सत्यमेव जयते

MINISTRY OF HOUSING AND URBAN AFFAIRS
GOVERNMENT OF INDIA

स्वच्छ भारत
एक कदम स्वच्छता की ओर

MANUAL ON STORM WATER DRAINAGE SYSTEMS

VOLUME-II

PART B: OPERATION AND MAINTENANCE
PART C: MANAGEMENT
FIRST EDITION

CENTRAL PUBLIC HEALTH AND ENVIRONMENT ENGINEERING ORGANIZATION (CPHEEO)

http://mohua.gov.in | http://cpheeo.gov.in | https://swachbharaturban.gov.in

May, 2019

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CHAPTER 1: INTRODUCTION

1.1 General

Operation & Mainenance (O & M) of storm water drainage 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 during entire period of its design life.

1.2 Need for Operation and Maintenance

The lack of attention to the important aspect of O & M leads to deterioration of the useful life of the system necessitating premature replacement of many system components. As such, even after creating the assets by investing millions of rupees, they are unable to provide the services effectively to the community for which they have been constructed.

Some of the key issues contributing to the poor O&M are as follows:

1. Lack of finance and inadequate data on O&M
2. Multiplicity of agencies, overlapping in their responsibilities
3. Inadequate training of personnel
4. Non-availability of operation & maintenance manuals.
5. Lack of awareness of the importance of storm drainage facilities by the community.
6. Lack of Management Information system and real time field information

Therefore, there is a need of exclusive Operation & Maintenance Manual for storm water drainage system.

1.3 Type of Maintenance

The drainage system is at its best, when it is maintained properly as designed. For this purpose, it is necessary that the drains keep their shape and slope in the designed manner during their life time. It is also necessary to ensure that the drains retain their full cross section, particularly for the monsoons. The system of maintenance can be classified into following three categories.

a) Continuous regular maintenance
b) Periodical maintenance
c) Special maintenance/Repairs for improvement

The extent of these repairs depends upon size of the drain, location of the drain, nature of habitation nearby and cross drainage structures. The difficulty in maintenance is also caused by a lesser degree of consciousness/civic sense. Malba, garbage, solid waste and road cleanings enter the drain resulting in silting and solidification of extraneous material making the maintenance difficult and reducing efficiency.

1.4 Organization of Maintenance

The organization responsible for the maintenance of the drainage system will vary with the size and type of the drainage system and the relative age of the system. The larger the Municipality , the larger and more complex will be its maintenance organization. The size of the organization will vary from a couple of employees to several hundred regular employees. The primary effort of the staff is to maintain conduits free flowing and unobstructed.

The drainage system with its components properly designed and installed is handed over to the person in charge of maintenance who assumes the responsibility to make it function satisfactorily for the benefit of the community. One should have sufficient experience in the design and construction of the system to enable him to perform his task efficiently with an understanding and appreciation of the problems that may arise during maintenance. One has not only to be a technical man but has also to deal with human relations in order to be successful in his work. Inservice training shall be imparted to the maintenance personnel to improve unpon the methods adopted based on the latest trends. Failure to develop a better understanding of human relations and also lack of development of the concept of service to the community generally results in the maintenance part becoming unpopular. The general public is also to be made aware of do's and don'ts to help in keeping the drains andconduits free flowing and unobstructed.

1.5 Basic considerations of O&M

1.5.1 Environmental Considerations

The O & M should address environmental impact of urban storm water runoff that is characterized by high level of sediment and other pollutant, both particulate and dissolved together with the volume and rate of flow of runoff.

1.5.2 Budget

Appropriate budgetary provisions for the O&M of storm water management system need to be provided so that it is carried out without any constraints such as human resources and finance.

1.5.3 Preventive Maintenance

Preventive maintenance is a set procedure whereby each component of the system goes through a systematic check and these components are brought into dependable use. An example can be, checking the local drains in regular interval, cleaning, and visual inspection and retrofitting structural components as and when needed. Carrying out these tasks regularly and timely shall be a preventive maintenance for the existing structures. Most often this is not fully recognized and what could have been saved by

preventive maintenance finally ends up as “break down repairs.” This situation needs the required importance for improved efficiency.

1.5.4 Workmanship and Quality of Equipment

Workmanship is defined as the art or skill of a worker with which something is made or executed. Materials and equipment shall be new and of a quality equal to or superior to that specified or approved. Work shall be done and completed in a thorough and competent manner, in strict conformity with the plans and specifications. In general, the work performed shall be in full conformity and harmony with the intent to attain the best standards of construction and equipment of the work as a whole or in part. No material shall be used in the work until it has been found satisfactory by the Engineer. All material and equipment are subject to test to determine their conformity with these specifications. Whenever standard specifications are referred to, they shall be the latest revised edition. All work and materials shall be subject to inspection by the engineer. The engineer may assign such assistants as he may deem necessary to inspect the materials to be furnished and the work to be done and to see that the same is strictly in conformity. The engineer shall be notified of the time and place of preparation, manufacture or construction of material for work or any part of the work, which he may wish to inspect, and of the time and place of making the factory tests required under the contract. Such notification shall be given a sufficient length of time in advance of the beginning of the work on such material or part or of the beginning of such test to allow arrangements to be made for inspecting and testing or witnessing, as the case may be, if such inspection and testing or witnessing are deemed practicable by the engineer.

All necessary machinery guards, railings and other protective devices shall be provided as specified by the Industrial safety authority, which would be the Inspectorate of Factories (IoF). Before final acceptance of the work, the contractor shall cause an inspection to be made by a representative of the IoF and got certified that all safety requirements have been complied with.

1.5.5 Outsourcing of O&M

Recent trend is to subcontract the O&M work. In this case, the contractor hires staff from local market and deploys them on the O&M work. He will only place the staff and earn the money and after paying to the staff earns his profit, but he may not have interest in O&M. If the contractor is also from the same firm who has built this system, his interests may be more sincere. In the case of exclusive O&M outsourcing not involving the potential O&M agency in the construction activity of the system involved, the proper qualifications, experience, personnel, etc., are to be ensured.

Improvements to the existing system for better O&M can be identified by the O&M contractor, but it has to be separately authorized by the ULB either to the O&M contractor himself or to another O&M contractor.

1.5.6 Key criteria for selection of O&M contractor

The qualification for a contractor to be awarded an O&M contract by the ULB shall include not only the qualification of the contractor firm itself in previous O&M works but also the CV and qualification and adequate experience of key personnel in the O&M staff mentioned in the document. The ULB should ensure that such personnel to be engaged for O&M shall be given training during the O&M period through the existing training institutes of major utilities / ULB's in the region and this should be mandated in the tender document for outsourcing of the O&M work.

Incentives for career advancement of operators like, for example, timescale in ULB services and additional allowances such as risk allowance or such other chances have to be explored to ensure efficient O&M of storm water drainage systems.

1.5.7 Complaint and Redressal

It is advisable to have the internet-based recording of complaints by the public or through regular manual channels but that is to be recorded to avoid future such circumstances. It will be good to also publish on the web the actions to solve them. A sample of complaint format is given in Table 1.1.

Table 1.1: Complaint Format

Name and address of complainant	Nature of complaint	Location of complaint	Action taken by the Authority

Note: ULB may develop its own online application for redressal of such complaints depending on the resources and manpower available with the ULB.

1.5.8 Do's and Don'ts for Community

The public are also responsible to help maintain the system and must not put solid wastes, vegetable cut bits, meat, plastics, etc, into the system. This is very well advertised by many ULB's, but the public continue to do so. Public awareness programme needs to be regularly organized. The details may be referred to Chapter 3 of *Part C: Management* of Manual on Storm Water Drainage.

CHAPTER 2:STORM WATER DRAINAGE SYSTEMS

2.1 Components of Drainage system

A storm water drainage system consists either network of drains connected with junctions or underground conduits connected with manholes and related appurtenances as given below:

- storm water drains
- storm water conduits
- Appurtenance:
    - Manholes of various types
    - Junction sump
    - Gutters
    - Street Inlets
    - Catch Basins
    - Detention tanks / engineered detention basins
    - Pumping stations
    - Outfall sructures

It is necessary to operate and maintain these components regularly inorder to keep them operational andin satisfactory working condition.

A. Maintenance of Storm Water Drains

2.2 Inspection and Maintenance of Surface Drainage System

2.2.1 Inspection and Examination

Inspection of storm water drains should be carried out in a proper manner. The first step is to identify visually the defects and condition of drains that may affect the water way including the following:

- Scour of the bed and sides.
- Full or partial blockage of the drain due to siltation or dumping of solid waste/debris.
- Damage to drain structure.
- Particular attention should be paid at special locations such as junction sump, gutters etc.
- Walking inspections should be timed to seasonal factors, particularly before the beginning of monsoon and post monsoon period.
- Interval between walking inspection *should not exceed one month*.

All stormwater management facilities shall be inspected by a qualified individual at a *minimum twice a year*. This Manual is intended to provide a practical tool to aid in the inspection and maintenance of drains. Inspection guidance will be focused on condition

of the asset through visual observations to evaluate how the asset is functioning relative to its intended design. A broad check list is given below.

i. Pavement crown or cross slope is maintained in design profile conducive to quick drainage.
ii. Road shoulders are clear and dressed for efficient clear off.
iii. If there is a need for new side drain chutes in high embankment.
iv. If the kerb channel is clean and slopes towards the inlet is to be provided
v. If the kerb inlets are clear
vi. Primary, secondary and tertiary drains should be desilted before rainy seasons
vii. Inspection after heavy rains is required to know the deficiencies in the system and reporting unsatisfactory performance and also rectifications.
viii. Inspection in October/November can be carried out and list defects for summer maintenance
ix. Gratings/metallic covers should be checked before monsoon for repair or replacement if any.
x. Discourage & enforce street, house sweeping and solid waste being dumped into open drains or gutter openings

A sample inspection sheet for storm water drain is given in Table 2.1.

Table 2.1: Inspection sheet for storm water drain

Site	**City**	**Street**	**Inspection date**	**Time**
From Manhole / Junction Sump (number)	**To Manhole / Junction Sump (number)**	**Drain Size (mm) Width × Depth**	**Material of construction**	**Covered / Uncovered**
Start	**End**			
Direction	**Type of problem**	**Nature of problem**	**Severity Level**	**Condition of slab cover / overall condition**
Action required / Follow up actions				

2.2.2 Frequency of cleaning of drain

Though, it is not practicable to assign individual frequencies for each element as a routine for each area, it should be such as to ensure that all elements are cleaned before the drain gets blocked. However, storm water drainage system should be inspected and cleaned pre monsoon, during monsoon and post monsoon.

2.2.3 Maintenance procedure

Periodical inspection and maintenance of drains is very necessary, as failure of drains will occur due to deficiency in maintenance. The principal activities in maintenance are:

a. Desilting
b. Clearing of weeds
c. Cleaning of obstruction, debris and blockage
d. Repairing of lining immediately at the commencement of damage or deterioration

Continuous action and attention in detail are important aspects pertaining to maintenance programmes. It is very essential that maintenance units should have all the drawings of existing drains showing all technical details on ground. The drain should be identified by suitable numbering with proper chainage. It should be to ensure that works are maintained as per details shown in the inventory prepared just after completion of the drainage scheme. After proper inspection, following maintenance activities should be carried out:

- All drains should bedesilted thoroughly before onset of monsoon. It is also essential that all the drains are in a state of good condition and works regarding, reshaping or profile correction, wherever required is completed well before the onset of monsoon.

