Training module on 

Water Supply, Sewerage and Drainage – O&M

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OUT LINE OF THE MODULE

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>DESCRIPTION</th>
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</thead>
<tbody>
<tr>
<td>BACKGROUND</td>
<td>Operation and maintenance refers to all of the activities needed to run a water supply and sanitation scheme, except for the construction of new facilities. The overall aim of operation and maintenance is to ensure efficiency, effectiveness and sustainability of water supply and sanitation facilities. The two activities of “operation” and “maintenance” are very different in nature. Operation refers to the direct access to the system by the user, to the activities of any operational staff (e.g. operators of motorised pumps), and to the rules or by-laws, which may be devised to govern who may access the system, when, and under what conditions. Maintenance, on the other hand, is to do with the technical activities, planned or reactive, which are needed to keep the system working. Maintenance requires skills, tools and spare parts. Maintenance can be classified as follows: Preventive maintenance, Corrective maintenance, Reactive maintenance.</td>
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INTENDED AUDIENCE(S) | Engineers, (AEE, Dy,E.E, EE) and operators, |

LEARNING OBJECTIVES | To provide knowledge on preparation of O&M plan, To familiarize with the preparation of cost estimate for O&M of water supply & sewerage systems, To provide knowledge on financial aspects of O&M, Institutional & legal framework for sustainability and Innovative approaches for O&M. |

MODULE OVERVIEW | STRUCTURE/ CONTENTS
Chapter 1 O&M – Overview
Chapter 2: Operation and maintenance scenario
Chapter 3: Water Supply
Chapter 4: Sewerage System

MODULE DELIVERY OUTLINE | (TOPICS UNDER EACH HEADING)
✓ **Awareness** on o&m planning of water supply and sewerage projects
✓ **Knowledge** on
✓ Improving the **Skills** of the staff in preparation
<table>
<thead>
<tr>
<th><strong>sustainable o&amp;m plans</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MODULE ACTIVITIES</strong></td>
</tr>
<tr>
<td><strong>SUPPORTING MATERIALS</strong></td>
</tr>
<tr>
<td><strong>MODULE FEED BACK</strong></td>
</tr>
<tr>
<td><strong>MODULE DEVELOPER</strong></td>
</tr>
</tbody>
</table>
Contents of the enclosed compact disc (CD)

1. soft copy of the module in PDF format
2. power point presentation of the module
3. Reference material for all sub modules
   a) CPHEEO Manual
   b) course material,
   c) Power point presentation
# Contents

1. O&M – Overview .................................................................................................................. 7
2. Operation and maintenance scenario ..................................................................................... 9
   2.1 Objectives of good O&M ............................................................................................... 9
3. Water Supply ......................................................................................................................... 12
   3.1 Introduction ..................................................................................................................... 12
3.2 Water audit and leakage control ......................................................................................... 12
3.3 Measures for reducing UFW/NRW ..................................................................................... 12
3.4 Water meter, instrumentation, telemetry & SCADA ............................................................. 13
   3.4.1 Water meters .............................................................................................................. 13
4. Sewerage System .................................................................................................................. 14
   4.1 Introduction ..................................................................................................................... 14
   4.1.1 Types of Collection System ....................................................................................... 14
   4.1.2 Hydraulics of Sewers ............................................................................................... 15
   4.1.3 Preliminary Investigation for Design of Sewer System ............................................ 15
   4.1.4 Types of Manholes ................................................................................................. 15
   4.1.5 Sewer Constructions ............................................................................................... 16
   4.1.6 Design & Construction of Sewage Pumping Mains ................................................. 17
   4.1.7 Dry Well, Operation of Pumps & Equipment .......................................................... 18
4.2 Sewer Systems .................................................................................................................... 18
   4.2.1 Introduction ............................................................................................................... 19
   4.2.2 Sewer Cleaning ....................................................................................................... 19
   4.2.3 Sewer Rehabilitation ............................................................................................... 20
4.3 Pumping Station .................................................................................................................. 20
   4.3.1 Introduction ............................................................................................................... 20
4.4 Sewerage & Sewage Treatment Systems ........................................................................... 21
   4.4.1 Designing of Sewerage System (C&T) ..................................................................... 21
   4.4.2 Basic Design Considerations: .................................................................................. 22
1. O&M – Overview

Introduction

Generally, water and sanitation projects experience their most serious problems with operation and maintenance and with cost recovery aspects. Hundreds of projects around the world demonstrate how the newly built infrastructure deteriorates after the project’s termination. Therefore, it is imperative to plan for operation and maintenance, with a planned withdrawal of external support as local ownership builds. This document is intended for managers and planners who are concerned with the challenging problem of how to implement effective operation and maintenance in water and sanitation projects.

