
8. If there is no more leak, backfill the excavation and restore the surface to its former condition;
9. Disinfect the repaired section.

c) For Polyethylene (PE) Pipes

Explain the detailed procedures for repairing PE pipeline as described in Box 5-4 and attachment – 5.5:

Box 5-4: Repair procedures of Polyethylene (PE) Pipes

1. Isolate the defective section by closing the appropriate valves and excavate main;
2. Cut the defective portion of the water main;
3. Check if the two separate ends of the cut can be pulled together to be joined. (This is usually possible because PB and PE pipes are laid in serpentine fashion as shown in Figure 4.4.) Otherwise, a small connecting section must be inserted;
4. Join the 2 separated ends. Use the butt-welding method;
5. Open the control valve to allow water to flow and observe for leaks;

5.6.1.3 Pipe Cleaning

The training facilitator identifies causes that requires pipe cleaning and explains the problems both in terms of quantity and quality, and the need to cleaning the pipelines.

- Water going through the pipelines may sometimes carry sand, sediments, and organic and other objectionable matter.
- When water velocity is low, these tend to get deposited and build up inside the pipes. The built-up deposits decrease the carrying capacity of the pipes and increase internal friction, making the pipelines less efficient.
- Less water can be delivered per given time, pumping costs increase, and the added and uneven pressure within the pipelines increases the likelihood of breaks and leaks.
- These effects are complicated when magnesium and calcium salts are present in the water (hard water), as their precipitation results in scaling inside the pipes. Likewise, when organic matter is present in the deposits, bacteria grow, causing undesirable odours, and an off-taste and colour in the delivered water.
- When disturbed, corrosion deposits in pipes or sediments caused by improper treatment have to be removed in order to prevent water quality deterioration.

The decision to conduct pipe cleaning results from the following situations:

- Consumers' complaints about water quality (colour, turbidity),
- After a new pipe has been laid or an existing pipe has been repaired,
- The need for removal of excessive disinfectant used to kill bacteria or living organism in pipes,
- Systematic cleaning as a part of regular preventive) network maintenance.

Explain the three techniques of pipe cleaning which are commonly used:

- Flushing,
- air scouring and
- Swabbing (or pigging).

1. Flushing

The method for removing solids which are not cemented to the inside surface of pipes is to flush with water at high velocity. Annual flushing is generally sufficient to maintain the pipelines clean. (But note that different water and pipe materials may need a different schedule.)

The nature of rural piped system is dead end. Dead end pipes should be flushed and disinfected at least once a year.

Furthermore, whenever mains are opened for repair, they should also be flushed and disinfected.

By opening washout valves or hydrant on the main, an increase water flow is generated to remove loose deposits. Approximate velocities required for transport of sand particles (ρ=2650 kg/m^3) as presented in Table 5.2 below.

Table 5-2: Required Flushing Velocity for sand particles, d=0.2mm (Brandon, 1984)

Pipe Diameter (mm)	V (m/sec)	Q (l/sec)
50	1.3	2.7
75	1.6	7.2
100	1.8	15.0
150	2.2	41.0
200	2.6	83.0

As a general guideline, the approximate quantity of water needed is equivalent to three full volumes of the pipe that is being flushed.

Box 5-5: Pipe Flushing Procedures

1. Isolate the water mains to be cleaned by closing the appropriate control valves,
2. Empty the water mains by opening the blow-off valve or other temporary outlet at the lower end of the pipeline. In some cases, to expedite the emptying of water mains without pumping, compressed air may be introduced at the highest point of the isolated system,
3. Inject water at high-induced velocity (as indicated in Table 5-2) until the objectionable materials are expelled,
4. As needed, disinfect the pipelines. After disinfection, flush the pipeline with clean water until the chlorine-odor is hardly detectable,
5. Put pipelines back to operation.

Flushing is a simple method of cleaning, but not always efficient. The

disadvantages are:

- Large amounts of water used (particularly in large diameters),
- the velocity increase in the pipe being flushed may disturb the flow

and pressure pattern upstream of the cleaned section, in areas with progressive corrosion, flushing offers only a partial improvement,

- Not all parts of the distribution system may be equally suitable for the generation of high velocities (e.g. in low pressure areas).

Flushing pipes as a preventative measure requires good planning. The following factors are to be taken into consideration:

- selection of the optimal pipe route,
- the location of valves that are operated in order to isolate the flushed route from the rest of the system,
- total length of section that is flushed in one run,
- choice of hydrants (number and location) that will have to be opened in order to generate the necessary velocity,
- Proper sequence of routes to be flushed.

The target of any flushing plan is to clean the system efficiently i.e. with the minimum quantity of water possible, as well as with the minimal operation of hydrants and valves.

5.6.1.4 Operation of Valves

- If valves are not opened and closed at regular intervals, they may become inoperative due to rust, corrosion or dirt.
- Valves should be operated at least twice each year. Records should be kept of the number of turns required to open or close each valve and of the position (open or closed) in which the valve was left.
- Kerosene or diluted lubricating oil poured down the valve key may help in loosening a valve stem which binds due to dry packing.

a) To check whether a valve is operational or not:

- First close the valve completely and then open it completely;
- Back off on the valve about one turn to avoid locking it in an open position; and
- If the valve does not operate properly, repair or replace at once.

b) Things to check:

- Ensure that the valve boxes are not full of mud or debris, or become buried;
- Inspect the valves for leaks around the valve stem;
- Ensure that the valve handles are intact;
- Ensure that each valve can be fully opened and fully closed;
- Record the inspection date, whether the valve is right- or left-handed, and whether it is normally open or normally closed;
- Record any needed repairs or replacements.

5.6.1.5 Repair, Maintenance of Water Meters

The water meters are mechanical devices, which normally deteriorate in performance over time. The fact that a meter does not show outward signs of any damage and has a register that appears to be turning does not mean that

the meter is performing in a satisfactory way.

It is necessary to ascertain the following preventive cares for water meter after proper installation.

a) Preventive maintenance:-

1. Proper handling, storage and transportation of water meters.
2. To clean the dirt box or strainer wherever installed.
3. To replace the gaskets, if any.
4. To clean the chamber in which the meter is installed and keep free from flooding, & seepage.
5. To remove the meter for further internal repair/replacement if it does not show correct reading pattern.

b) Breakdown maintenance:-

Replacement of broken glass, lid and fallen wiper wherever provided:-

These are the only basic breakdowns observed during periodical inspection. If a meter found not working, then it shall be removed immediately and sent to meter service workshop. In meter workshops normally following steps are performed to carry out the repairs.

1. Disassembling of water meters including strainer, measuring unit, regulator, registering device, etc.
2. Clean all disassembled spare parts in detergent solution in warm water.
3. Inspect the cleaned parts and replace worn parts and gaskets, if any.
4. Inspect the meter body spur threads and cover threads.
5. Inspect the sealing surface on meter body and paint the meter body, if necessary.
6. Inspect the vane wheel shaft pinion, bearing & pivot.
7. Inspect the vane wheel chamber.
8. Reassemble the water meter properly after reconditioning.
9. Calibrate & test the repaired water meter for leakage & accuracy as per guideline (BS or other standards).

   Make entry in the life register of that water meter for keeping history record.

5.7 Troubleshooting

5.7.1 Troubleshooting for Pipeline

Discuss the potential unexpected problems, what might be the causes and some possible solutions.