- During the rains also, there is a need to monitor at the exit and entry point of water for the presence of undesirable collection of rubbish, polythene/paper bags blocking the passage of water and in everyway ensuring free unobstructed flow of rain water.

- The condition of road camber also needs to be watched. During rains, specially after heavy showers, all cross drainage structures should be inspected to observe any blockage due to debris, log of wood and other such materials. After that, the deficiencies in the drainage system should be assessed and problem locations identified and record kept updated. Necessary corrective measures should be implemented immediately after rains.

- The missing / corroded slabs of the covered drains are also required to be identified and replacement/repairs need to be carried out on priority to avoid accidents.

Some of the common deficiencies encountered in storm water drains and suggested remedy is given in Table 2.2:

Table 2.2: Deficiencies and remedies forstorm water drains

Deficiency	Cause	Remedy
Ponding	Inadequate cross-section, formation of depression or settlement in bed, bed erosion	Deepening the drain, re-filling eroded or depressed area.
Silting	Invert slope inadequate, excess soil entry into the system, less flow compared to design section	Improvement in slope if possible. Check entry points for silt rubbish etc. Provision of grating atentry points
Blockage due to debris vegetation etc.	Uneven drain bed, absence of maintenance, cleaning	Desilting and cleaning. Provision of grating at entry Points
Erosion of bed and cross section	Steep invert slope, caving in of sides because of lack of lateral support	Provide flatter slope with drops, if needed. Adequate side support, re-alignment, if required.

Source: IRC: SP :50-2013

2.2.4 Safety of maintenance personnels

It is important to be well equiped prior to start of work, as per the guidelines of OSHA with special emphasis to the particular type of works. In the hierarchy of controls, personal protective equipment is considered first to avoid work-related injury or illness. Basic guidelines that should be followed before starting maintenance works.

- Obtain proper training in principles of excavation safety and be thoroughly familiar with equipments to be used.
- Make sure an updated first aid kit, emergency contact information and hand held radios or cell phones are available at the site of work.
- Operate equipment safely in accordance with manufacturers specifications
- Wear highly visible apparel while working at site
- Do not enter a trench or excavation unless it is protected against caving.
- Identify where to dispose off removed sediments and wastes prior to cleaning the drains – record should be maintained and disposal should be at designated place assigned by ULB
- Use shovels, trowels or high suction vacuum to remove wastes and sediments.
- Do not clean out sediments and wastes with bare hands.
- During operation if road is open to traffic use traffic control devices such as flaggers, pavement markings etc. – elaborate daytime, accidents,
- Remove all temporary traffic controls when no longer required.
- Repair identify and address

2.2.4.1 Personal Safety

Following personal safety equipments should be used by maintenance staff while maintaining the storm surface drains.

- Eye protection: – Spectacles/goggles, shields, visors etc.
- Hearing protection : – Ear muffs and plugs etc.
- Hand protection : – Gloves and barrier creams etc.
- Foot protection : – Hard toed shoes/boots etc.
- Head protection : – Helmets, caps, hoods, hats
- Working from heights : – Harness and fall arrest devices etc.
- Skin protection : – Hats, Long sleeved clothes etc.

B Inspection and Maintenance of Storm Water Conduits

2.3 Inspection and Examination of Storm Water Conduits

The inspection can be carried out directly or indirectly. The direct inspection involves the visual inspection and examination of the health of a particular drainage appurtenance. However, this is applicable only for the open channels and pumping stations. Indirect inspection is more commonly used for closed storm conduits. A number of techniques based on the use of a camera etc. may be used for indirect inspection of the storm conduits. The selection of a particular technique for inspection will depend upon a number of factors including the cost involved, availability of finances with the maintenance department, type of the appurtenance, potential defects, etc. The suggested period of preliminary inspection is based on the best professional judgment prevailing in Indian conditions and shall be carried out as in Table 2.3.

Table 2.3: Preliminary inspection for Manholes &Conduits

S.No.	Name of components	Inspection frequency
1.	**Conduits & Manholes**	
	300 mm – 600 mm Dia	Once in 6 months
	>600 mm – 1000 mmDia	Once in 1 year
	>1000 mm Dia	Once in 2 years
2.	**Gutters and Inlets**	Once in 6 months (Before monsoon)
3.	**Outfall structure**	Once in 6 months (Before monsoon)

2.3.1 Visual inspection of storm conduits

If an abnormality is detected during direct internal inspection or externally noticed from outside, the maintenance engineer should judge the urgency and the content of the abnormality, and then make a proper inspection and study.

2.3.2 Manhole Visual Inspection

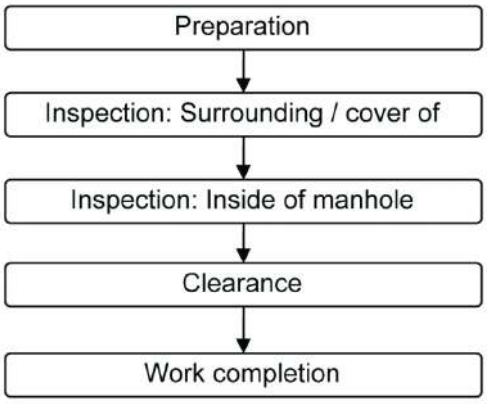
The visual inspection of manhole is performed manually by inspector with proper safety equipment. The manhole cover & internal surroundings of the manhole should be inspected as per checklist given below:

- Status of internal surface of manhole.
- Status of drains on the upstream and downstream sides viewed from the manhole.
- Status of groundwater infiltration.

To inspect the internal parts of the drains from the manhole, either a mirror or a strong light shall be used for observation, or with the help of TV camera meant for inspecting conduits.

Features of manhole visual inspection:

- Inspection accuracy is high because the inspector actually observes the abnormality personally.
- Economy comparison to inspection using a TV camera.
- The inspected results become very useful O&M data.
- The procedure for manhole visual inspection is shown in the flow chart



2.3.3 Closed Circuit Television (CCTV) Surveillance

Closed circuit television (CCTV) survey is a commonly used indirect inspection technique and is used to investigate the condition, in particular the structural integrity of the drains in close details. It is essential that CCTV surveys are conducted during low flow conditions. If the flow quantity is large, the drain upstream should be temporarily blocked and the flow diverted. An adequate lighting system should also be adopted so as to produce a clear picture of the drain. Pipes which are silted and the surfaces coated with grease should be cleansed prior to the survey. Such a survey helps the maintenance department in determining the priority of the remedial works and future inspection programme.

The CCTV inspection can be used for drainage pipes of diameter 100-900 mm. Above 900 mm diameter (man entry and restricted also), there are limitations due to lighting problems and camera line angles. Continuous advances are being made in the quality and range of TV cameras. The type of camera selected should be robust so that it can be used in pipes and give good quality pictures. The traction of the cameras is by pulling winches, by pushing or self-traction. The former two are not used much at present. However, self-traction is suitable for use in pipes above 225 mm diameter.

Other constraints in the use of self-traction are the weight of the trolley and electricity requirements.

Heavy silting of pipes/drainage channels precludes the use of self-traction. The cameras are attached to trolleys or mounted on a pair of skids or single flat tray. Inspection of the storm conduit by CCTV is limited to the top portion only. The objects under scrutiny are parallel to the camera and viewing is at an angle of 40 to 50 degrees. With radial scanning head, inspection normal to the channel wall is also possible. A typical arrangement is as shown in Figure 2.1.

Any abnormality detected in the pipeline during the CCTV inspection should be recorded on videotapes or as photographs. The inspection results should be recorded in the appropriate inspection forms.

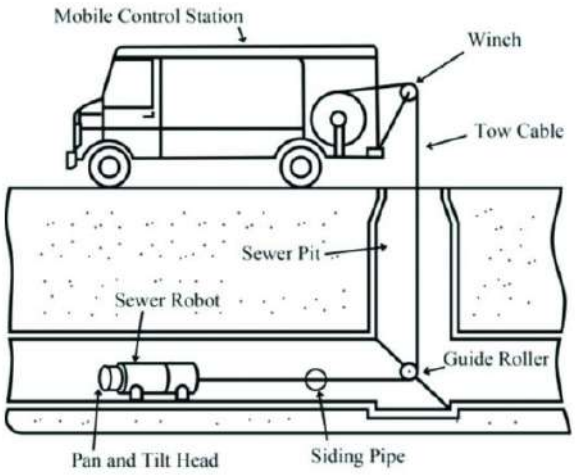


Figure 2.1: Typical CCTV Equipment

2.3.4 Maintenance of Records and Follow up Action

When inspections and examinations are performed, an inspection sheet should be prepared and recorded for manholes and pipes as shown in Table 2.4 and 2.5.

Table 2.4: Inspection sheet for manhole

Inspection Sheet		**No.**
Location (Manhole No. etc)		
Inspection Dates		**Inspector**
Inspection Items	**Manhole cover**	Abrasion, difference in level, damaged
	Inside of manhole	Corrosion, damages to floor, metal steps corroded, inferior pipe end, rubbish, odour

	Pipe	Corrosion, damage, coupling dispacement, inadequate inclination, roots of trees, earth, sand and mortar, road subsidence
	Lateral drains	Damage, displacement, earth and sand, road subsidence
Inspection result		
Fllow up Actions	▪ Necessary ▪ Not Necessary	▪ Contracted ▪ Self
Date of order		
Date of schedule		
Date of completion		
Remarks		

Source: Adapted from Sewerage and Sewage Treatment Manual, 2013

Table 2.5: Inspection sheet for storm conduit

Site	**City**	**Street**	**Inspection date**	**Time**
From Manhole (number)	**To Manhole (number)**	**Pipe Size (mm)**	**Type of pipe**	**Direction**
Start	**End**			
Type of problem	**Nature of problem**	**Severity Level**	**Surface Condition**	
Action required / Follow up actions				

Source: Adapted from Sewerage and Sewage Treatment Manual, 2013

Note: Street inlets should be checked whether the gratings are in proper position, bent or distorted etc. It should also be checked whether ther are clogged due to dumping of garbage, leaves etc.

2.3.5 Maintenance procedure

The principal effort in the maintenance of storm water conduit is to keep them clean and unobstructed. The storm conduits will erode, clog or otherwise deteriorate. The capital investment in the drainage system financially justifies the preventive maintenance of storm water drainage works, particularly storm conduits drainage that includes the measurement of rate of flow, cleaning , flushing, supervision of connections, protection of existing storm conduits etc. The complaints most frequently received about the

systems are caused by clogging, brekage of pipe etc. Clogging is generally confined to the storm conduits too small for a man to enter. Storm conduits become clogged by deposition of silt and sand that form pools in which debris and other solid materials accumulate. Storm conduits are sometimes misused as receptacle for rubbish, waste building materials, ashes and other solid wastes deposited in them through manholes or unautorised openings. Manhole covers are sometimes stolen exposing drains to easy access for such dumping of wastes. Such difficulties may be avoided by locking the covers or fastening them down so that they can be removed only by special tools. Maintenance also includes emergency repairs as a result of accidents, weather conditions or other unexpected damages or facilities.