Operation and maintenance (O&M) activities, which encompass not only technical issues, but also managerial, social, financial and institutional issues, must be directed towards the elimination or reduction of the major constraints which prevent the achievement of sustainability (BRIKKE 2000). Operation and maintenance is a crucial element of sustainability, and a frequent cause of failure of water supply and sanitation service facilities in the past. Many failures are not technical ones. They may result from poor planning, inadequate cost recovery, or the outreach inadequacies of centralised agencies (DFID 1998).

Operation and maintenance has been neglected in the past, or been discussed and introduced only after a project was completed. This neglect or delay in applying proper operation and maintenance has adversely affected the credibility of the investments made, the functioning of the services, the well-being of rural populations, and the development of further projects. However, the importance of O&M has gained considerable visibility over the past few years, and it appears that policy-makers and project designers are now more conscious of the direct links between improved O&M practices and the sustainability of water supply and sanitation services. There is also greater recognition of the need to approach these projects in a comprehensive way, emphasising not only the design and construction but also post-construction activities (BRIKKE 2000).

There is the O&M manual for Water Supply Systems by CPHEEO, but there is no such manual for Sewerage Systems. Moreover, unless there is an O&M manual, ULBs cannot justify budget allocations to meet their obligations under such a manual. The net result is this lack of attention to the important aspect of Operation & Maintenance (O&M) of sewerage systems leads to deterioration of the useful life of the systems necessitating premature replacement of many system components and also affecting overall sanitation. As such, even...
after creating such assets by investing millions of rupees, they are unable to provide the services effectively to the community for which they have been constructed, as they remain defunct or underutilized most of the time.

1.2 **key issues** contributing to the poor Operation & Maintenance have been identified as follows:

i. Lack of finance, inadequate data on Operation & Maintenance  

ii. Multiplicity of agencies, overlapping responsibilities  

iii. Inadequate training of personnel  

iv. Lesser attraction of maintenance jobs in career planning  

v. Lack of performance evaluation and regular monitoring  

vi. Inadequate emphasis on preventive maintenance  

vii. Lack of operation manuals  

viii. Lack of appreciation of the importance of facilities by the community  

ix. Lack of real time field information etc.

Therefore, there is a need for clear-cut sector policies and legal framework and a clear demarcation of responsibilities and mandates within the water supply sub-sector and Operation & Maintenance (O&M) of sewerage. From the Indian experience, it has been observed that by and large, about 20 to 40% of the total annual Operation & Maintenance cost goes towards the personnel (Operation & Maintenance Staff), 30 to 50% of the cost is incurred on power charges and the balance is utilized for consumables, repairs and replacement of parts and machinery and miscellaneous charges. In most of the cities in India, the tariffs are so low that they do not even cover the annual Operation & Maintenance cost. Hence it is a felt need to capacity building in municipal engineers to improve O&M in sewerage systems & Water Supply Systems.

The O&M capacity building is required to encompass various issues pertaining to an effective O&M such as technical, managerial, administrative, personnel, financial & social aspects etc.
2. Operation and maintenance scenario

2.1 Objectives of good O&M

Quality maintenance of sewerage system consists of the optimum use of labour, equipment, and materials to keep the system in good condition, so that it can accomplish efficiently its intended purpose of collection and transportation of sewage to the treatment plant.

2.1.2 Type of Maintenance

There are three types of maintenance of a sewerage system:

1. Preventive,
2. Routine
3. Emergency.

Preventive or routine maintenance should be carried out to prevent any breakdown of the system and to avoid emergency operations to deal with clogged sewer lines or over flowing manholes or backing up of sewage into a house or structural failure of the system. Preventive maintenance is more economical and provides for reliability in operations of the sewer facilities. Emergency repairs, which would be very rare if proper maintenance is carried out well also, have to be provided for. Proper inspection and preventive maintenance are necessary.