Table 5-3: Troubleshooting for Pipelines

No.	Problem	Problem Cause	Possible Solution
1	Numerous repeated breakages in pipeline	Pipeline laid too shallow and pipe exposed to traffic loading Wrong type of pipe	Consider relocating or replacing the pipeline. (Consult with a water Engineer, qualified water technician or plumber.)
	No water in	▪ Breakage, burst	Check pipeline carefully,

	pipe	▪ Blockage – air lock ▪ Closed valve ▪ Source is dry ▪ Design problem	starting at the intake level and check at various points whether water is reaching each point. (Consult with a water engineer or qualified water technician.)
	Poor water quality	Polluted raw water ÌÌ Burst that has Introduced Pollutants or sediments ÌÌ Faulty treatment	Investigate the problem and identify a suitable solution. Carry out a water quality test if appropriate.
	Low pressure	High friction losses from movement of the pipework, restriction in pipes, bursts, low ÌÌ abstraction, excessive consumption	Identify whether a maintenance solution will resolve low pressure; this may include water rationing, or the problem is related to a design issue. (Consult with a water engineer or qualified water technician.)

5.7.2 Troubleshooting for Watermeter

Explain the troubleshooting requirements for watermeter using Table 5-4. Identifying the problems, the causes and remedial measure to make it operational.

Table 5-4: Troubleshooting of Water Meter

No.	Trouble	Cause	Remedies
1	Meter reads in reverse direction	Might have installed in reverse direction	Check the arrow of the meter body and installed the meter properly, if necessary
2	Meter not recording	Impeller to register link broken	Remove the meter for service and repair
3	Continuous moving pointer/digit rotates but not change in indicator	Pointer and drum link missing Drum defect	Remove meter for servicing and repairs
4	Dial/glass foggy	Climatic Condition	Wait for climate change, if it is rainy season

5	Meter suspected slow or fast	Inlet flow disturbance, missing internally defective, deteriorated magnets in case of magnetic meters	Clean the external filter/dirt box where provided and the in-built strainer Ensure full open condition of upstream valve, if doubt persists, remove meter for testing, servicing and repair
6	Bush/Gland leakage	Gland deformity	Remove meter for testing and servicing
7	Regulator, head, body leakage	Regular washer damaged, loose screw	Remove meter for servicing and repair
8	Physical damage to meter including broken seal	Improper installation	Remove meter for testing, servicing and repair
9	No water available past the water meter even though inlet side is charged	Semi positive /positive displacement meter with jammed piston	Meter is acting as a stop valve. Remove it for inspection, servicing and repair

In case of smaller size water meters, it is advisable to check cost benefit ratio before getting them repaired.

5.7.2.1 Prevention of Tampering of Water Meters

In order to prevent tampering, following precautions should be taken:

1. The water meters, shall be installed properly in the chamber with lock and key or in the C.I. covers with lock and key in order to avoid tampering.
2. The water meters must be sealed properly.
3. The water meters shall not allow reversible flow; it should register flow in forward directions only.
4. The water meter dials should be easily readable without confusions.
5. The lid, glass of water meters must be made up of tough materials as per any standard and shall be replaced timely.
6. The wiper or dial as far as possible is avoided.
7. In case of magnetically coupled meters, the proper material to shield magnets must be provided in order to avoid the tampering of such meter by outside magnets in the vicinity of meter.
8. Periodical inspection/checking at site is essential to ensure the proper working of meter.
9. Special sealing arrangements may be necessary and provided for bulk meters whereby unauthorized removal of the meter from the connection can be detected.

In spite of above, to tackle the problems of tampering suitable penalty provisions/clauses shall be there in the rules or the water supply agreement

with the consumer. This will also discourage the consumer tendencies of neglecting water meter safety.

5.7.2.2 Trend of replacement of Water Meter

In general, if a water meter goes out of order due to any physical damage or non operation of registration device and is beyond economical repair it should be replaced with immediate effect. In Indian context, the performance of water meter depends upon -

1. The quality of water meter produced by manufacturer and it differs from manufacturer to manufacturer.
2. the design of pipeline & fittings in line with meter;
3. the workmanship & care when handling and installing the meter;
4. the pattern of water passing through the meter;
5. the type of supply of water whether it is continuous or intermittent;
6. the meter maintenance, testing;
7. The proper selection of meter.

The performance of a water meter is required to be watched continuously with suitable history sheets. Any abnormality noticed needs immediate action. Timely removed faulty meter, & especially mechanical type meter, prevents cascade and cumulative damages.

Looking at the amount of transactions involved, bulk meters shall be given priority in replacements. Based on the experience gained for a specification work, a well planned programme for periodical meter testing, servicing, repairs and replacement wherever necessary shall be designed.

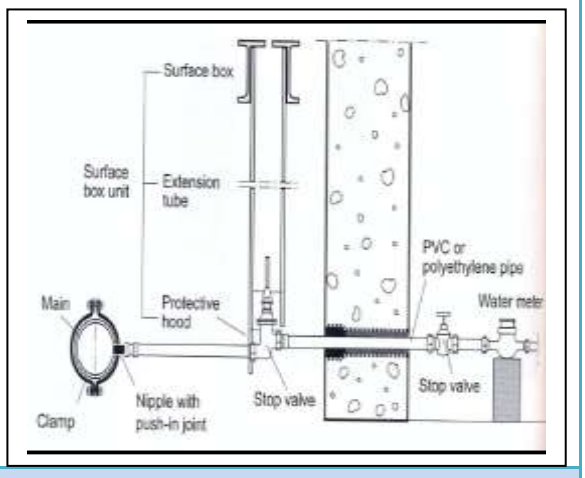
5.8 Service Lines Repair

The causes of leakage and breakage in service pipes are: Shallow and inadequate laying of service high water pressure in the system, internal and external corrosion of pipes.

The following actions should be taken in the repair of service pipes.

- Leakage in service pipes should be located, if necessary, by sounding.
- Joint leakage should be repaired by cutting out the part and replacing it.
- Service lines clogged from sediment from mains should be cleaned by dragging or pushing a scraper through them or by blowing with compressed air.
- Service pipes uncared for after a house demolition or road widening should be removed as they may cause leaks.

Service line should be regularly inspected for cross-connections.



5.9 Step 4: Spares, Tools, &

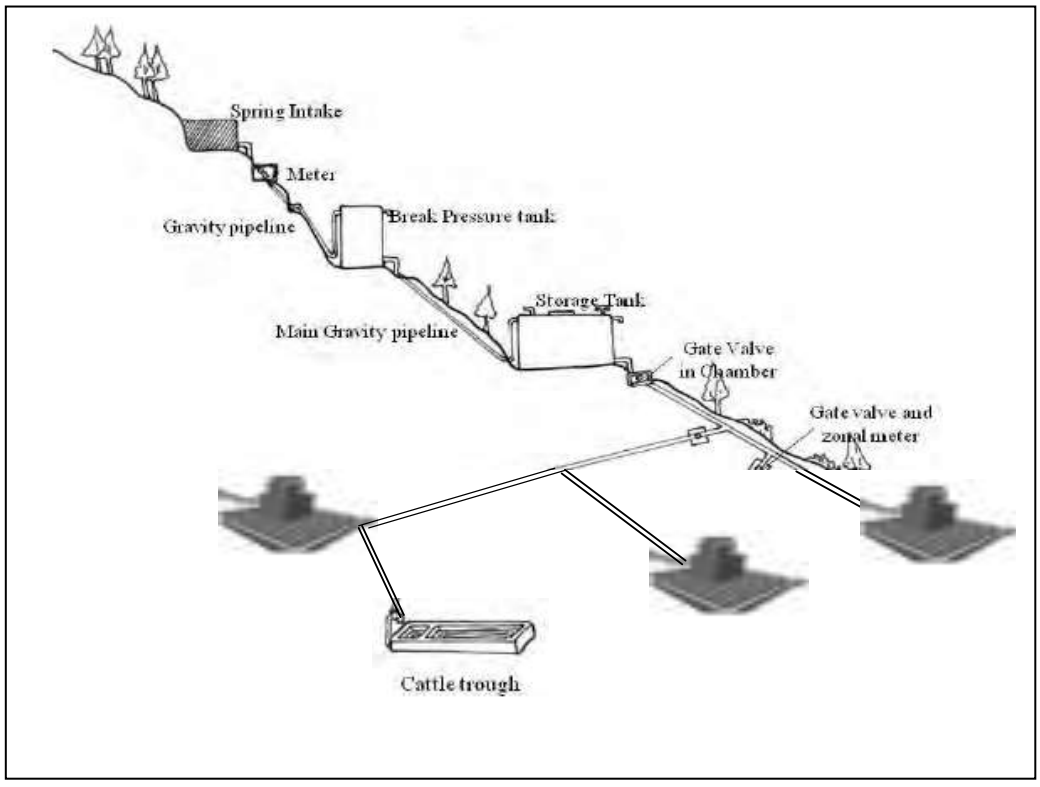
Spare Parts & Materials for pipelines include:

- Pipe lengths for the diameters common in project;
- Fittings for appropriate diameters;

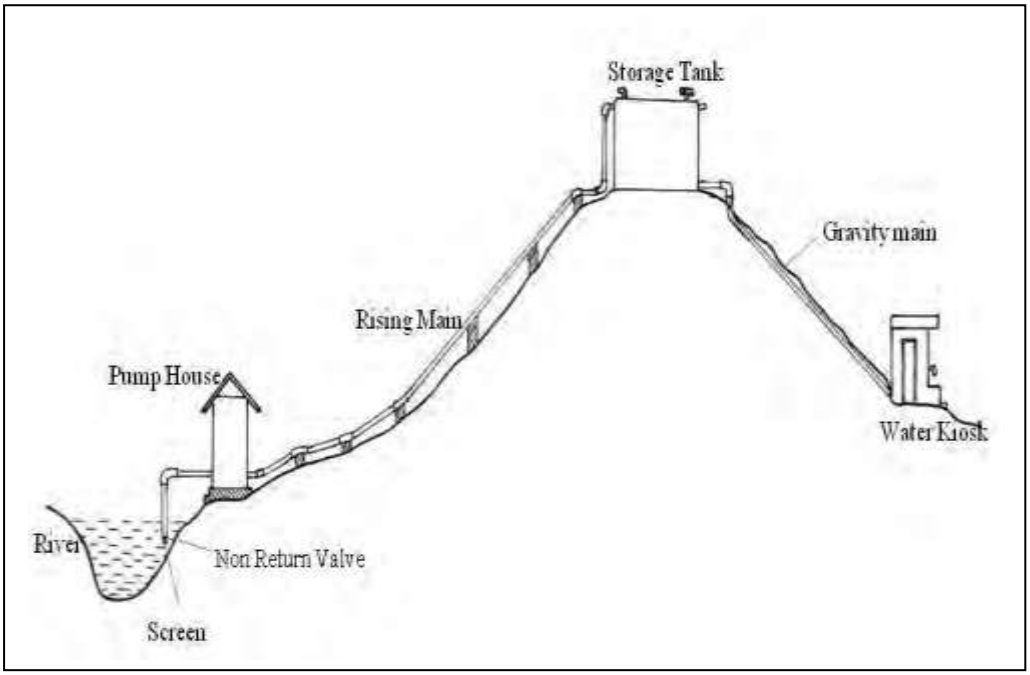
Technical Assistance	▪ Valves; ▪ Taps & tap washers; ▪ Threading Tape; and ▪ Glue Supply Chain – most pipeline materials can be purchased at a well provisioned hardware store. Technical Assistance – technical assistance should be sought if a pipeline keeps bursting at a particular point. This may indicate: ▪ Lack of anchor blocks or supports; ▪ Hammer pressures; ▪ Unusual stress on the pipe; and ▪ Poor design.
Review	▪ Are participants able to carry out basic pipeline repairs? ▪ What are the factors that may cause problems in a pipeline? ▪ How are these factors prevented?

Session Attachments

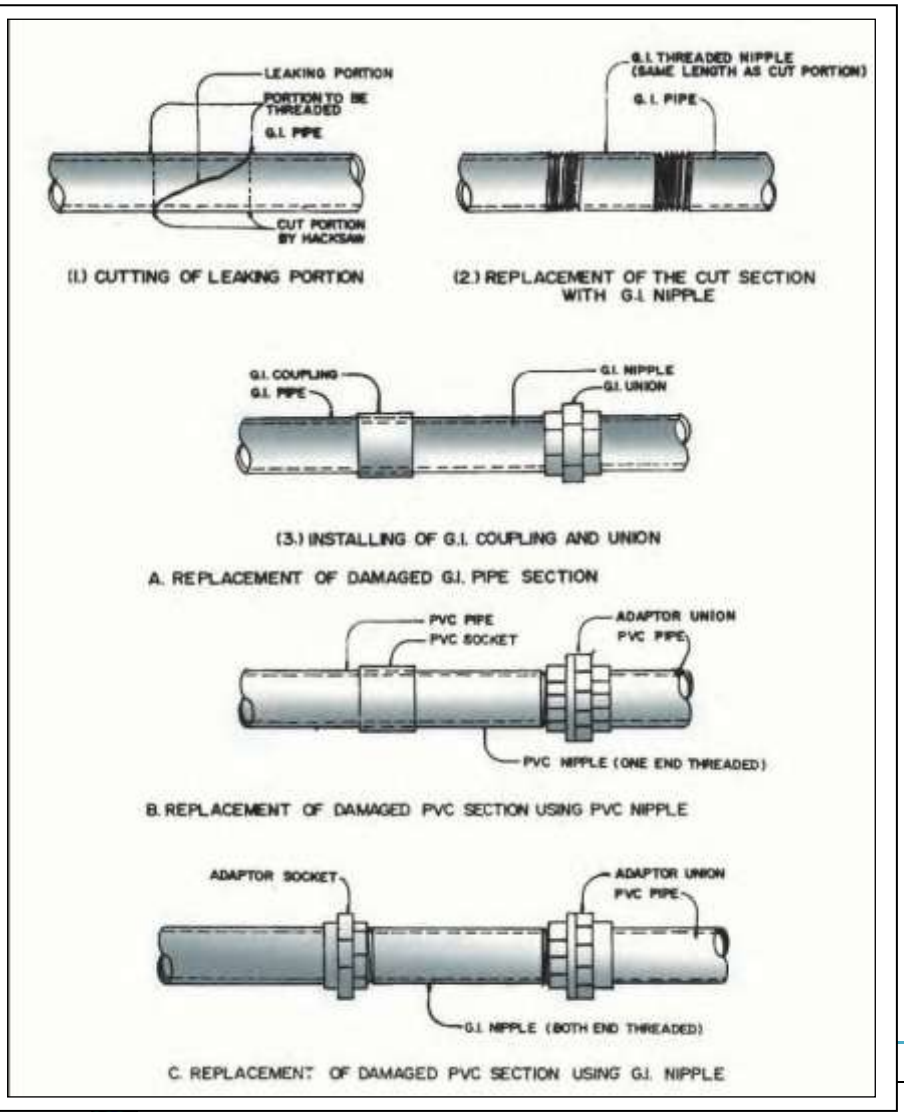
Attachment 5-1: Typical Gravity System Pipeline



Attachment 5-2: Typical Pumping System Pipeline

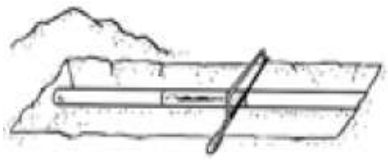


Attachment 5-3: GI Pipes Repair Procedures

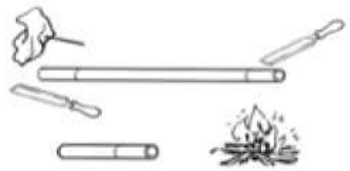


Attachment 5-4: Procedure for repair of broken PVC pipe

1. Isolate the leaking section by closing the sluice or the gate valve.
2. Dig the trench along the leaking pipe to find the leaking place that needs to be repaired. Dig the trench wide enough to give yourself working space. Dig the trench two meters on each side of the leaking point, to allow you to control the pipe.