Every storm water system needs to be properly maintained to reduce or eliminate costly repair problems. The lack of proper maintenance is most common cause of storm water system failure. Prior to finalizing inspection programme, operation and maintenance plan should be developed for particular facilities that can help coordinate inspection and maintenance activities for the particular type of system and track any problem that may have been encountered while performing inspection and maintenance. Special attention should be paid to any signs of deterioration in the systems both hydraulically and structurally, since any structural defect, blockage, leakage or siltation detected at its early stage of formation would allow preventive remedial works to be carried out at lower cost. The frequency of inspection should be determined principally based on the nature and importance of the installations, the likely consequence in the event of malfunctioning of the system, the frequency of drainage complaints received in the vicinity and the resources available.

The maintenance engineer should first delineate the entire underground storm drains covered area into suitable sectors considering size and depth of conduit, spacing of manholes, condition of conduits and method of cleaning whether mechanical or manual. Each such sector should be placed under a maintenance gang consisting of one supervisor and six men. The work of each maintenance gang should consist the following:

a) Check the accumulation of silt deposited in manhole, damage walls or steps, manhole covers, clogged vertical pipe of drop manholes etc. as per results of inspection program as detailed in following sections. While cleaning of the pipes and manholes will be undertaken, repair etc. may be carried out simultaneously by construction gang of mason and helpers.

b) Check the storm conduit line between two successive manholes for silting and flow conditions and removes the deposited silt.

2.3.6 Desilting and cleaning of storm water conduits

During course of inspection of storm conduits as mentioned above if it is found that particular reach of storm water conduit is either heavily silted or clogged then cleaning and desilting of conduits should be carried out either manually or with mechanical

equipment.Storm water conduit cleaning works require usual implements like pick axes, manhole guards, tripod stands, danger flags, lanterns, batteries, safety lamps, silt drums, ropes, iron hooks, handcarts, plunger rods, observation rods, shovels, portable pump set either diesel or petrol engine etc. In addition, storm conduit cleaning work calls for the special equipment like conduit rods, rodding machine with flexible conduit rods, scraper etc.

2.3.7 Conduit Rods

These rods are used for cleaning small storm conduits. The conduit rods may be of bamboo or teak wood or light metal usually about one meter long at the end of which is a coupling, which remains intact in the storm conduit but can be easily disjointed in the manhole. Sections of the rods are pushed down the storm conduit. In case of only shallow conduits where man entry is not necessary, the front or the advancing end of the conduit rod is generally fitted with a brush, a rubber ring for cleaning or a cutting edge to cut and dislodge the obstructions. These rods are also useful to locate the obstruction from either manhole.

2.3.7.1 Rodding Machine with Flexible Conduit Rods

This consists of a machine, which rotates a flexible rod to which is attached a cleaning tool such as auger, corkscrew or hedgehog and sand cups.

The flexible rod consists of a series of steel rods with screw couplings. It is guided through the manhole by a bent pipe. The machine propels the rod with the tool attached to one end, the other end being fixed to the machine. The rotating rod is thrust into the bent pipe manually with clamps with long handles for holding the rod near the couplings. As the rod is thrust inside, the machine also is drawn towards the manhole. The rod is pulled in and out in quick succession, when the tool is engaging the obstruction so as to dislodge or loosen it. When the obstruction is cleared, the rod is pulled out by means of clamps keeping the rod propelled to facilitate quick and easy removal. The various tools are shown in Figure 2.2.

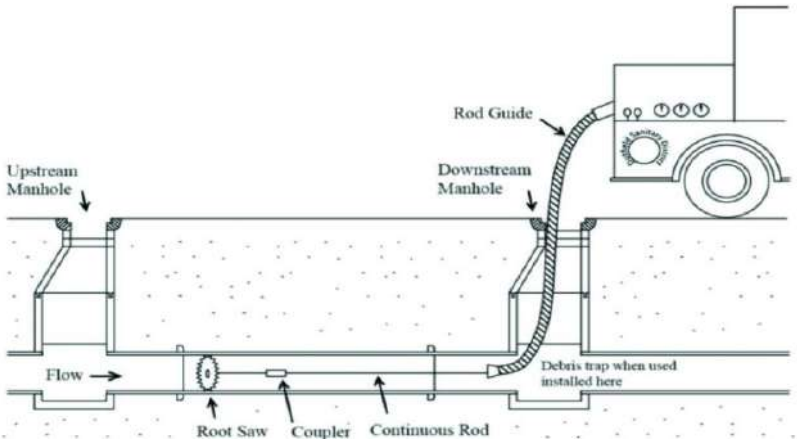


Figure 2.2: Power rodding operation

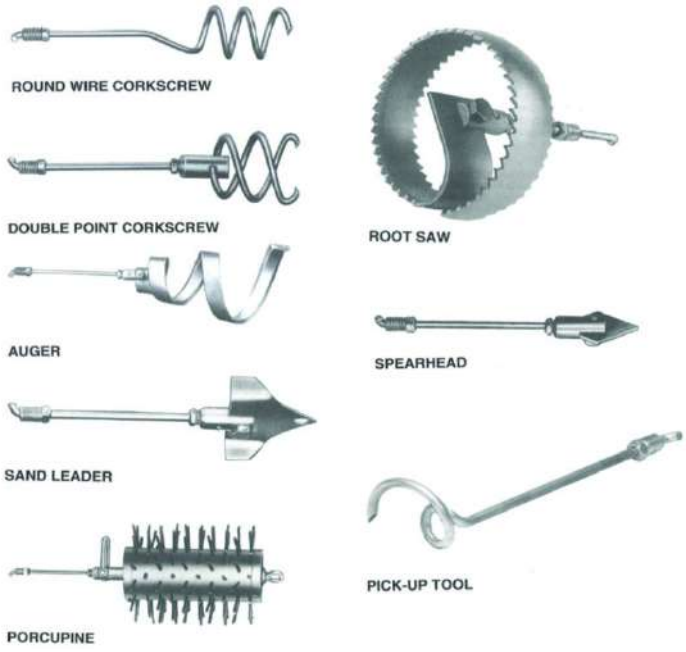


Figure 2.3: Rodding heads

2.3.7.2 Scraper

This method shall be used for storm conduits of diameter larger than 750 mm. The scraper is an assembly of wooden planks of slightly smaller size than the storm conduit to be cleaned. If the scraper cannot be lowered through the opening of manhole, it has to be assembled inside the manhole. The scraper chains, attached to a control chain in the manhole into which it is lowered, are then connected to a winch in the next downstream manhole by means of chains. The winch is then operated to push the debris ahead of the scraper. The upward flow behind the scraper and the water dropping from the top of the scraper will also assist in pushing it in the forward direction. This ensures that the bottom and the sides of the conduit are cleaned thoroughly. The scraped debris is removed manually. Circular scrapers are used on small conduits below 350 mm diameter for cleaning. They are commonly known as discs and these discs are both collapsible and made of metal or a wooden pair separated by about 200 mm by steel rods.

Note: Details of other storm water conduits cleaning equipment may be referred to Sewerage and Sewage Treatment System Manual, CPHEEO, 2013.

2.3.8 Conduit Rehabilitation

Storm Conduits which are expected to be critical after inspection, have to be taken up for rehabilitation. Conduit rehabilitation is necessitated either to improve the hydraulic performance of the existing line or due to danger of the conduit line deteriorating further and leading to eventual collapse or failure.

Conduit rehabilitation may be carried out by repair, renovation or by renewal of the conduit. The condition of the storm conduit sometimes improved by repair work or sometimes it is requires to increase its carrying capacity or to increase its life, known as renovation and when the storm conduit line is reconstructed or replaced to the same dimensions as existing, it is known as renewal.

2.3.8.1 Repair

This refers to partial replacement or repair of damage to the facility. Repair provides utility, but not an increase in functions, so it does not contribute to extension of the service life of the facility. Repair simply maintains the capacity and life and does not cause a change in fixed assets. It includes the following:

2.3.8.2 Non-structural lining

These techniques are primarily used to seal the buried pipes and are quite effective in arresting the deterioration process of buried pipe line. This type of lining, however, does not provide any structural strength to the pipe line. Two main processes are:

a) Coating
b) Spot repairs

(a) Coating: A wide variety of materials including cement mortar, epoxy resins, and polyurethane, are available to coat the interiors of pipes. These materials are usually sprayed onto the pipe for corrosion protection. Structural spray-on lining is also available, made from quick setting epoxy resin or polyurethane material.
Pipe lines may be restored by treating manhole lengths with a chemical solution. The length is first sealed and filled with one solution which is then pumped out. The length is refilled with another solution which is subsequently pumped out. The chemical reaction between the two components seals joints and cracks in the pipe and stabilizes the surrounding soil.

(b) Spot repair: Internal grouting of pipe joints and radial cracks can be accomplished with a packer. The packer is moved in to place over the pipe joint or radial crack, then bladders are inflated at each end of the packer and grout is then injected into and around the damaged area. When the repair is completed the bladders are deflated and the packer removed from the system. Cementitious grout, resins, and urethane, are the common grout materials used. Internal mechanical seals are also available. They are generally made from a special EPDM rubber gasket reinforced with internal stainless steel compression hoops. They form a tight yet flexible pressure seal over the damaged area.
A section of felt tube saturated with at thermo-setting resin up to approximately 6 m can be pulled into the existing pipe at the point of needed repair. This short tube section differs from a conventional cured-in-place liner by the curing process. No heat is required to cure the resin. Ambient temperature cures the pipe just in few hours.

2.3.8.3 Renewal

This means improvement and replacement of facilities not caused by expansion of drainage area. It includes improvement, which is reconstruction or replacement of the facility that has not yet reached the specified service life, and replacement which is reconstruction or replacement of the facility that has reached the specified service life. This is further discussed in the rehabilitation method below.

2.3.8.4 Rehabilitation Methods

Under the traditional method of conduit relief, a replacement is made or additional parallel storm conduit is constructed by digging along the entire length of the existing pipeline, while these traditional methods of conduit rehabilitation requires digging and replacing the deficient pipe with (the dig-and-replace method), trenchless methods of rehabilitation use the existing pipe as a host for a new pipe or liner. Trenchless conduit-rehabilitation techniques may correct pipe deficiencies in the storm water drainage system that require less restoration and cause less disturbance and environmental degradation than the traditional dig-and-replace method. Trenchless conduit-rehabilitation methods include:

I. Pipe bursting or in-line expansion
II. Slip lining
III. Cured in place pipe line

i. Pipe Bursting or In-line Expansion

Pipe bursting or in-line expansion is a method by which the existing pipe is forced outward and opened by a bursting tool. During in-line expansion, the existing pipe is used as a guide for inserting the expansion head (part of the bursting tool). The expansion head, typically pulled by a cable rod and winch, increases the area available for the new pipe by pushing the existing pipe radically outward until it cracks. The bursting device pulls the new pipeline behind itself. The pipe bursting process is illustrated in Figure 2.4.