2.1.3 Necessity of Maintenance

Sewer maintenance functions are most often neglected and given attention only as emergency arises. Adequate budgets are seldom provided for supervision, manpower and equipment, unlike the case for maintenance of other utilities like electric cables, telephone cables, gas and water mains. Such attitude towards sewer maintenance is found even in large cities. Considering the health hazards that the public at large has to face, it is appropriate to provide sufficient funds to take care of men, material, equipment and machinery required for efficient maintenance.

All efforts should be made to see that there is no failure in the internal drainage system of premises; a serious health hazard results when sewage backs up through the plumbing fixtures or into the basements. The householder is confronted with the unpleasant 380 task of cleaning the premises after the sewer line has been cleaned. Extensive property damage may also occur, particularly where expensive appliances are located in the basements. Maintenance helps to protect the capital investment and ensures an effective and economical expenditure in operating and maintaining the sewerage facilities. It also helps to build up and
maintain cordial relations with the public, whose understanding and support are essential for the success of the facility.

2.2 Factors leading to poor O&M

- Non-availability of sufficient skilled HR, gap in adoption to new technologies, in sufficient capacity building opportunities, poor motivation, laxity etc.
- Lack of finance, inadequate data on Operation & Maintenance
- Inappropriate system design; and inadequate workmanship
- Multiplicity of agencies, overlapping responsibilities
- Inadequate training of personnel
- Lesser attraction of maintenance jobs in career planning
- Lack of performance evaluation and regular monitoring
- Inadequate emphasis on preventive maintenance
- Lack of appreciation of the importance of facilities by the community
- Lack of real time field information etc.

2.3 Responsibility for O&M of the assets created

The ‘ULB’ or ‘Development Authority’ should own the asset created in their areas and plan for O&M of the same. Role and responsibility shall be clearly defined duly specifying the intuitional mechanism.

2.3.1 Creation of public awareness for owning the assets.

Operation and maintenance (O&M) activities, which encompass not only technical issues, but also managerial, social, financial and institutional issues, must be directed towards the elimination or reduction of the major constraints which prevent the achievement of sustainability (BRIKKE 2000). Operation and maintenance is a crucial element of sustainability, and a frequent cause of failure of water supply and sanitation service facilities in the past.

2.3.2 Benefits to be accrued to general public from the assets created:

Any asset created is aimed to deliver some sort of service to the general public. The public will also have expectations from the assets created by the public authority. The above two have to be integrated.
2.3.3 Expected gaps in the benefits to the public:
After creation of the asset or completion of the project, the O&M authority has to study and plan the O&M and shall assess possible gaps if any due to changed scenario in ground conditions.

2.3.4 Efficient O&M practice:
Shall aim at minimization/nullifying the gaps in the benefits to public.
3. Water Supply

3.1 Introduction

Providing drinking water supply is one of the huge investment infrastructure facilities and is directly linked to public health. Many cities in India are still not able to supply adequate quantity of water with potable quality; reasons include lack of awareness, funds, commitment etc. Population growth is another major reason for the inadequate supply of water, which needs augmentation of water supply schemes. Apart from the above, identification of sources of water supply, their conservation and optimal utilization also needs attention. As a boon to the country, a new mission called Jawaharlal Nehru Urban Renewal Mission (JN NURM) has been initiated by Government of India, launched by Prime Minister on 3rd December 2005 with an allotment of Rs. One Lakh Crore towards urban infrastructure Development, in which Water supply is one of the prime focused areas.

The objective of drinking water supply system is to supply safe and clean water in adequate quantity conveniently and as economically as possible. The scope of water supply system starts from planning of water supply system including Source Water Assessment & Protection (SWAP), treatment, transmission, storage and equitable distribution of treated water to consumers. The above all are sustainable when there is good monitoring, operation and maintenance of the system to minimize the non-revenue water and improve performance of public water supply systems.