3. Cut out the leaking piece using a hack saw.
4. Cut out a new piece of pipe. The new piece must be longer than the old one. Measure the length of the old piece; add 75 millimeters on both ends. This will be your “socket pipe”.
5. File the edges of the pipe where you cut. Clean the cut ends of the pipes with the mutton cloth. Also file and clean the ends of the pipes in the trench.

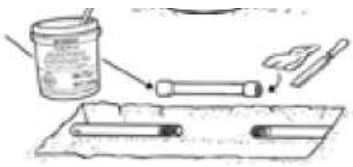


6. Cut a short piece of the same diameter pipe to use for forming the sockets. Make a small fire.

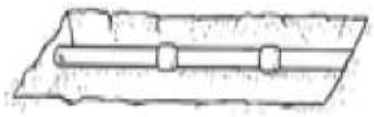
7. Heat the end of the socket pipe for a distance of 75 mm as your mark shows. Keep rotating the pipe so that it is equally heated all the way round.

8. When the heated part is soft, insert the other short piece of pipe and rotate it until a socket is shaped. The socket should be 75 mm deep.

9. When the socket is correct, dip it unto a bucket of water to cool. Make another socket at the other end.



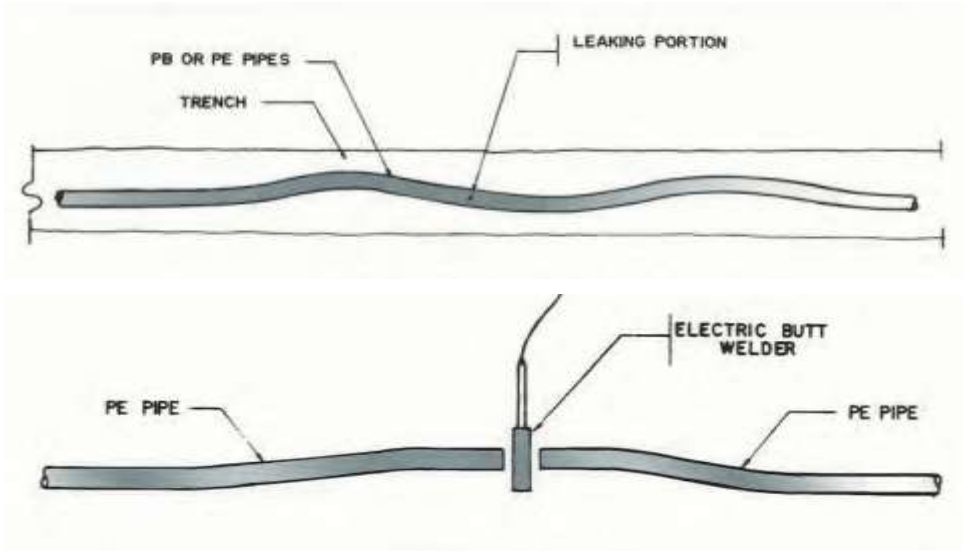
10. File the edges of the socket pipe. Clean the ends of the socket pipe with mutton cloth. Apply tang it inside the sockets and outside the pipe in the trench. Be sure to read the instructions on the tin of the tang it. Obey the instructions.



11. Connect the pipes. Do not move the connection for at least five minutes. Fill the trench except for the part that has been repaired. Do not let water go through for some hours. Turn on the water and check for leaks. If there are no leaks, cover the rest of the pipe.

This kind of repair needs two people, you and your relief operator.

Attachment 5-5: PE Pipes Repair Procedures



6 SESSION – F: O&M REQUIREMENTS FOR STORAGE TANKS

Module - C	TECHNICAL O&M REQUIREMENTS FOR RURAL PIPED SYSTEM
6.1 Session Outline	This session covers the following core topics for technical O&M management: ▪ Introduction ▪ Types of Service Reservoirs/Tanks ▪ Components of Service Reservoir ▪ Operation of Service Reservoir ▪ Specific O&M Requirements for concrete and steel service reservoir ▪ Troubleshooting for service reservoir ▪ Spare parts, Tools and Technical Assistance Requirements
Appropriate Facilitator	This session is supposed to be offered by Water Engineer having theoretical and practical experiences.
6.2 Objective	At the end of the session, the participants will be able to: ▪ identify the main components of service reservoir or a tank ▪ describe the functions of the key components ▪ Carry out operation and maintenance tasks.
Outputs	An O and M schedule
Session Timing	4 hours
Methodology	This is intended to be a practical session. The components will be taught by demonstration of the system itself, not using drawings or descriptions. The flip chart can be used to illustrate details if necessary. Reinforce the learning by allowing participants to handle the parts and describe their functions to each other.
Materials	▪ valve key/wheel ▪ pipe wrench ▪ brush or broom ▪ materials to make tank repairs
Session Guide and Contents	
6.3 Introduction	Water supply provision is pumped from the water source to the system's water tank or service reservoir, from which it is delivered to the consumers through the distribution pipelines.

The service reservoirs can be constructed either:

- Underground,
- Ground level or,
- Elevated (water towers)

Different kinds of service reservoir/tanks are available depending on the material of that makes them such as:

- Reinforced concrete (floor, walls, roof)
- Masonry walls on reinforced concrete floor & roof;
- Ferro cement;
- Plastic;
- Corrugated iron; and
- Steel (ground or elevated).

Tanks with different names occur in different kinds of projects relating to their function and placement, e.g.:

- rainwater harvesting tank
- rock catchment tank
- Berkad (Somali name for an underground tank)
- storage tank
- Break-pressure tank.

The training session covers standard forms of tanks.

6.4 Components of Service Reservoir

The training facilitator should explain the various components of service reservoir/tanks using attachment 6-1 and Table 6-1.

Table 6-1: Components of Service Reservoir

No.	Component	Function
1	Inlet valve	valve to control flow into the service reservoir; if closed water does not enter service reservoir
2	Inlet pipe	lets water into tank above service reservoir water level
3	Float valve	valve on inlet pipe that automatically closes when the service reservoir / tank is full of water
4	Washout	pipe and valve that is opened to allow cleaning of the service reservoir /tank
5	Overflow	disposes of excess water
6	Manhole/cover and ladder (external & internal)	allows inspection and cleaning of service reservoir /tank

	7	Ventilation pipe	allows circulation of air to keep the water aerated; must have mesh/netting over ends of pipe to prevent insects or animals from entering tank

6.5 Operation of Service Reservoir

6.5.1 General Procedures

The main function of Service Reservoir (SR) is to cater for daily demands and especially peak demands of water. Operators must be concerned with the amount of water in the storage reservoir and the corresponding water levels at particular times of the day.

Procedures for operating the Service Reservoir will depend upon the design of its storage capacity and on the water demand.