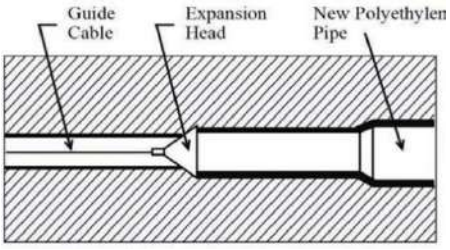


Figure 2.4: Pipe bursting process
Source: JICA, 2011

ii. Slip lining with fusion welded continuous pipe

Slip lining is a well-established method of trenchless rehabilitation. During the slip lining process, a new liner of smaller diameter is placed inside the existing pipe. The annular

space, or area between the existing pipe and the new pipe, is typically grouted to prevent leaks and to provide structural integrity. If the annulus between the sections is not grouted, the liner is not considered a structural liner. Continuous grouting of the annular space provides the seal. Grouting only the end-of-pipe sections can cause failures and leaks. In most slip lining applications, manholes cannot function as proper access points to perform the rehabilitation. In these situations, an insertion pit must be dug for each pipeline segment. Due to this requirement in most applications, slip lining is not a completely trenchless technique. However, the excavation required is considerably less than that for the traditional dig-and-replace method. System and site conditions will dictate the amount of excavation. Methods of slip lining include continuous, segmental and spiral wound methods. All three methods require laterals to be re-connected by excavation or by a remote cutter. In continuous slip lining, the new pipe, jointed to form a continuous segment, is inserted into the host pipe at strategic locations. The installation access point, such as a manhole or insertion pit, must be able to handle the bending of the continuous pipe section. Installation by the segmental method involves assembling pipe segment at the access point. Slip lining by the segment method can be accomplished without rerouting the existing flow. In many applications, the existing flow reduces frictional resistance and thereby aids in the installation process. Spiral-wound slip lining is performed within a manhole or access point by using interlocking edges on the ends of the pipe segments to connect the segments.

iii. Cured in place pipe

A felt tube saturated with a thermosetting resin is either pulled into the existing pipe or inserted through as water pressure pushes the tube tightly against the pipe wall. The water in the tube is then heated to the curing temperature from 70-80 degrees Celsius. The plastic resin on the tube cures the solid pipe inside the existing pipe creating a new lining. Installation goes quickly leaving no annular space to be sealed. Odd cross sections, bends, and minor deformations can be accommodated. This method is particularly useful when flow capacity must be maintained or slightly increased.

2.4 Safety Procedures

2.4.1 Safety requirement for working confined space

Working in a confined space such as an underground drain, box culvert, tanks, etc., is potentially dangerous. Great care must be taken at all times, particularly when working under adverse weather conditions. The legislative requirements of the Factories and Industrial Undertaking (Confined Spaces) Regulation have to be followed. The essential elements of which include:

- Appoint a “competent person - define” to carry out a risk assessment and make recommendations on safety and health measures before undertaking work in confined space.
- Allow only “trained and certified workers” to work in the confined space.

- Operate a “permit-to-work” system.
- Conduct levels of oxygen of the confined space before entry. (oxygen level reference should be given)
- Provide adequate ventilation.
- Isolate the confined space.
- Ensure a “standby person” is stationed outside the confined space to monitor the weather condition and maintain communication with the workers inside.
- Ensure the use of approved breathing apparatus (if recommended in the risk assessment report) and other necessary personal protective equipment by workers inside the confined space.
- Formulate and implement appropriate emergency procedures to deal with serious or imminent danger to workers inside the confined space.
- Provide necessary instructions, training and advice to all workers to be working within a confined space or assisting with such works from immediately outside the confined space.

Based on experience, it is considered necessary to add a second line of defence to enable an early warning signal to be given out so as to increase the possibility of escape or being rescued when the prescribed safety measures fail. The following enhanced safety measures are introduced for confined space work, unless the risk assessment demonstrates that such measures produce no added benefit to safety at work.

- Continuous Gas Monitoring: The person entering a confined space shall bring along, a gas detector, which can give out warning signals, of the sudden presence of dangerous gases or oxygen deficiency, to continuously monitor the ambient condition of the confined space so as to enable immediate evacuation.

- Personal Alarm: A personal alarm of dead-man type, which is able to give out signals soon after a person loses his mobility, shall be worn by all persons entering a confined space to facilitate early rescue.

2.5 Maintenance of Rising Mains

Rising mains are generally of mild steel or DI pipes, regular checking of pipeline should be exercise to detect leakage or bursting of pipe, a team should be formed to move along a pipe and visually locate leakage etc. which should be immediately repaired. Bursting of rising main anywhere in the alignment can be easily detected by the fall of pressure at the pump head. The operator should inform the maintenance team whenever he detects the fall in pressure indicated by pressure gauge fitted in delivery side of the pump. Spare pipes and fitting should be kept in a store to replace he burst pipes in time.

CHAPTER 3:PUMPING STATION

3.1 General

Pumping machinery in course of long operataion is subjected to wear, tear, abrasion and therefore it is vulnerable to failures. In storm water drainage system where pumping is employed to pump out the storm water such failures might cause flooding of upstream zones causing risk to property and life. Therfore, correct operation and timely maintenance and upkeep of pumping stations and pumping machinery are of vital importance. This necessitates due attention to be paid to all aspects for efficient functioning of pumping machinery.

3.2 Operation of the Pumps

Summarized below are a few points to be observed while operating the pumps.

a) Dry running of the pumps should be avoided.

b) Centrifugal pumps have to be primed before starting if they are not self-priming.

c) Pumps should be operated only within the recommended range on the head discharge characteristic 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 the name plate on the motor.

e) Delivery valve should be closed at the time of starting. Pumps of high specific speed draw more power at shut off. Such pumps should hence be started with the delivery valve open. While stopping, the position of the delivery valve should be as at the time of starting.

f) The delivery valve should be operated gradually to avoid surges.

g) When pumps are to operate in parallel, the pumps should be started and stopped with a time lag between two pumps. The time lag should be adequate to let the pressure gauge stabilize.

h) When the pumps are to operate in series, they should be started and stopped sequentially, but with the minimum time lag as possible. 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.

(g) 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,

(h) The running of the duty pumps and of the stand byes should be so scheduled that all pumps are in ready-to-run condition.

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

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

3.3 Starting the Pumps

Checks before Starting

The following checklist should be gone through **before starting** the pump:

i. Ensure that power is available in all three phases.
ii. Ensure that the trip circuit for relays is in a healthy state.
iii. Check voltage in all three phases. The voltage in all phases should be almost same and within +/-10% of rated voltage, as per permissible voltage variation.
iv. Check functioning of the lubrication system.
v. Check stuffing box to ensure that it is packed properly.
vi. Check and ensure that the pump is free to rotate.
vii. Check over current setting if the pump has not been operated for a week or longer period.
viii. Ensure that the water level in the sump/intake is above low water level and the inflow from the source or preceding pumping station is adequate.

Starting of Pumps

The procedure for starting and operating the pumps is as follows:

i. To start a non – priming centrifugal pump, the suction pipes and the pump should be fully primed. Positive suction centrifugal pump should be primed by opening the suction wall and letting out air from the casing by opening air vent. If vacuum pump is provided, the pump can be primed by operating vacuum pump till steady stream of water is let out from1eJivery of vacuum pump. In the absence of vacuum pump, priming can be done by pouring water in casing and evacuating air through air vent or by admitting water pumping main by opening bypass of reflux valve and delivery valve. Check all joints in suction pipe and fittings.

ii. Close the delivery valve and then loosen slightly.

iii. Switch on the motor, check that the 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 the head.

vi. When the motor attains a steady speed, the delivery valve hold be gradually opened in steps.

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 for leakage through mechanical seal and vibrations, if any.

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

Stopping the Pump

Stopping the Pump under Normal Condition

The following steps should be followed for stopping a pump of low- and medium - specific speed:

a) Close the delivery valve gradually. Sudden or fast closing should not be resorted to; it can rise to water hammer pressures.
b) Switch off the motor.
c) Open the air vent in case of a submersible pump.
d) Stop lubricating oil or clear water supply in case of an oil-lubricated or clear water lubricated VT pump as applicable.

Stopping after Power failure/tripping

In case of power supply to the pumping station fails or trips, following actions should be immediately taken.

a. Close all delivery valves on delivery piping of pumps, manually if necessary, as actuators can-not be operated due to non-availability of power.
b. Check and ensure that all breakers and starters are in open condition i.e. off-position.

c. All switches and breakers should be operated to open i.e. off-position.
d. Information about power failure should be given to all concerned, particularly to the upstream pumping station to stop pumping so as to prevent overflow.

3.4 Preventive Maintenance of Pumping Machinery

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. Such premature failure or breakdown causes immense hardship to the consumers and staff, and unavoidable increase in repair cost. Inefficient running of the pump increases burden of power cost. The importance of preventive maintenance, therefore, needs to be emphasized.

The general guidelines for maintenance schedules for pumps and associated electrical and mechanical equipment are listed below. However, these should not be considered as comprehensive, as the characteristics of equipment and site conditions differ from place to place. For example, in dust-laden environmental or places where occurrence of storms is frequent, renewal of oil and grease in bearing will have to be done at lesser intervals than specified in general guidelines due to blowing-in dust in motor.

1 **Check Water –Seal Packing Glands for Leakage -** See that the packing box is protected with a Clear Water- supply from the outside source; make sure that water seal pressure is at least 5 psi greater than the maximum pump discharge pressure. See that there are no cross connections. Check the packing glands for leakage during operation. Allow a slight seal leakage when pumps are running to keep them cool and in good condition. The proper amount of leakage depends on the equipment and operating conditions. Sixty drops of water per minute is a good rule of thumb. If excessive leakage is found, hand-tighten gland nuts evenly but not too tight. After adjusting packing glands make sure that the shaft turns freely by hand. If serious leakage continues, renew packing shaft or shaft sleeve.

3 **Check Grease –Sealed Packing Glands-** When grease is used as packing gland seal, maintain constant grease pressure on packing during operation. When a spring loaded gease cup is used, keep it loaded with grease.

3. Operate Pumps Alternately - If two or more pumps of the same size are installed, alternate use to equalize their wear, keep motor windings dry and distribute lubricant in bearing.

4. Inspect Pump Assembly - Check floats control, noting how they respond to rising water

5. Check Motor Condition.

6. Clean Pump - First lock out power and tag switch. Clean-out hand holes are provided on the pump volute. To clean the pump, close all valves. Then drain the pump and remove all solids.

7. Check Packing Gland Assembly - Packing gland assembly is the unit's most abused and blesome part. If stuffing box leaks excessively when gland is pulled up with mild pressure remove packing and examine the shaft sleeve carefully. Replace grooved shaft sleeve because the packing cannot be held in the stuffing box with shaft sleeve. Place the packing one strip at a time, tamping each strip thoroughly and staggering joints. Position the lantern ring properly. If grease sealing is used, completely fill the lantern ring with grease before putting the remaining rings of packing in place.

8. Check Mechanical Seals - Mechanical seals usually consist of two sub-assemblies:

    - A rotating ring assembly
    - A stationary assembly

    Inspect the seal for leakage and excessive heat. If any part of the seal needs replacing, replace entire seal. Always make sure that the mechanical seal is surrounded with water before starting and running the pump.

9. Inspect and Lubricate Bearings - Unless otherwise specifically directed for a particular pump model, drain lubricant and wash out oil wells and bearings with solvent. Check bearings to see that all rings turn freely with shaft. Repair or replace if defective. Refill with proper lubricant.