3.2 Water audit and leakage control

- Objectives of water audit
- Planning and preparation
- Monitoring of flow systems
- Objectives of leakage control
- Leakage reduction and monitoring
- Assessment of leakages
- Assessment of UFW
- Benefits of water audit

3.3 Measures for reducing UFW/NRW

- Creation of DMAs
- 100% metering
- Scraping of illegal & un-authorized connections
- Regulating / Rationalization on continuation of PSPs
3.4 Water meter, instrumentation, telemetry & SCADA.

3.4.1 Water meters.
- Sizing of Water meters.
- Installation of Water Meters.
- Repairs, Maintenance & Trouble Shooting of Water Meters.
- Prevention of Tampering of Water Meters.
- Trend of Replacement of Water Meters.
- Automatic Water metering Systems.
- Relevant National & International Standards.

3.4.2 FlowMeters.
- Types of Flow Meter.
- Installation of Flow Meter.
- Maintenance of Flow Meter.
- Calibration of Flow Meters.

3.4.3 Telemetry and SCADA systems.
- Telemetry.
  - Data for collection by telemetry.
  - Processing Data from Telemetry.
- SCADA systems.
  - Data collected in SCADA.
  - Analysis of Data from SCADA.
  - Limitations of SCADA

3.4.4 Procurement of all types of Meters.
- Planning for location of meters.
- Selection of type of meters to suit ground conditions.
- Study of different types of meters available in national/international market.
- Study of Performance of meters installed in other schemes.
- Specification of meters as per standards.
- No. of meters required and cost estimation.
- Procurement of meters as per standard procedures
- Service after sale by manufacturer.
4. Sewerage System

4.1 Introduction

In this rapidly urbanizing world, water and wastewater management have a significant impact on health and economy of the community. Due to uncontrolled population growth, cities are getting expanded and infrastructure developments are not able to cope with the demands of the public. As on today, not even one city in India is fully covered with underground sewerage system. India’s present Urban Population is 31.2% of the total population and is projected to increase to 42% of the total population by the year 2015. Underground sewerage systems for the cities make very valuable contribution to the process of sustainable urban development. Due to increase in population density, inefficient onsite disposal systems like septic tanks and open drains are no more solutions for sustainable development. If domestic sewage is not properly carried and disposed, it results in contamination of surface water/ground water and causes serious health problems to the community. Where the wastewater management is improper, the cost of health care associated with diseases is an additional burden on the economic resources of the community. It is also reported that, a regular sewerage system, proper treatment and disposal are more economical than the onsite disposal systems.

Good sewerage system will protect the environment; improve the community health and the quality of life. For proper design, operation and maintenance of sewerage systems, basic knowledge on planning, estimation of responsibility of all the authorities to fulfill their obligations to maintain good health and hygiene conditions of the cities and towns. Waste water generation, flow characteristics, design principles of sewers, treatment and disposal methods are very essential. It is the social and civic

4.1.1 Types of Collection System

- Separate Sewers
- Combined Sewers
- Pressurized Sewers
- Vacuum Sewer System
- Materials
- Shapes and Sizes of Sewers
- Minimum Size of Circular Sewers
- Flow in Circular Sewers
Min Velocity
  o Potential for Sulphide Build up
Max Velocity
  o Mannings’s Formula
  o Design Depth of Flow
Slope of Sewer

4.1.2 Hydraulics of Sewers
- Flowing under Pressure
- Types of Flow
- Hazen Williams Formula
- Sewer transitions
- Connections of Different Sewers
- Vertical Drops and other Energy Dissipaters
- Inverted Siphon
- Hydraulic Calculations of Inverted Siphon
- Velocity in inverted Siphon Sewers
- Size & Arrangement of Pipes
- Inlet and Outlet Chambers
- General Requirements

4.1.3 Preliminary Investigation for Design of Sewer System
- Detailed Survey
- Layout of the System
- Profile of Sewer System
- Available Head
- Plans and Nomenclature
- Precautions
- Introduction to the state of the Art Software in Analysis of Sewer Network (Sewer Cad etc).