- Reservoir water level should be read every 1 to 2 hours and recorded, to secure functioning of the reservoir.
- Daily water delivery and its hourly changes should be recorded by self-recording flow meters or main line meter.
- Water level in the reservoir should not fall below the limit in which air and deposited substance will be absorbed into the effluent pipe.
- Valves, water level meter, flow meter and gauges should be checked regularly to ensure their proper operation.
- Reservoirs should be emptied, cleaned, repaired and disinfected at regular intervals.
- Leakage in reservoir should be checked regularly. To investigate the leakage, full the reservoir to full and close influent and effluent valves. Then check for any change in the water level. A fall in the water level indicates leakage. If leakage is located, immediate repair should be made.

6.6 Specific Service Reservoir O and M Tasks

6.6.1 Concrete Reservoirs

- Drain and clean reservoir by draining the stored water into the distribution system, until about 10 cm remains. Use this water to clean and scrub tank floors and walls. Remove all water, sediments and loose materials,
- Check for cracks in concrete reservoirs and repair,
- Check manhole cover (sufficiently tight fitting),
- Check interior piping for corrosion; clean and repaint,
- Disinfect tank after thoroughly rinsing the interior of the reservoir by adding a chlorine solution to the water at a sufficient rate to provide a chlorine solution of 2mglliter when the tank is full. Keep the chlorinated water in the tank for 24 hours before putting the storage reservoir back into service. The disinfected water is suitable for domestic consumption.

6.6.2 Steel Tanks

- Check general condition for loose scale, leaking seams and rivets; repaint if necessary.

- Inspect ladder, roof, and structure forms, base and stand tower foundation.
- Inspect condition of paint work - empty tank, examine interior paint. If heavy corrosion exists, arrange for withdrawing the tank from service to permit repainting. Carry out proper cleaning and repainting by suitable paint for drinking water. After painting, carry out the disinfection for concrete reservoirs as mentioned above.

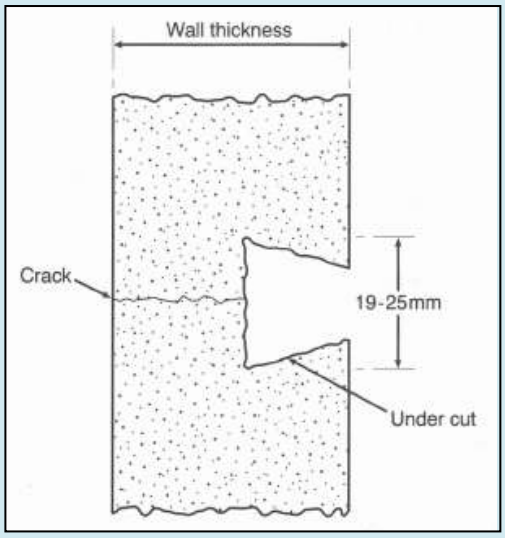
6.6.3 Crack Maintenance

a) Repairs Using Cement Mortar

Cracks in concrete tank walls should be repaired from the inside; if at all possible, by chiselling a cut in the cracked area and filling with a stiff cement mortar (1:3 mixes by volume). Keep the repair wet for at least 24 hours before putting the tank back into operation. Remember to disinfect the tank if necessary.

If it is not possible to reach the inside of the tank easily, try undercutting (dovetailing) from the outside as follows:

- Drain to below the crack line.
- Using a cold chisel, make a cut on the reservoir cracked/leak with the following dimensions: Width 19-25 mm and depth 19-25 mm
- Clean and wet the cut before applying a stiff mortar (1:3 mix).
- Clean and wet the holes cut in the reservoir and apply the cement mortar paste.
- Keep the mortar wet for at least 24 hours before putting the tank back into operation.
- Disinfect the tank;
- Rinse the tank with clean water;
- Put the repaired tank back into operation.



b) Repairs Using Proprietary Fast-Setting Cements

There are a number of proprietary fast-setting hydraulic cements specially formulated to quickly stop leaks and the seepage of moisture through holes or cracks in concrete or masonry walls.

Some brands are “Quickrete”, “Parson Quick Plug”, and “Dry Lok Fast Plug.” These are generally based on Portland cement, but have ingredients that make the compound expand as it sets. Most of these proprietary blends are supplied as a dry powder to be mixed with clean water, and set within 3 to 15 minutes depending on the brand.

These formulations are durable and can be expected to last for the life of the concrete structure being repaired. They do not contain toxic elements, are highly impervious to water, and thus are suitable for use with potable water systems.

Application Procedure:

1. Open up the crack or hole by making a cut along the damaged area using a cold chisel. This will make it possible for the compound to form a plug. As the compound sets, it expands to complete the seal;
2. Before applying the compound, brush away all loose particles;
3. Mix the compound in accordance with the manufacturer's directions, which usually results in a paste of sticky consistency. The compound is hydraulic cement that begins to bind once it comes into contact with water. Once the water is mixed in, the paste must be used within minutes;
4. Apply the paste and force it into the crack. Start from any edge;
5. When sealing leaks beneath the water level in an un-drained reservoir, use a trowel or your hand with a glove. Hold the mixture in place for 3 to minutes or until no water passes through the leak;
6. Keep the repaired leak damp for 15 or more minutes (see directions).

c) Repairs Using Epoxy

Epoxy is an adhesive sealant available commercially in plastic packs of 15 grams or more. It consists of two components: A (Resin) and B (Hardener). Epoxy is generally used in repairing small leaks. Repairing a reservoir using this compound requires the following steps:

1. Drain the reservoir;
2. Dry and clean the surface to be repaired. In the case of steel tanks, roughen the surface to ensure good adhesion. In the case of concrete surfaces, clean out all loose particles;
3. Squeeze equal amounts of component A (Resin) and B (Hardener) on a suitable palette, and mix thoroughly;
4. Apply the mixture immediately to the leak;
5. Allow 2 to 4 hours for the epoxy to set. (Check instructions on the package if more or less setting time is needed);
6. Put the reservoir back to operation.

d) Repairs on Steel Tanks Using Electric or Acetylene Welding

1. Drain the reservoir;
2. Dry the surface to be repaired;
3. Weld the hole or break directly if small. If the leak is large, cut a metal plate with size lightly greater than the hole and then weld it in place;
4. Clean and smoothen the welded surface;
5. Paint the repaired area;
6. Disinfect the reservoir;
7. Put the reservoir back into operation.

6.6.4 Cleaning of Service Reservoir

To ensure the quality of the water supply, the service reservoir must be

cleaned and disinfected periodically. Failure to apply this routine will result in the accumulation of solids and proliferation of bacteria in the tank, making the water unsafe for drinking.

Cleaning is usually done once a year, but it always must be done whenever the water in the reservoir contains an appreciable amount of dirt.

Routine inspection is the best way to determine when a tank requires maintenance and cleaning. A visual inspection can be made from the roof manhole with water level lowered to about half full or less.

The following activities are normally involved in cleaning of service reservoir/tank:

- Make alternate arrangement for water supply to consumers served by the SR,
- Close the inlet line before commencing cleaning of SR,
- Draw the water from the SR till 20-30cm water is left in the SR.
- Close the outlet valve so that no water will be used while the tank is being cleaned.
- Collect sample of water and silt/mud accumulated in the Tank and get the biological analysis and for presence of snails and worms. If snails and worms are found find the source and eliminate it.
- Drain and dispose off the remaining water and silt.
- Wash the interior of tank walls and floor with water hose and brushes.
- Inspect the interior of walls and ceiling of tank for signs of peeling off or deterioration.
- Apply disinfectant (Supernatant of Bleaching powder) to the walls and floor before start of filling the tank/SR.