10. Check Operating Temperatures of Bearings - Check bearing temperature with the thermometer, not by hand. If anti-friction bearings are running hot, check for over lubrication and relieve if necessary. If the sleeve bearings run too hot, check for lack of lubricant. If proper lubrication does not correct the condition, disassemble and inspect the bearing. Check the alignment of the pump and motor if high temperature continues.

11. Check Alignment of Pump and Motor - If misalignment recurs frequently inspect the piping system. Vertical pumps usually have flexible shafting which permits slight angular misalignment. However, if solid shafting is used, align exactly.

12. Inspect and Service Pumps –

    - Remove the rotating element of the pump and inspect thoroughly for wear
    - Remove deposits or scales, if any. Clean out the water seal piping
    - Examine the wearing rings. Replace the seriously worn wearing rings to improve efficiency. Also, check the wearing rings for clearance. Generally, it should be

no more than 0.003 inch, per inch on the diameter of the wearing rings.

3.4.1 Daily Observations and Maintenance

(a) Daily Maintenance

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

(b) 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 the following irregularities:

1. Changes in sound of the 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. Spark or leakage current in motor, starter, switch-gears, cable etc
9. Over heating of motor, starter, switch gear, cable etc

(C) Record of Operations and Observations

A log book should be maintained to record the hourly observations. It should cover the following items:

i. Timing when the pumps are started, operated and stopped during 24 hours;
ii. Voltage in all three phases;
iii. Current drawn by each pump-motor set and total current drawn at the installation;
iv. Frequency;

v. Readings of vacuum and pressure gauges;
vi. Motor winding temperature;
vii. Bearing temperature for pump and motor;
viii. Water level in intake/sump;
ix. Flow meter reading;
x. Daily PF over 24-hour duration;
xi. Any specific problem or event in the pumping installation or pumping system e.g. burst in pipeline, tripping or fault, power failure.

Table 3.1: Typical Pumping Station Operation Log

Typical Pumping Station Operating Log				
Date:				
Operators:				
Pump Unit No	**No-1**	**No-2**	**No-3**	**Remarks**
Motor Start Time				
Motor Stop Time				
Motor Reading				
Voltage				
Amps				
Elapsed Hour				

3.4.2 Monthly Maintenance

i) Check for free movement of the gland of the stuffing box; check gland packing and replace if necessary.
ii) Clean and apply oil to the gland bolts.
iii) Inspect the mechanical seal for wear and replace, if necessary.
iv) Check the condition of bearing oil and replace or top up, if necessary.

3.4.3 Quarterly Maintenance

(i) Check the alignment of the pump and its driver. The pump and motor should be decoupled while correcting the alignment, and both pump and motor shafts should be pushed to either side to eliminate the effect of end play in bearings.

(ii) 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 with 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 to one-half. A fully packed housing will overheat the bearing and result in reduction of life of the bearing. .

(iii) Tighten the foundation bolts and hold-down bolts of pump and motor mounted on base plate or frame.

(iv) Check vibration level with instruments, if available; otherwise by observation.

(v) Clean the flow indicator and other instruments and appurtenances in the pump house.

3.4.4 Annual Inspections and Maintenance

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

(i) Clean and flush the bearings with kerosene and examine for flaws developed, if any, e.g. corrosion, wear and scratches. Check the end play. Immediately after cleaning, the bearings should be coated with oil or grease to prevent ingress of dirt or moisture.
(ii) Clean the bearing housing and examine for flaws, e.g. wear, grooving etc. Change oil or grease in the bearing housing.
(iii) Examine the shaft sleeves for wear or scour and rectify, if necessary. If the shaft sleeves are not used, the shaft at gland packing should be examined for wear.
(iv) Check the stuffing box, glands, lantern ring, and mechanical seal and rectify, if necessary.
(v) Check clearance in the wearing ring. It should be within the limit recommended by the manufacturer. An 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 the same should be investigated. Normally, if the clearance in wearing rings increases by about 100 per cent for small pumps and 50-75 per cent for large pumps, the rings should be renewed or replaced to restore the original clearance.
(vi) Check the impeller hubs and vane tips for any pitting or erosion.
(vii) Check the interior of volute, casing and diffuser for pitting, erosion, and rough surface.
(viii) All vital instruments i.e. pressure gauge, vacuum gauge, ammeter, voltmeter, watt-meters, frequency meter, tachometer, flow meter etc should be calibrated.
(ix) Conduct performance test of the pump for discharge, head and efficiency.
(x) Measures for preventing ingress of flood water should be examined. Ingress of flood water in sump, well, tube-well or bore-well should be strictly prevented. A seal cap should be provided above tube-well/bore-well.
(xi) Check the vibration level.

3.4.5 History Sheet

A history sheet should be maintained for all pumps. It should contain all important particulars, cords of all maintenance, repairs, inspections and tests etc. It should generally include the following:

- Details of the pump, rating, model, characteristic curves, performance test report etc.
- Addresses of both the manufacturer and the dealer along with their phone and fax number and e-mail addresses.
- Date of installation and commissioning.
- Brief details of monthly, quarterly and annual maintenance and the observations made during inspections.
- Details of breakdowns and repairs along with fault diagnosis, replacement of major components i.e. impeller, shaft, bearings, wearing rings.
- Results of annual performance test, including discharge and efficiency.
- Yearly operation hours of the pumps.
- Brief findings of energy audit.

Inspection reports should be prepared for each storm water pumping stations according to the equipment installed.
An example of an annual inspection report for pumping station is shown in Table 3.2.

Table 3.2: Annual Inspection of Pumping Station

Date					
Mechanical	**General condition of equipment**				
	Storm Water Pump			**Sump Pump**	**Remarks**
	No. 1	**No. 2**	**No. 3**		
1. Pump					
Bearings					
2. Gates					
Gate Operator (manual)					
Gate operator (motor)					
Stems					
3. Crane and Hoist					
4. Trash racks					
Drive chain					
Bearings					
Gear reducers					
Electrical	**Date**				
4 Motors					
5 Motor bearing					
6 Switchgear Controls					

7 Control panels						
General						
1. Water Levels	**Elevation**	**Remarks**				
Forebay						
Sumps						
Building and grounds	**Date**					
	Remarks					
1. Sump						
2. Forebay						
3. Discharge chamber						
4. Gatewell to river outlet						
5. Structure						
6. Fire extinguishers						
7. Tools and cabinets						
8. Painting						
9. Caulking						
10. Grating, rails and ladders						
11. Water system and plumbing						
12. Louvers and ventilators						
13. Windows						
14. Doors						
Remarks						

Recommended maintenance/inspection tasks for equipment in pumping stations are summarised by frequencies and are listed in Table 3.3. Because the required maintenance / inspection and their frequencies may differ depending on the equipment installed, maintenance plans should be prepared according to manufacturer's instruction manuals of related equipment.

Table 3.3: Recommended maintenance for pumping equipment

	Start up	**monthly**	**3 month**	**6 month**	**1 year**	**5 year**	**Oper Hrs**
Trash rake					CL		
Motors				AL	PG	CL	
Heaters	GI						
Gear reducers		GI		CH			
Drive chain	PG						PG
Pillow blocks				PG			
Torque limit buckling					PG		
Shear pin & Sprocket		GI					

	Start up	**monthly**	**3 month**	**6 month**	**1 year**	**5 year**	**Oper Hrs**
Trip cam		GI					
Control panel					GI, CL		
Sub – station drainage					GI		
Building structure			GI				
Trash-rack				GI			
Toilet facility				GI			
Domestic water				GI			
Holding tank			GI		PO		
Siphon breakers			GI				
Unit heaters					GI		
Fire extinguishers		GI		GI			
Switch gear	GI						
Bus & connections					GI, CL		
Instruments & lamps	GI				GI, CL		
Heaters					GI		
Lighting panel	GI				GI		
Control panel	GI				GI		
Grounding					GRT		
Float control	GI				GI		
Main pump motors							
Entrance channel						GI, RS	
sump					GI, RS		
Gates				GI, O, CL			
Stem	GI			CL, SG			
Thrust nut	GI			CL, SG			
Manual operators					PG		
Motor operators					GI, CL		

Legend

O	Operate	**GRT**	Ground Resistance Test	**MR**	Megger and Record
CH	Change	**TO**	Test Oil	**PG**	Pressure Grease
CL	Clean	**GI**	General Inspection	**SG**	Surface grease
AL	Add Lubricant	**PO**	Pump Out	**TS**	Test
RS	Remove Silt	**RC**	Remove Condensate		

Source: JICA, 2011

3.5 Maintenance Schedule for Motors

3.5.1 Daily Maintenance

I. Clean the external surface of the motor.
II. Examine the earth connections and motor leads.
III. Check the temperature of the motor and see whether it is overheated. The permissible maxim temperature is above the level which can be comfortably felt by hand. Hence, the temperature observation should be made with RTD 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 is a sign of defect.)
IV. In case of an oil-ring lubricated bearing:
    - Examine the bearing to check whether oil rings are working.
    - Note the temperature of the bearing.
    - Add oil, if necessary.
V. Check for any abnormal bearing noise.

3.5.2 Monthly Maintenance

i. Check the belt for proper tension. In case it is excessive, it should immediately be reduced.
ii. Blow dust from the motor.
iii. Examine the oil in oil lubricated bearing for contamination by dust, grit, etc. (This can be judged from the colour of the oil).
iv. Check the functioning and connections of anti-condensation heater (space heater).
v. Check the insulation resistance by meggering.

3.5.3 Quarterly Maintenance

(i) Clean oil lubricated bearings and replenish 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 to one-half. A fully packed housing will over-heat the bearing and result in reduction of life of the bearing.

(ii) Wipe the brush holders and check the contact faces of brushes of slip-ring motors. If the con-tact faces are not smooth or are irregular, file them for proper and full contact over slip rings.

(iii) Check the insulation resistance of the motor.

(iv) Check for tightness of cable gland, lug and connecting bolts.

(v) Check and tighten foundation bolts and hold-down bolts between motor and frame.

(vi) Check the vibration level with an instrument, if available; otherwise by observation.

3.5.4 Half Yearly Maintenance

(i) Clean the windings of the motor; bake and varnish, if necessary.

(ii) In case of slip ring motors, check the slip-rings for grooving or unusual wear. Polish them with smooth polish paper, if necessary

3.5.5 Annual Inspections and Maintenance

i. Clean and flush the bearings with kerosene and examine for flaws developed, if any, e.g. wear and scratches. Check the end-play. Immediately after cleaning, the bearings should be coated with oil or grease to prevent ingress of dirt or moisture.

ii. Clean the bearing housing and examine for flaws, e.g. wear, grooving etc. Change oil or grease in the bearing housing.

iii. Blow out dust from the windings of the motor thoroughly with clean dry air. Make sure that the pressure is not so high as to damage the insulation.

iv. Clean and varnish dirty and oily windings. Re-varnish the motor if it is subjected to severe operating and environmental conditions e.g., operation in dust-laden environment, polluted atmosphere etc.

v. Check the condition of stator, stamping, insulation, terminal box, fan etc.

vi. Check the insulation resistance to earth and between phases of motors windings, control gear and wiring.

vii. Check the air gaps.

viii. Check the resistance of earth connections.