4.1.4 Types of Manholes
- Drop Manholes
- Junction Manholes
- Side Entrance Manholes
- Flushing Manholes
- Different Diameters of Sewers in the Same Manhole
- Construction of Brick & RCC Manholes
- Covers and Frames
4.1.5 Sewer Constructions

- Types of Loads
- Loads on Conduit due to backfill
- Types of Installation or Construction Conditions
- Loads for different conditions
- Embankment or Projecting Conduit Condition
- Trench Condition
- Tunnel Condition
- Effect of Submergence
- Loads on Conduit due to Superimposed Loads
- Concentrated Loads
- Distributed Loads
- Conduits under Railway Track
- Supporting Strength of Rigid Conduit
- Laboratory Test Strength and Field Supporting Strength
- Protection and Bedding of Sewers
- Guidelines
- Bedding in Quicksand Soil Conditions
- Types of Bedding
- Load Factors for Bedding
- Supporting Strength in Embankment Conditions
- Conduits under Simultaneous Internal Pressure & External Loading
- Cross Drainage works
- Sewer Ventilators
- Prevention of Cross Connection
- Protection of water Mains
- Construction Methods
- Laying & Jointing of Different Sewers
- Testing of Sewer Lines
4.1.6 Design & Construction of Sewage Pumping Mains

- Design Flow
- Design of Suction Water Level
- Discharge Level
- Power Source
- Screen & Grit Chambers
- Amount of Screenings
- Degritting
- Treatment and Disposal of Screenings & Grit
- Measures against Odor

Pumps

- Types of Pumps
- Types of Pump Stations
- Number of Pumps and Selection of Pump Stations

Wet Well

- Wet Well Design Criteria
- Structural Design Criteria
- Pump Basics
- System Head
- Operating Point
- Parallel Operation
- Cavitation in Pumps
- Prime Movers
- Surges and Water Hammer
- Piping & Valves
4.1.7 Dry Well, Operation of Pumps & Equipment

- Protective Equipment
- Alarm System
- Flow Measurement
- Corrosion Prevention & Control in Pumpsets
- Rehabilitation and Reconstruction of Pumping Station
- Installation of Pumps
- Design Formula
- Computation of Pump kW
- Velocity Consideration in Design of Pumping Mains
- Injection and Relay Pumping Main
- Anti Vortex.

4.2 Sewer Systems

Introduction
In engineering parlance, operation refers to daily operation of the components of a sewerage system such as collection system, pumping stations, pumping mains, STP’s, machinery and equipment, etc., in an effective manner by various technical personnel, and is a routine function. The term maintenance is defined as the art of keeping the structures, 5 plants, machinery and equipment and other facilities in optimum working order. Maintenance includes preventive maintenance or corrective maintenance, mechanical adjustments, repairs, corrective action and planned maintenance. However, replacements, correction of defects etc., are considered as actions excluded from preventive maintenance. For replacements with regard to sewerage and sewage treatment, the broad categories of infrastructure which need to be addressed are as follows:

- Collection System including house service connections and manholes
- Pumping Stations
- Pumping Mains
- STPs

Utilization of biological sludge and containment of chemical sludge. There are standard O&M manuals for these in developed countries. However, O&M manual is not yet prepared in detail in India. The following conditions prevail:
Most of the towns are only partially sewered
Most of generated greywater continues to flow in road side drains
Per capita water usage is practically only 25 to 30% as used in advanced countries
Water as used is mainly from local groundwater also with high TDS, sulphates etc
The sulphates are an agent of corrosion of concrete in sewers
Wash basins, kitchen sinks etc do not have blenders below the sink
Detergent powders have significant grit content
Volumes of water usage are only about 30 to 40% 
Cattle are also housed inside the cities and their dung washed into sewers
The cattle shed washing occurs during noon times after the peak flow has passed
These cattle shed washed dung settles in sewers and builds up to choke
The budgets of most ULBs are inadequate for purchasing sewer cleaning machines
Though sewer divers are banned, still manual labour is used to "rod" and clean the sewers
Pumping stations are not connected by website to know of flooding in the station area
Removing sewer blocks takes longer times due to manual work

4.2.1 Introduction
- Objective of Maintenance:
- Type of Maintenance:
- Necessity of Maintenance:
- Inspection & Examination of Sewer:
  - Man Hole Visual Inspection
  - Inspection using Pole Mounted TV Camera
  - Inspection using CCTV
  - Inspecting Infiltration
- Inspecting Corrosion & Deterioration:
  - Concrete corrosion
  - Precautions
  - Maintenance of Records & Follow up action.