Frequency of cleaning of SR depends on the extent of silting, development of bio films and results from water quality monitoring.

6.6.5 Maintenance of Reservoir Appurtenances

a) Monthly Maintenance Tasks

- Lubricate float control pulleys.
- Inspect float for leaks.
- Check level indicator for free operation.
- Sweep roof, catwalks and ladder landings.

b) Manholes

Manholes should always be covered and locked to keep out foreign materials that could contaminate the water supply and also to prevent accidents.

c) Overflow Pipe and Air Vents

1. Covered reservoirs or tanks should be vented to allow the passage of air to and from the reservoir as the water level changes. Use fine screens on the vents to prevent the entrance of animals and insects, and keep the screens in good repair.
2. Keep access manhole covers in place to prevent accidents and

contamination.

3. Slope the ground away from the reservoir in all directions to prevent surface water from flowing towards it.
4. Leaks in the cover or walls that allow surface water or shallow groundwater to seep in are dangerous. Repair leaks at once.

- closing and opening the control valves once a month
- releasing a jammed float valve
- holding the float valve in the up position; there should be no flow
- holding the float valve in the down position; there should be normal water flow
- checking the float valve for leaks and seal leaks
- replacing the rubber washer if there is a leaking float valve (see Attachment-6.1)
- replacing the pin on the float valve arm
- Opening the washout and clearing silt from the tank once a month. (Note: The tank should be almost empty and the outlet valve must be closed before cleaning.)
- checking that the manhole is properly covered to prevent insects and animals from entering tank
- repairing any cracked or damaged tanks and covers
- repairing the mesh or netting over the ventilation pipes
- checking the support tower for elevated tank for structural defects
- Checking the ladder in the tank to ensure it is safe to use.

6.6.6 Records at Service Reservoir

1. Records to be kept on the operation

- Water levels in the SRs (for all compartments) at hourly intervals.
- Time and relevant operation of control valves with time of opening and closure or throttling position of the valves.
- Hourly flow meter readings both on the inlets and outlets.
- Hourly residual chlorine readings of inflow water and outflow water.
- The man-hours spent on routine operations at the SR in previous year and the cost thereof.

2. Maintenance Record

Maintain record on each of the following maintenance/repair works along with the cost of materials and labour.

- When the gland ropes of the valves at the SR were changed,
- When the spares of the valves were changed,
- When the manhole covers were changed/replaced,
- When the water level indicator was repaired or replaced,
- When the reservoir was last cleaned,
- When the out-fall drain for scour and overflow was last cleaned,
- When the ladder was changed,

<table>
<tr><td></td><td>

When the structure of the reservoir was last repaired to attend to structural defects or arrest leakage,
When the reservoir was last painted,
When the piping at the reservoir was last painted,
Total cost of repairs and replacements at the SR in previous year along with breakup of material cost and labor cost with amount spent on outside agencies for repairs and replacements.

</td></tr>
<tr><td>6.7 Troubleshooting for Service Reservoir</td><td>
Discuss the potential unexpected problems, what might be the causes and some possible solutions.
<table>
<tr><th>Problem</th><th>Problem Causes</th><th>Possible Solution</th></tr>
<tr><td>Overflow from tank</td><td>Failure of float valve
Gate valve blocked (outlet side)
Airlock in pipeline (outlet side)</td><td>Replace the rubber washer (see Attachment 2).
Replace the pin.
Remove and clear the valve (replace if necessary). Check/open the nearest air valve.</td></tr>
<tr><td>Leaks from tank wall</td><td>Crack in wall</td><td>Repair on the inside – this will depend on the type of tank.</td></tr>
<tr><td>Cracks in roof</td><td>Settlement of roof
Too much loading on roof</td><td>Seal all cracks; add additional support if necessary.</td></tr>
</table>
</td></tr>
<tr><td>6.8 Spares, Tools and Technical Assistance</td><td>
Tools:

shovel and brush for removing silt
masonry tools for cement plastered tanks
pliers for repair of float valve

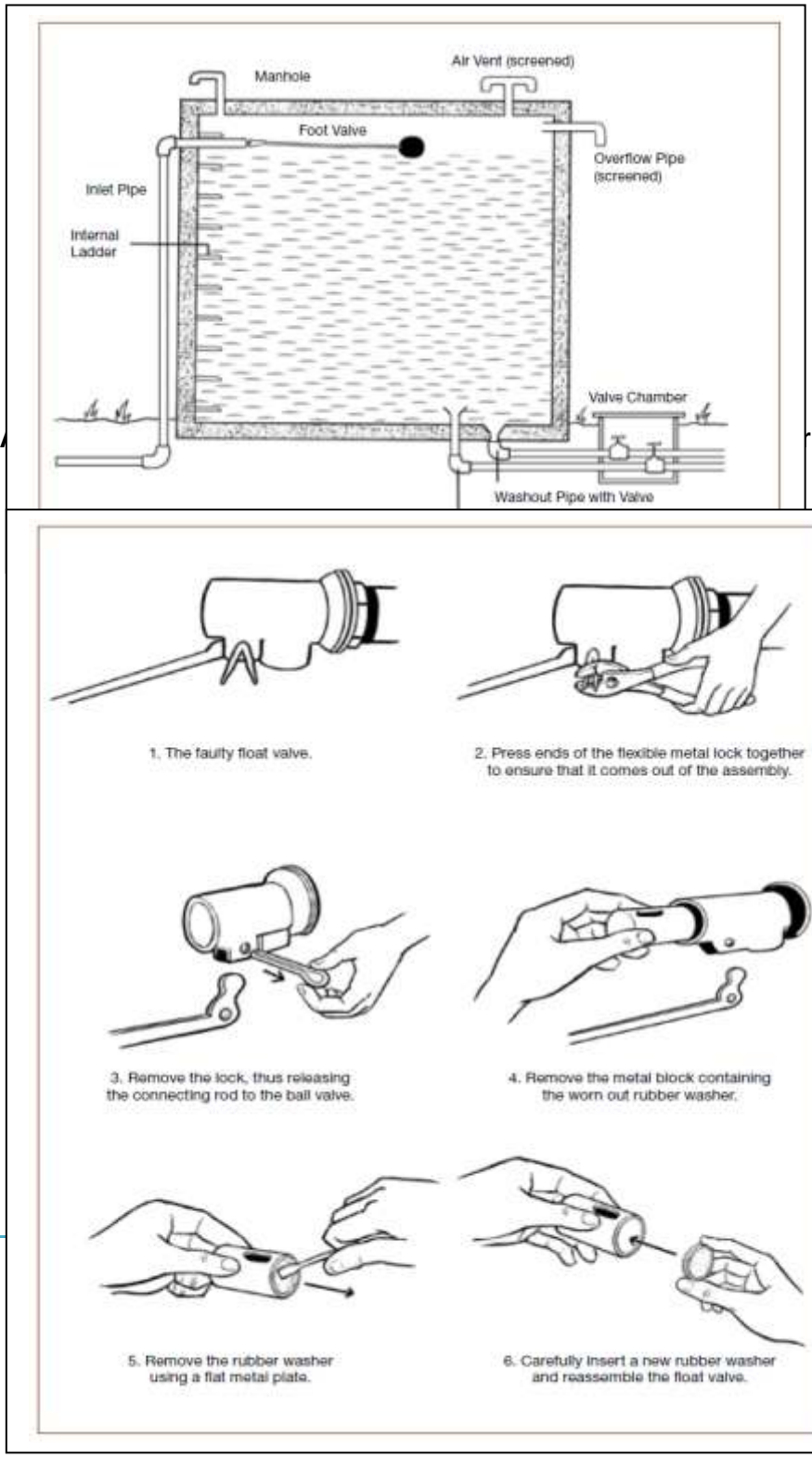
Spares – include:

pin for float arm
mesh, strainer
Check requirements of fittings for pipe inlets and control valves.