3.5.6 History Sheet

As with a pump, a history sheet should be maintained for the motor. It should contain all important particulars, records of periodical maintenance, repairs, inspections and tests. It should generally include the following:

i. Details of motor, rating, model, class of duty, class of insulation, efficiency curve, type test result and type test certificate etc;

ii. Date of installation and commissioning;

iii. Addresses of both the manufacturer and the dealer with their phone and fax numbers and e-mail addresses.
iv. Brief details of monthly, quarterly, half yearly and annual maintenance and the observations made regarding the insulation level, air gap etc during inspections.
v. Details of breakdowns and repairs along with fault diagnosis.
vi. Running hours at the time of major repairs.

3.6 Miscellaneous O&M Aspects

3.6.1 Lubrication

Pumps, motors and drives should be oiled and greased in strict accordance with the recommendation of the manufacturers. Cheap lubricant may often turn out to be expensive in the end. Oil should not be put in the housing while the pump shaft is rotating because the rotator action of the ball bearing will pick up and retain a considerable amount of oil. When the unit comes to rest, an overflow of oil around the shaft or out of the oil cup will result.

3.6.2 Mechanical Seals

Many pumps use mechanical seals in place of packing. Mechanical seals serve the same purpose as packing that is, they prevent leakage between the pump casing and shaft. Like packing, they are located the stuffing box where the shaft goes through the volute; however, they should not leak. Mechanical seals are gaining popularity in the wastewater field.

Mechanical seals have two faces which mate tightly and prevent water from passing through them. One half of the seal is mounted in the pump or gland with an “O” ring or gasket, thus providing sealing between the housing and the seal face. This prevents water from going around the seal face and housing. The other half of the mechanical seal is installed on the pump shaft. This part also has an “O” ring or gasket between the shaft and the seal to prevent water from leaking between the seal part and the shaft. There is a spring located behind one of the seal parts which applied pressure to hold the two faces of the seal together and keeps any water from leaking out. One half of the seal is stationary arid the other half is revolving with the shaft.

3.6.3 Bearings

Pump bearings usually last for years if serviced properly and used in their proper application. There are several types of bearings used in pumps such as ball bearings, roller bearings and sleeve bearings. Each bearing has a special purpose such as thrust load, radial load and speed. The type of bearing used in each pump depends on the manufacturing design and application. Whenever a bearing failure occurs, the bearing should be examined to determine the cause and, if possible, to eliminate the problem. Many bearings are ruined during installation or start up.

Bearing failure may be caused by:

1. Fatigue failure
2. Contamination
3. Brinelling
4. False brinelling
5. Thrust failures
6. Misalignment
7. Electric sparking
8. Lubrication failure
9. Cam failure

Table 3.4: Troubleshooting: Pumps

Trouble	**Possible Cause (No as per list below)**	**List of Causes**
Pump does not deliver water	1,2,3,5,6,7,9,10,15,18 ,21,23,26,28,29,30,31 ,33,40,41,42	1- Pump not fully primed. 2-Pressure at eye of impeller has faller pour pressure, causing cavitations clogging on suction side). 3-Suction lift too high. (Reduce suction lift after calculating permissible suction lift from and NPSHR). 4-Excessive amount of air in liquid. 5-Air pocket in suction line (Check point in suction line is above center line of pump and ¡f so, lower the line). 6-Air leaks into suction line. 7- Air leaks into pump through stuffing boxes or mechanical seal. 8-Net opening area of foot valves less. 9. Foot valve/strainer partially or fully clogged or silted up. 10-Suction bell mouth or foot valve insufficiently submerged. 11- Water-seal pipe clogged. 12-Seal cage improperly mounted ¡n stuffing box, preventing sealing, fluid from entering space to from the seal. 13-Circular motion in suspended suction pipe observed. (The problem indicates occurrence of vortex.) 14-Foot valve leaks. 15- Flap of foot valve jammed. 16-Concentric taper ¡n suction line causing air pocket (Replace with eccentric taper). 17-Occurrence of vortex ¡n intake, sump or well
Insufficient discharge delivered	2,3,4,5,6,7,8,9, 10,1 3,1 6,1 7,1 8, 20, 21, 23, 24, 27, 28, 29, 30, 31, 33,39,40,41	
insufficient pressure developed	2,3,4,21,23,24,26,27, 28,33,39	
Pump loses prime after starting	22,25,28,33,37,38,49, 53,54,55, 56, 58	
Pump requires excessive power	22,25,28,33,37,38,49, 53,54,55,56,58	
Stuffing box leaks excessively	34,36,44,45,46,47,48, 50,51,52	
Gland packing has short life	11,12,34,36,44,45,47, 48,49,50, 52	
Bearing has short life	17,2O,32,34,35,36,37 ,3,41,44,48,51,54,55, 56,57,58,59,60,61,62, 63	
Pump vibrates or noisy at all flow	10,17,19,20,22,33,34, 36, 37, 38, 40, 41, 43, 45, 46, 47, 48, 51, 52, 53,55,56,57,58,59,60, 61,62,63,65	
Pumps vibrates or noisy at low flow	1,2,3,9,10,17,20,21,2 7,39	

Trouble	**Possible Cause (No as per list below)**	**List of Causes**
Pumps vibrates or noisy at high flow	25,28	(Check whether all parameters for vortex-free operation are satisfied; take remedial measures). 18-Casing not air-tight and therefore breathing in. 19-Short bend/elbow on suction side. 20-Inadequate clearance below suction bell mouth. (Raise bell mouth to achieve recommended bottom clearance for vortex-free operation). 21-Speed too low for pump driven by diesel engine. 22-Speed too high for pump driven by diesel engine. 23-Wrong direction of rotation. 24-Total head of system higher than design head of pump. 25-Total head system lower than design head of pump. 26-Static head higher than shut off head of pump. 27-Pump characteristics unsuitable for parallel operation of pumps. 28-Burst or leakage ¡n pumping main. 29-Pumping main partially or fully clogged. 30-Air trapped in pumping main. 31-Malfunctioning of line valve causing partial or full closure. 32-Capacity of thrust bearing inadequate. 33-Foreign matter in impeller. 34-Misalignment. 35-Foundations not rigid or broken/loose foundation bolts or supporting structural member (RCC/ structural steel beams) not rigid (Dis-mantle existing foundation and cast new foundation. Strengthen supporting RCC/ structural steel beams). 36-Pump (impeller) shaft bent. 37-Rotating part rubbing on stationary part. 38-Pump shaft bearing (bush bearing or anti-friction bearing) worn. 39-Wearing rings worn. 40-Impeller damaged. 41-Impeller locking pin or collect1oose. 42-Pump shaft or transmission shaft broken. 43-Transmission shaft bent.
Pump oscillates axially	38	
Coupling Fails	34,36,38,60,62	
Pump overheat and/ or seizes	1,2,3,1 1,12,17,20, 24, 26, 27, 31, 34, 36, 37,38,44,45,47,8,49,50,53,54,55,56,57,58	
Pumps rotate in reverse direction on shutdown or after power failure or tripping	14,64	

Trouble	Possible Cause (No as per list below)	List of Causes
		44-Shaft or shaft sleeves worn or scored at the packing. 45-Gland packing improperly installed. 46-Incorrect type of gland packing for operating conditions. 47-Shaft running off center because of worn bearing or misalignment. 48-Rotor out of balance, causing vibration. 49-Gland too tight, resulting in no flow of liquid to lubricate gland. 50-Failure to provide cooling liquid to water cooled stuffing boxes. 51-Excessive clearance at bottom of stuffing box between shaft and casing, causing interior packing to be forced into pump. 52-Dirt or grit in sealing liquid, leading to scouring of shaft or shaft sleeve. 53-Excessive thrust caused by mechanical failure inside the pump or by the failure of the hydraulic balancing device, if any. 54-Excessive grease or highly viscous oil in antifriction bearing housing or lack of cooling, causing excessive bearing temperature. 55-Lack of lubrication causing overheating and abnormal friction in anti-friction bearing, bush bearing or transmission shaft bearing. 56-Improper installation of anti-friction bearing (damage during assembly, incorrect assembly of stacked bearings, use of unmatched bearing as a pair etc). 57-Dirt in bearings. 58-Rusting of bearing from water in housing. 59-Mechanical seal worn out. 60-Coupling bushes or rubber spider worn out or a wear in coupling 61-Base plate or frame not properly leveled. 62-Coupling unbalance. 63-Bearing loose on shaft or in housing. 64-Reflux valve (NRV) does not close tightly during shut down, after power failure or tripping. 65-Critical speed close to normal speed of pump.

CHAPTER 4: STORM WATER RECHARGE STRUCTURES

4.1 Introduction

Periodic maintenance of recharge structures is essential because infiltration capacity reduces rapidly as a result of silting, chemical precipitation and accumulation of organic matter.

Success of artificial recharge schemes and related developmental activities primarily depend on the cooperation of the community and hence, should be managed at the local level. From a basin management perspective, the division of a basin into many micro-catchments is, hence, an essential recognition of the community role. The success of implementation and optimal utilisation of the schemes depend on participation and active contribution of the public.

Structural maintenance is normally carried out either by government agencies or through initiatives of stakeholders. In case of surface spreading structures, annual maintenance consists of scraping the infiltration surfaces to remove accumulated silt and organic matter. In the case of injection wells, periodic maintenance of the system consists of pumping and /or flushing with a mildly acidic solution to remove encrusting chemical precipitates and bacterial growths on the well screens. The intervals between periodic cleanings can be extended by converting injection wells into dual purpose wells. However, in the case of spreading structures constructed with an overflow or outlet mechanism, annual desilting is a must.

Several issues are to be considered in the operation and maintenance of artificial recharge structures. These have been categorised as issues of high concern and moderate concern (ASCE, 2001). Safety, optimisation techniques and programs, value of wet-dry cycles, frequency of pond cleaning and condition of filters attached to the structures fall under issues of high concern, whereas security issues and rising ground water levels are among those of moderate concern in this regard.

4.2 Operational Data Requirements

Realistic estimates of the quantum of water entering and leaving the recharge area/basin/sub-basin are essential for assessing the volume of water that is recharged. Stream gauging stations in streams are needed if natural flows or a combination of natural flow and imported water are being recharged. In case the entire water being recharged is imported, suitable devices should be used to measure the inflow into the structure. The accounting of a system that has both surface and sub-surface recharge structures should also include devices to measure precipitation and evapotranspiration, which should be added to the inflow and outflow respectively. Initial measurements should be of sufficient frequency to determine how each of the parameters being measured varies with time. Once the variation is determined, a schedule that provides accuracy and economy can be set, which should integrate all the data being measured for optimizing data collection costs.

The data that should be measured for a recharge system include but are not limited to the following:

- Flow rate, duration and quality of source water.
- Inflow and outflow rates, duration and quality of inflow and outflow into and out of each unit of the recharge system.
- Recharge rates versus time for each unit and for the system as a whole.
- Depth to water and quality of ground water in the area being recharged and adjacent areas.
- Power usage by individual units and for the system as a whole.
- Depth to water in the recharge structures versus time (in case of surface structures)
- Thickness and composition of surface clogging layer when the structure is dry (in case of surface structures).
- Pressure versus time (in case of pressure injection)
- Depth to water in recharge well versus time in case of gravity head recharge wells.
- Precipitation and evaporation from surface ponds.
- Temperature of water at inflow and outflow locations.
- Time, rate and volume of pumping for each structure and for the system as a whole.