4.2.2 Sewer Cleaning
- Sewer Cleaning Equipment
- Dredger
- Hydraulically propelled devices
- Jetting machines
- Suction units
- Disposal of Silt & Sludge
- Cleaning records and their utilization
Rehabilitation
Safety practices
Information to prevent Accidents & Records.

4.2.3 Sewer Rehabilitation
- Rehabilitation Methods
  - Slip Lining
  - Cured in place pipe
  - Modified Cross section Lining
- Maintenance of Machinery & Apparatus for Rehabilitation
- Protection of Sewer Systems
- Protection against Infiltration & Ex-filtration
- Measures against Infiltration of Rainwater
- Ex-filtration of Untreated Sewage
- External Sewer Rehabilitation Methods
- Internal Sewer Rehabilitation Methods
- Safety Practices
- Measures against Accidents

4.3 Pumping Station
4.3.1 Introduction
- Types & Structure of Pumping Stations
  - Dry Pit
  - Wet Well
  - Lift Stations
- O&M
➤ Operation of Pumps
➤ Undesirable Operations
➤ Piping & Appurtenance Maintenance
➤ Screens
    o Types of Screens
    o Manual & Mechanical Screens
    o Valves & Actuators
    o Accessories
    o Disposal of Screenings
➤ Grit Removal
    o Preventive Maintenance
    o Disposal of Grit
    o Pump Equipment
    o Preventive Maintenance
    o Accessories
➤ Flow Measuring Devices
    o Weir Flow
    o EM Flow
    o Ultrasonic Flow meters
➤ Fluorescent Tracers
➤ Troubleshooting

4.4 Sewerage & Sewage Treatment Systems
➤ Design period
➤ Tributary Area
➤ Per Capital Sewage Flow
➤ Infiltration
➤ Sewage from Commercial Institutions
➤ Industrial Effluents to be Discouraged
➤ Storm Runoff
➤ Estimation of Storm Runoff
➤ Storm Frequency
➤ Intensity of Precipitation
➤ Time of Concentration.

4.4.1 Designing of Sewerage System (C&T)
➤ Need for Safe Sanitation System
➤ Loss to the nation due to poor Sanitation
➤ Initiatives of GoI, and Reforms under 74th CAA
➤ NUSP-2008
➤ Concepts of Totally Sanitized Cities
➤ SLB’s on Sewage Management
➤ CSP
4.4.2 Basic Design Considerations:

- Engineering & Environmental Considerations
- Financial aspects
- Community Awareness
- Inter & Intra Departmental Coordination
- RS & GIS Applications
- Design Period
- Population Forecast
- General Considerations
- Project Area
- Reuse and Disposal
- Layout & Arrangement of Sewerage
- Guidelines on HSC’s

Survey & Investigation

- Survey on Pollution Loads and Receiving Bodies
- Survey on Existing Facilities
- Preliminary Project Surveys
- Developmental & Fiscal Aspects.
Summary of module

A comprehensive operation and maintenance plan shall be prepared to cover all the facilities. This plan shall contain what actions are to be taken, when these activities are to be taken, how these actions are to be taken and why these actions are required. Good housekeeping is required to ensure that all equipment, buildings, surrounding areas and facilities are kept clean and orderly and shall look that it is being frequently cleaned and attended to. A central operation and maintenance cell shall be created which will have responsibility for supervision, monitoring and analysing all operation maintenance activities contained in the operation and maintenance plan. Supervisors shall be assigned duties to check the operation and maintenance by adopting check lists prepared by the management with reference to the plan. Officers shall be identified for monitoring whether the operation maintenance plans are followed or whether supervision of the plan is being done. The supervisor’s check lists, checked by monitoring officers shall be analysed by the top management to locate persistent deficiencies and initiate corrective action. The first line supervisors shall be rewarded for timely identifying deficiencies in O&M.