Supply chain – most tank materials can be purchased at a well-provisioned hardware store.
Technical assistance – this should be sought if the tank wall has major leaks or if the roof shows significant cracks and the structural integrity of the roof is in doubt.
</td></tr>
<tr><td>Review</td><td>

What are the main problems that can occur to the tanks within the scheme?
Can these problems be fixed by the WAO/EWB staff?
Is there an O & M plan?

</td></tr>
<tr><td>Session Attachments</td><td>Attachment 6.1: Sketch of a typical storage tank
Attachment 6.2: Diagram for replacement of the rubber washer on a float valve</td></tr>
<tr><td></td><td>Attachment 6-1: Sketch of a typical Service Reservoir/Tank</td></tr>
</table>


Manhole
Air Vent (screened)
Foot Valve
Overflow Pipe (screened)
Inlet Pipe
Internal Ladder
Valve Chamber
Washout Pipe with Valve
1. The faulty float valve.
2. Press ends of the flexible metal lock together to ensure that it comes out of the assembly.
3. Remove the lock, thus releasing the connecting rod to the ball valve.
4. Remove the metal block containing the worn out rubber washer.
5. Remove the rubber washer using a flat metal plate.
6. Carefully insert a new rubber washer and reassemble the float valve.

7 SESSION – G: O&M REQUIREMENTS FOR CONSUMERS POINTS

MODULE – C	TECHNICAL O&M REQUIREMENTS FOR RURAL PIPED SYSTEM
7.1 Session Outline	This session covers the following main topics ▪ Introduction to consumer points ▪ Identification of various components and types of consumer points ▪ O & M Tasks for consumer points ▪ Troubleshooting for Consumer Points ▪ Records and Report requirements
Appropriate Facilitator	This training session should be offered by well experience Water Engineer.
7.2 Objective	At the end of the session, the participants will be able to: ▪ identify the main components of consumer water points ▪ describe the functions of the key components of the water points ▪ Carry out water-point maintenance.
Outputs	An O and M schedule
Session Timing	2 Hours
Methodology	This is intended to be a practical session. The components will be taught by demonstration of the system itself, not using drawings or descriptions. Reinforce the learning by allowing participants to handle components and describe their functions to each other.
Materials	▪ Valve key/wheel ▪ Pipe wrench ▪ Brush or broom ▪ Bucket ▪ Clock or timer
Session Guide and Contents	
7.3 Introduction	This is a general discussion of the O and M tasks for various consumer points which include: ▪ Public tap stand ▪ Cattle trough ▪ Individual connection.
7.4 Identification of	**7.4.1 Water-point components** With reference to the drawings in Attachment 7 1, identify and

Components

demonstrate the function of the key components:

Table 7.1 depicted the various components of public water points.

Table 7-1: Function of components of public water point

No.	Items	Function
1	Service/gate valve	stopcock or gate valve that opens or closes the water supply
2	Pipe stand	protects and supports the pipe at the water point
3	Tap / bibcock	valve to control flow at water point
4	Float valve/ball cock	To control water in cattle trough
5	Water Meter	Measures flow though the pipe
6	Water Meter box	To protect meter
7	Apron	concrete surround to water point
8	Drainage channel	leads the water away from the water point to a soak-pit or drain
9	Fence	A barrier constructed around the water point to prevent the entrance of authorized persons and animals

1. Flow measurement

Measure the flow from the water point using a bucket and clock (how long does it take to fill the bucket?) or record readings on the flow meter. Measure the flow from another water point and compare the results. Discuss why the flows may be different.

Reasons may include:

- location of water point; points close to tank may get more water
- water pressure; height of tank above water point gives pressure
- pipe leaks reduce pressure
- Blockages in pipes, valves or meter.

2. Water-point maintenance

A noticeable problem at many consumer points is associated with the care and management of the taps.

Consideration should be given to:

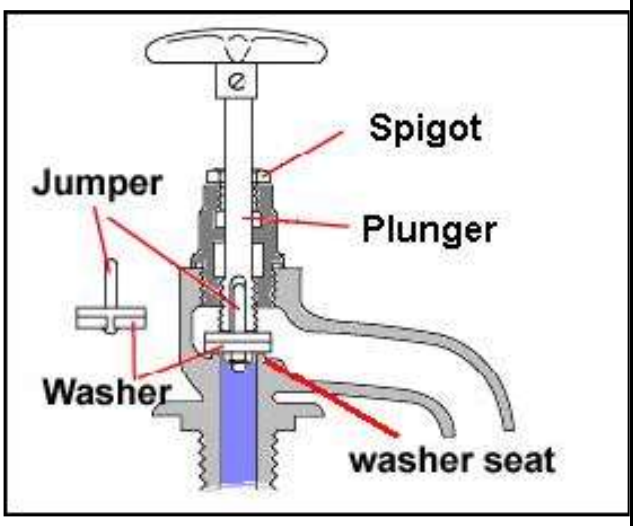
- Using good-quality taps (brass – check against fake materials!)
- Consider the use of push-type (self-closing) taps where appropriate.

7.5 Specific Water-Point O&M Tasks

Identify the O & M tasks associated with the water points. These may include:

- Check perimeter fence & repair
- Check water kiosk structure & repair

- Check tap
- Check tap by opening and closing tap and check for leakage or damage
- Replace washer if tap leaks (See Attachment 2) or replace tap
- Repair erosion around pipes or tap stand
- Repair leaking or damaged pipes
- Repair damaged valve chambers
- Close and open service valves once a month
- Repair cracked or damaged concrete surround or drain, Small cracks should be repaired at once by filling them with cement mortar (grouting),
- Check for stagnant water around water point and clear/open drain to soak away
- Clear bush and keep compound around water point clean and free of rubbish and animal or human waste
- Check meter is working properly
- Check ballcock on cattle trough & repair pin and/or washer if needed
- Remove meter, clean sieve and replace sieve and meter.



Ask participants what problems might occur if maintenance of the water points is not carried out properly. Identify any components that require maintenance and demonstrate and discuss O and M procedures.

1. Repair of Globe Valves, Public Faucets and Other Related Valves

a) Tools Needed:

1. Flat jawed or monkey wrench (large enough to fit the packing nut of the valve/faucet)
2. Rubber sheet or soft cloth (to protect the finish of the faucet or packing nut)
3. Screw driver
4. Faucet seat dresser.

b) Materials Needed:

1. New faucet washer or valve seat and disc,
2. Lubricated candle wick for stem packing,
3. Waterproof grease,
4. Washer screws.

c) Procedure:

1. Familiarize yourself with the different parts of the faucet or valve,
2. Examine and find out the location of the leak. If water is coming out from the mouth or outlets, the trouble is due to a damaged washer or damaged seat or both. If water is coming out from around the stem when the valve is open, the stem packing is defective,
3. Close the control valve to cut off water supply to the defective valve/faucet,
4. Open the packing nut with a wrench. Place a piece of rubber sheet or cloth over the wrench jaws to avoid marring t he valve/faucet finish,
5. Repair the defective valve/faucet,
6. Replace the handle and tighten the handle screw,

Turn on water supply and observe for leaks.

7.6 Troubleshooting for Water Points

Discuss the potential unexpected problems and what might be the cause.