The data mentioned above helps fine-tune the recharge facility and provides the basis for corrections in case of problems. Periodic tests of pump efficiency, sampling of water quality and ground water level measurements should also be made and recorded on a defined schedule.

Measurement of any flows that pass downstream of the last recharge structure is needed if the total recharge from the operation is to be assessed. The volume of water passing the downstream gauging station, adjusted for precipitation and evaporation can be subtracted from the measured inflow volume to determine the quantum of water recharged.

4.2.1 Water Level Measurement

Measurement of ground water level in the aquifer, also known as ‘static water level’ or ‘potentiometric head’ is very important in artificial recharge schemes. Water levels have to be measured after a sufficient time has elapsed since stoppage of pumping or recharge to allow the water level to become stabilized and the drawdown/mounding effects to be minimized. Measurement of water levels in wells adjacent to a surface or subsurface recharge structure are also important as they help determine the shape and rate of growth of the recharge mound.

4.2.2 Water Quality Measurement

Complete water quality sampling and testing of a recharge scheme including source and aquifer should be done initially to determine the suitability of water for the intended use. The testing will provide a basis for the design of any other water quality treatment

facilities that may be needed. After implementation of the scheme, periodic water quality assessment should be made. Proper training should be imparted to the personnel involved to ensure that the samples are not contaminated during collection and transportation.

4.3 Preventive Maintenance

Preventive maintenance of artificial recharge structures implies a periodic action taken to forestall major repair or replacement of its components. It may be drying up and scarifying of recharge ponds, periodic pumping of recharge wells, or regular application of lubricants / protective substances to the mechanical parts or replacement of minor parts that are subject to deterioration or repeated failure. It also involves regular observation and recording of the behaviour of both static and dynamic components of the system to detect changes in their inherent condition that indicates the need for unscheduled maintenance. These include reduction in the recharge rates, temperature of mechanical parts or rate of settlement.

4.3.1 Maintenance of Surface Recharge Structures

Artificial recharge structures such as percolation ponds and check dams are examples of 'wet/dry cycle' operation (ASTE, 2001) in which the structures get filled up one or more times during monsoon and remain dry during the summer season. These structures can be maintained by removing the silt deposited at the bottom of the structure periodically. The optimal amount of cleaning would remove the accumulation of surface material that has reduced the recharge capacity of the structure.

4.4 Potential Problems

The Problems normally encountered in recharge projects are mainly related to the source water available for recharge, which generally require some sort of treatment before use in recharge installations. They are also related to the changes in the soil structure and the biological phenomena, which take place when infiltration begins, to the changes of land ownership and legal aspects.

4.4.1 Suspended Material

A major requirement for waters that are to be used in recharge projects is that they should be silt-free. Silt may be defined as the content of un-dissolved solid matter, usually measured in mg/l, which settles in stagnant water having velocities not exceeding 0.1 m/hr. This definition comprises a large variety of materials such as clay particles, organic matter and fine particles of calcite. The silt content of river water depends upon the type of soils in the area of run-off, the vegetative cover of this area, its topographic slopes, meteorological characteristics prevailing in its catchment and intensity of rainfall.

Suspended matter may clog the soil in two different ways. Near the surface, the interstices of the soil may be filled up and a layer of mud may be deposited on the surface. On the other hand, they may penetrate deeper into the soil and accumulate there. A layer of mud is formed on the surface by particles, the settling velocity of which exceed infiltration velocities. Smaller suspended particles are filtered out in the uppermost layer of the soil. The filtration process is governed not only mechanical factors, but it seems to be strongly influenced by electro-chemical surface forces. Still finer particles, especially very fine grains of montmorillonite clay, are carried further into the soil. Observations in spreading grounds composed of medium-grained dune sands, showed that these particles become lodged at depths ranging from 10 to 20 m below the surface, and some of these particles are carried even deeper. Semipervious layers situated deep below the sand filter out even those particles and become progressively clogged.

Methods to prevent or minimize the clogging effect by suspended matter can be classified into the following broad groups:

a) Periodical removing of the mud cake and scraping of the surface layer
b) Installation of a filter on the surface, the permeability of which is lower than that of the natural strata (the filter must be removed and replaced periodically)
c) Addition of organic matter or chemicals to the uppermost layer
d) Cultivation of certain plant-covers, notably certain kinds of grass

Scraping of the surface layer is effective only in coarse-grained soils. In soils composed mainly of sand, repeated compaction by heavy machinery may easily nullify any benefit gained from scraping. Various chemicals and organic matter have been used to restore infiltration capacities. These include gypsum, various organic compounds, cotton-gin trash and alfalfa (grown while the pond is still wet and then spaded under). The growth of a permanent grass-cover has proved to be an effective method for maintaining infiltration capacities, but it is difficult to select a grass which grows under a given climatic and soil condition and is able to withstand alternate periods of flooding and drying.

Clogging by biological activity depends upon the mineralogical and organic composition of the water and basin floor and upon the grain-size and permeability of the soil. The only feasible method of treatment developed so far consists in thoroughly drying the ground under the basin. Experiences seem to indicate that short periods of operation (about one month), followed by drying, are more effective than prolonged periods of operation, even if they are followed by a prolonged and most thorough period of drying during the hot summer.

Clogging and consequent destruction of bore holes may occur as a result of erosion of the aquifer. If velocities of flow are too high, fine sand and particles from local clay layers may be dragged outward into the aquifer and clog it or even cause collapse of the well. The common-sense precautions against these mishaps in semi-consolidated aquifers are to keep injection rates somewhat below the rate of proved safe continuous

pumping and to avoid frequent sudden changes of the injection rate, which may cause vibrations. Experience has shown that no deterioration of the aquifer occurs if these reasonable precautions are taken.

Air bubbles, which are sucked into the well through the injection pipe, cause violent vibrations when they finally escape upwards. The possibility of air seepage must therefore be completely eliminated. The only certain way to achieve this is to design and operate the installation so that positive pressures (exceeding atmospheric pressure) are maintained everywhere in the injection pipe, even if this entails a reduction of injection rates.

Bore holes are much more prone to silting than spreading grounds. No acceptable standard of turbidity can be given. Clarity of the Water should conform to the standards of good drinking water. Clogging of the bore hole wall by bacterial growth may occur, even if water of potable standard is injected. Even when chlorination at the well-head carried out, the wells may still require periodic re-development by mechanical means and pumping.

4.5 Maintenance of Roof Top Rainwater Harvesting System

Maintenance of roof top rainwater harvesting system (RRHS) is simple and costs little. As the entire system is household-based, it becomes one of the assets of the household and hence could be maintained best by the users themselves. It requires continuous care and maintenance just as any other asset in the household. In fact, maintenance of RRHS should get priority over other household assets, as it ensures the good health of all people in the household. Cleanliness of surroundings as well as the system including its various components such as roof, gutters, filtration unit and the storage tank, will ensure supply of water of potable quality throughout the water scarcity period for the drinking and cooking purposes of the household.

4.5.1 Tips for Maintenance of the RRHS

- ✓ Always keep the surroundings of the tank clean and hygienic
- ✓ Remove algae from the roof tiles and asbestos sheets before the monsoon
- ✓ Drain the tank completely and clean the inside of the tank thoroughly before the monsoon
- ✓ Clean the water channels (gutters) often during rainy season and definitely before the first monsoon rain
- ✓ Avoid first 15 or 20 minutes of rainfall depending on the intensity of rain. Use the first flush arrangement to drain off this first rainwater.
- ✓ Change the filter media every rainy season
- ✓ Cover all inlet and outlet pipes with closely knit nylon net or fine cloth or cap during non-rainy season to avoid entry of insects, worms and mosquitoes
- ✓ Withdraw water from the system at the rate of 5 litres/head/day. This will ensure availability of water throughout the water scarcity period.

- ✓ Leakage or cracks in the storage tank should be immediately attended to. This will obviate the need for major repairs caused by propagation of cracks.
- ✓ Heavy loads should not be applied on the lid.
- ✓ Water should not be allowed to stagnate in the collection pit
- ✓ The tap should have lock system to prevent pilferage or wastage of water
- ✓ The filter material should be washed thoroughly before replacing in the filter bucket
- ✓ In coastal areas, the outer side of the tank may be painted with corrosion-resistant paint at least once in 3 years and in other areas lime (Calcium Carbonate) based whitewash may be applied regularly.

People may be educated by providing the above tips for maintenance of the system through pictures, handouts and wall posters. The implementing agency should visit the structures as follow-up to monitor and motivate the users in proper maintenance of the systems. There could be informal group discussions among the users on the maintenance aspects of the Roof Top Rainwater Harvesting Systems.

As a precautionary and preventive measure, the water from the storage tank may also be tested for the presence of disease causing microorganisms. This task may be taken up by the implementing agency as an immediate follow up of the construction of the systems. This helps the agency to find out the users attention to the maintenance of the system as well as necessary awareness to be given on various maintenance aspects.

Note: Adapted from ‘Manual and Artiicial Recharge of Ground Water of CGWB, Sep, 2007’ for the benefit of users of the Manual.

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MINISTRY OF HOUSING AND URBAN AFFAIRS
GOVERNMENT OF INDIA

स्वच्छ भारत
एक कदम स्वच्छता की ओर

MANUAL ON STORM WATER DRAINAGE SYSTEMS

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PART C: MANAGEMENT

FIRST EDITION

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CHAPTER 1: INTRODUCTION

1.1 General

It is important that storm water drainage system works efficiently as per design objectives throughout its design life. To achieve this objective, Part C includes four chapters that comprehensibly address aspects of Institutional set up, public awareness, capacity building, training and financing capital investment, operation-maintenance expenses etc.

Institutional Arrangement is necessary to assess the capabilities of the institution that are entrusted in identifying, formulating and implementing such projects and operating and maintaining the same after its commission. The organization responsible for these functions must fulfil the requirement in respect of institutional structure, personal, management procedures, etc.

Public awareness is the growing recognized mechanism to dissuade people from habit of indiscriminate littering and dumping of debris and solid waste either on ground or nearby drains / rivers or streams. Therefore, public awareness plays a pivotal role in creating awareness, mobilizing people and making participatory approach through advocacy and transferring of knowledge and scheme.

Capacity building and training are necessary input in developing and strengthening skills, abilities of the personnel employed on operating and maintaining storm water facilities to obtain maximum benefit when the system operates to its optimal capacity in compliance with design requirement.

Financial Management and Sustainable Operation & Maintenance Though ULBs have mandatory responsibility to formulate, construct, operate and maintain storm water drainage projects but their ability to discharge these functions are limited on account of their meagre financial resources. They receive financial aid either from State Government or Government of India in the form of loan and grant. International financial institutions also extend financial assistance in the form of long term loan through Government of India to such capital intensive projects like storm water drainage schemes, sewerage scheme, water supply scheme etc.

CHAPTER 2: INSTITUTIONAL ARRANGEMENTS

2.1 General

This section discusses the institutional arrangements in relation to the management aspects of storm water drain. Even with the creation of storm water infrastructure, if these are not operated, maintained / managed properly, it may fail to provide the desired level of services on a sustainable basis. Hence, an organisation which is efficient is required for planning, design, and sustainable operation and maintenance of storm water drainage systems sewerage systems. Therefore, measures must be taken for institutional strengthening so that the efforts made can be sustained over a period of time and the system put in place can be well managed. Institutional strengthening can be done by adequately decentralizing the administration, delegating adequate powers at the decentralized level, inducting professionals into the administration and providing adequate training to the existing staff. This chapter covers the various aspects of management of storm water drains.