Table 7-2: Troubleshooting of public water point

Problem	Problem Causes	Possible Solution
Leaking service or gate valve	▪ Worn-out valve	Replace the valve. Check that the valve is not being used where a tap is more appropriate.
Little or no water flowing	▪ Storage tank empty ▪ Tank outlet pipe blocked ▪ Distribution pipe leaking or broken ▪ Airlock in distribution pipe	▪ Check the flow in the transmission pipeline. ▪ Check the strainer and outlet valve. ▪ Repair the pipe. ▪ Check/open the nearest air valve. ▪ Remove and clear the valve (replace if

		▪ Service or gate valve blocked or closed ▪ Meter blocked	necessary). ▪ Remove and clean the sieve/filter in meter.

7.7 Scheduled Maintenance

7.7.1 PM Programs and Schedules

The maintenance program is made up of a collection of individual maintenance actions. Each major unit in a water facility has a specific maintenance program designed for that particular unit. This program will range from routine daily inspections and tasks, to others done weekly, monthly, quarterly, semi-annually and annually. The columns at the right of each page of the PM checklist, show the frequency of the maintenance items, i.e. D = Daily, W = Weekly, M = Monthly, Q = Quarterly, SA =Semi-annually, and A = Annually.

7.7.2 PM Checklist

The following PM checklists are based on the information obtained from the existing manufacturer's operation and maintenance manuals. It provides instructions for inspecting, cleaning, lubricating and adjusting equipment used in different water supply systems.

Table 7-3: Preventive Maintenance Checklist for Transmission and Distribution System

No.	PM Checklist	D	W	M	Q	S	A
4.1	**Transmission and Distribution Mains**						
4.1.1	Check and update system maps						●
4.1.2	Record daily water production transmitted and distributed	●					
4.1.3	Regularly check mains for inadequate pipe diameter, corrosion, and poor pipe network; correct problem					●	
4.1.4	Check for leakage in distribution mains and service connections for inoperative meters and water waste			●			
4.1.5	Flush dead ends at regular intervals					●	
4.1.6	Check and update records of distribution mains and valves						●
4.1.7	Inspect transmission and distribution mains periodically; protect pipe against electric corrosion & erosion, etc.						●
4.2	**Service Reservoir**						
4.2.1	Keep premises clean		●				

4.2.2	Clean storage reservoirs or elevated tanks						●
4.2.3	Check for cracks or leaks						●
4.2.4	Check float valves or other control devices for proper function						●
4.2.5	Inspect paint condition of metal parts; repair if necessary						●
4.2.6	After repair, disinfect reservoirs and tanks						●
4.2.7	Check vent screen, replace or repair if necessary					●	
4.3	**Valves**						
4.3.1	Check for proper functioning				●		
4.3.2	Clean valve chamber				●		
4.3.3	Lubricate valves using kerosene or lubricating oil				●		
4.4	**Service Connection**						
4.4.1	Inspect for cross-connection			●			
4.4.2	Check for leaking pipes			●			
4.4.3	Check inoperative meters			●			
4.5	**Public Stand Post**						
4.5.1	Inspect for leakage				●		
4.5.2	Check function of taps and meters				●		
4.5.3	Inspect concrete plat form				●		
4.5.4	Keep area clean	●					
4.6	**Water Meters**						
4.6.1	Check for correct installation						●
4.6.2	Check for proper functioning (on-site inspection)						●
4.6.3	Check for accuracy, repair or replace (every 2 years)						

7.8 Record and Report

7.8.1 Record System

A record system has to be developed which should be realistic and apply to the operating problems involved at the particular transmission, distribution and service reservoir sites. The most efficient way to keep records is to plan what data is essential and then prepare the formats followed by the persons to fill the data, frequency and to whom the

record is to be sent for review and report.

Sample records to be maintained at transmission, distribution and service reservoir sites are given below for guidance.

The following details shall be recorded:

a) Transmission Lines

1. Updated transmission system maps with alignment plans. Longitudinal sectional plans,
2. Record of daily readings of flow meter at upstream and downstream end of pipeline,
3. Record of water level of reservoir at both upstream and downstream end of transmission system.
4. Pressure reading of the transmission system.
5. Identification of persistent low pressure location along the pipeline.
6. Record of age of pipes.
7. Identify pipelines to be replaced.
8. Identify source of leaks.
9. Record of Bulk meter/water meter reading before the delivery into overhead tank.
10. Record of residual chlorine.
11. Record on when the pipeline leaks were repaired or pipe changed and the cost of materials and labour cost thereof.

b) Service Reservoir

1. Water levels in the reservoir,
2. Time and relevant operation of control valves with time of opening and closure or throttling position of the valves,
3. Daily flow meter readings both on the inlets and outlets,
4. At least one a day Residual chlorine readings of inflow water and outflow water,
5. Gland ropes of the valves/Spares at the SR were changed,
6. Manhole covers were changed / replaced,
7. Water level indicator was repaired or replaced,
8. Reservoir was cleaned,
9. Out-fall drain for scour and overflow was last cleaned,
10. Ladder was changed, when the structure of the reservoir was last repaired to attend to structural defects or arrest leakage,
11. Reservoir/Pips was last painted,
12. Total cost of repairs and replacements at the SR in previous year along with breakup of, material cost and labor cost with amount spent on outside agencies for repairs and, replacements.

c) Distribution Lines

1. Updated system map,
2. Pressure and flow readings at selected monitoring points,
3. Persistent low pressure or negative pressure areas,
4. Age of pipes/quality of pipes,
5. Pipelines to be replaced,

	6. Presence of undesirable materials, 7. Water budget for each zone served by one SR, 8. Number of connections given, 9. Number of meters out of order, 10. Quantity measured at outlet of reservoir, 11. Quantity distributed/measured or billed, 12. Water budget for each zone served by one SR 13. Source of leaks and persistent leak points, 14. Status of bulk meters - functioning or not, 15. Status of consumer meters, 16. Facilities for repairs of consumer meters, 17. Number of unauthorized connections, 18. Residual chlorine levels at the pre-selected monitoring points, 19. Bacteriological quality of the water sampling points, 20. Persistent areas where residual chlorine is absent/where water samples are found contaminated , 21. Record of carrying out repairs on the following 22. The pipe line leaks or replacement of pipes. 23. Change of gland ropes of the valves in distribution system. Record on man hours spent on routine operations in the distribution system in the previous year and the cost thereof,
7.9 Spares, Tools, and Technical Assistance	Tools – See above for tools required. Spares – the following spares are usually required: ▪ Tap washers ▪ Tap ▪ Spare meter ▪ Meter sieve ▪ Gate valve ▪ Ball valve Spare Pin for ballcock Supply Chain – most materials can be purchased at a well provisioned hardware store. Note: Check supplier and quality of taps and meters available. Technical Assistance ▪ Technical assistance should be sought if the meter frequently has air or gets blocked. ▪ Servicing of meters is a specialized skill and should be undertaken by technician ▪ Persistent water quality problems should be investigated with a water quality specialist, based on laboratory analysis of water quality.
Session Review	Check that the objectives of the session have been met by asking participants to explain what they have learned and demonstrate that

	they can carry out the maintenance without assistance.
Attachments	Attachment 1: Consumer water points Attachment: 2 Replacement of a worn-out washer on a tap stand

Annexes

Annex A: References

SNNP Region Water Bureau, Preventive Operation & Maintenance of Water Lifting Devices in the SNNPRS, A General Guideline, SNV in collaboration with Hawassa University, September, 2009.

Operation and Maintenance Manual for Rural Water Supplies, Government of India Ministry of Drinking Water and Sanitation MAY, 2013

A Trainer's Manual for Community Managed Water Supplies in Kenya, 2012