2.2 Organisation Setup

Storm water drain services have been historically under the control of public health engineering departments governing the entire State for capital works and local bodies like corporations, municipalities, and town / gram panchayats for O&M. In a large country like India, the management of storm water drain can be performed effectively if administration is adequately decentralised. Decentralisation can be at the **City level, the Zonal level, and the Ward level.**

A focussed attention can be delivered if all functions of the city administration are decentralised at Zone/Division levels and senior officers are placed in-charge of each Zone/Division functioning independently with adequately delegated powers. The 74th Constitutional Amendment envisages formation of Ward Committees in each city that has a population of above 3,00,000. These Ward Committees, as and when formed, may be very usefully involved in the Ward level.

2.2.1 Central Government

The role of the Central Government is to administer uniformity in the features by bringing out policies, manuals and advisories and disbursing grant funds under various Central Government Programs. External aid is also procured through the GOI for major projects fulfilling certain norms. In-service training programs are provided in co-ordination with recognized training institutes. Assistance from financial institutions and other bodies like HUDCO, LIC, etc., are also available.

2.2.2 State Government

The State Governments offer to assist the local bodies in planning and implementation of storm water drainage schemes of individual or a group of local bodies. Financial support is also given for these schemes in the form of grant-in-aid and loan, etc., for capital investment. The State Governments monitor general progress of schemes of local bodies in respect of planning, implementation and O&M. Unlike the central government the state in most cases have more than two departments which are in one way or the other responsible for activities pertaining to urban development. Director Local Bodies under the department of Municipal administration/Local Self-Government or U.D. is the nodal officer to deal with ULBs on administrative matters. However, in case of Municipal Corporations the administrative arrangement is significantly different in some states and they are in most cases directly supervised by U.D or LSG or Municipal administration. These arrangements vary from state to state.

2.2.3 Urban Local Bodies

It is obligatory for every local body (Municipal corporation, Municipality, Nagar Panchayat, etc.) to properly maintain the storm water drains under their respective jurisdictions. Depending upon the financial status of each local body, the State/Central Governments come to the help of these local bodies to meet a part/whole of their capital investment cost on schemes in the form of grant-in-aid and/or loan. The expenditures on annual O&M of these schemes however, have to be met by the ULB out of its own revenue generated from taxes. As per the respective acts, local bodies have been empowered to levy and recover tax from the habitation where storm water drainage service is provided by the local bodies.

2.3 Dedicated Cell

In order to efficiently address (a) day to day O & M issues related to storm water drains and (b) to carry out preventive maintenance a dedicated cell to be formed in each ULB. This dedicated cell will have its own helpline number, manpower, vehicles and related equipments at their disposal.

2.4 Responsibility of Senior Management Personnel

The senior management personnel should define the role of the department and set out strategies for long-term objectives. They should be in close contact with other agencies involved in infrastructure services and work for coordination with government and private agencies in design, construction, O&M, monitoring and evaluation of the functioning of the agency. They shall also determine and administer staffing structure, service conditions, job descriptions, salary levels, performance

standards, staff training and promotions.

2.5 Responsibility of Middle Management Personnel

Middle management personnel should contribute in the formulation of a long-term plan for O&M and contribute in preparing projects for expanding and making the facilities work effectively. For achieving this they should:

1. Update system data, select design criteria and decide how to meet the technical standards and social needs in the most cost effective way,

2. Formulate and implement programmes for efficient use of storm water in non-potable uses, identifying opportunities for implementation of best management practices and preparedness for disaster prevention, etc.

3. For defining the type of service and coverage and formulate medium-term programmes for O&M. These programmes should aim at (a) Expanding coverage of service, (b) Making best use of existing physical, financial and human resources, (c) Improving quality of services provided, (d) Rehabilitation (as part of preventive maintenance) of component parts of sewerage installations and equipment with a view to extend their useful life, (e) Reducing costs and raising productivity in the agency's O&M programmes, (f) Supervising the O&M, (g) Monitoring environmental conditions, (h) Promoting awareness of and educating users about the proper use of storm water drainage system.

Middle management personnel should determine the technical, economic and organisational feasibility of the O&M plan. They should determine priorities and set targets for implementation of long-term plan for O&M. In addition they should consolidate all the short term O&M plans prepared by the operational management level and submit it to senior management to ensure that it is compatible with the long term plan. They should monitor and re-allocate resources where necessary to ensure that the targets set in the plan are achieved.

2.5.1 Responsibility of Operational Management Personnel

Operational management personnel are primarily responsible for short-term planning and participate in formulating medium-term and long-term O&M plans. They shall have responsibilities in the planning, design and construction work as well as O&M of the agency's equipment.

They also propose medium-term activities to operate and maintain the storm water drainage system and participate with middle management personnel in defining objectives, strategies and resources both to extend and to ensure full use of the

coverage of services.

They should also evaluate the feasibility of medium-term investments for O&M. In line with long-term and medium-term programs for O&M, they should formulate short-term objectives, targets and programs.

They should assess the resources required and allocate them, monitor and evaluate the performance in the following areas:

i. Studies and designs needed for rehabilitation of the installations or for expansion of the services

ii. Maintain the units under operation so that they work efficiently and last as long as possible

iii. Update the ledger data

2.6 Assignment of Responsibilities

Work details regarding duties are shown in Table 1.1. These have to be read inter-alia with the foregoing sections which describe the management is headed by a Chief Engineer (CE) or Superintending Engineer (SE) at the senior management level and supported by Executive Engineer (EE) or Assistant Executive Engineer (AEE) at the middle level and Assistant Engineer (AE) or Junior Engineer (JE) at the operational level depending on whether it is an ULB or PHED. The engineers are assisted by mechanics and operators.

Table 2.1: Job Description

No	Duty	Description
1	Execution of general affairs related to SWD	General affairs, Personnel, Salary, Welfare, Dissemination
2	Budget Execution	a. Procurement of materials and administration (Fuel, Chemicals, consumables) b. Contract of construction c. Contract of outsourcing
3	Asset Management	Administration of fixed assets, maintenance and repair
4	Coordination of Service Charges	User survey, user charges, collection of user charges, survey of uncollected service charges

No	Duty	Description
5	O&M of SWD	1. Maintenance and Inspection a. Planning, preparing detail plans and supervising implementation of inspection and survey of SWD b. Planning, preparing detail plans and supervising implementation of cleaning of SWD c. Planning, preparing detail plans and supervising implementation of rehabilitation and replacement works d. Protection of SWD e. Approval and authorization of SWD related matters 2. Rehabilitation and Replacement a. Preparing detailed plan, design, and implementation of rehabilitation
6	O&M of pumping station	1. Maintenance and Inspection a. Establishment of guidelines, and preparation of maintenance and inspection plan for machine and electrical equipment b. Preparing detailed plans and implementation of outsourcing the above activities 2. Rehabilitation and Replacement a. Preparing detailed plan, design, and implementation of rehabilitation
7	Water quality control	a) Planning and Execution of water quality tests b) Execution of survey and research c) Data compilation, analysis and report preparation d) Counter measures in case of any abnormal situation e) Adjustment of water quality analysis equipment f) Close check of data

No	Duty	Description
8	Ledger management	a) Preparation and keeping ledger b) Revising and reading ledger c) Maintenance of drawings and literature (Plan, profile, Storm water drain network map, electrical system, etc.)
9	Others	a) Report to authority b) Understanding the status and improvement on safety and sanitation c) Dissemination of knowledge and public awareness d) Training of staff and operators

Source: Adapted from JSWA, 2003

2.7 Reporting Structure

The reporting structure in regard to storm water division is concerned is as follows.

The management is headed by a Chief Engineer (CE) or Superintending Engineer (SE) at the senior management level and supported by Executive Engineer (EE) or Assistant Executive Engineer (AEE) at the middle level and Assistant Engineer (AE) or Junior Engineer (JE) at the operational level depending on whether it is a ULB or a PHED. The engineers are assisted by mechanics and operators. The operational level officers report to the middle level officers who in turn report to the senior level management. The senior level management reports to the head of the organization if it is a Nagar Nigam, CE reports to the Municipal Commissioner, if it is a PHED, CE reports to the Managing Director and so on.

2.8 Contact Details to be displayed

Nowadays it is becoming a standard practice to provide the contact details of the concerned officers in the website of the organisation and / or on the name boards in the organisation. Nevertheless, this practice shall be followed in the ULB / PHED / Nagar Nigam etc. dealing with storm water. The contact details shall also include the name and contact details of the officer who is allotted the portfolio of disaster management.

CHAPTER 3: CAPACITY BUILDING AND TRAINING

3.1 General

Capacity building may be defined as the process of developing and strengthening of skills, instincts, abilities, processes and resources that are needed by an organization or a community to survive, adapt and thrive in changing conditions. This chapter covers the aspects of capacity building and training in brief and with a guiding link to the CPHEEO Manual on Sewerage & Sewage Treatment Part C which elaborates in greater detail where necessary.

3.2 Capacity Building

For optimal operation of any system, capabilities have to be developed. In the case of storm water drainage works, the maximum benefit of the system would be achieved only when the facilities operate continuously, to its optimal capacity and in compliance with the design requirements. For efficient and effective operation of such systems, capacity building both Institutional and Human Resources should be strengthened as under:

- Institutional capacity building (it can be attained through working manuals, guidelines, clear rules & regulations and set procedures with clarity).

- Human resources development / individual capacity building, through training.

3.3 Institutional Capacity Building

At an institutional level, capacity building is needed to render the services more efficiently and economically, not necessarily profitably, without unnecessarily levying unreasonable tariffs on the end users, which may compromise the affordability for many users. This requires:

a. The creation of a dedicated municipal information unit in our country for the purpose of collection, collation and analysis of comparable data on municipal services and finances on a yearly basis from across the country. This municipal unit will also be responsible for developing a concise set of successful models based on such data set and;

b. Developing a performance appraisal system for evaluating and recognizing the best-performing institutions, so as to confer recognition on a rotational basis in various categories of government institutions, such as corporations, municipalities, townships & panchayats etc.

3.4 Human Resources Capacity Building

There is a scarcity of trained professionals for planning, design, implementation and O & M in our country, especially with most of the ULBs. It is, therefore, necessary to induct such talent from outside the organizations or develop the expertise from within the organizations through capacity building programmes.

At an individual level, human resources have to be developed so as to have trained personnel who can not only plan, design, implement, operate and maintain the systems, but also can come up with novel ideas or solutions. Such level of capacity can be built up by training programmes, refresher courses and visits to similar agencies so as to understand how they are able to handle situations and provide innovative solutions, etc.

It is also advisable not to create too many training centres all over the country but to regionalise these centres. It is also advisable to incorporate field related on hands training rather than only class room training.

3.5 Fund Allocation for Capacity Building

It has to be recognised that capacity building is not a one-time activity and needs to be continuous. Hence, appropriate fund allocations in the budget have to be made in order provide an effective capacity building program.

3.6 Training Needs Assessment

A training programme can be thought of as a planned exercise whose primary objective includes a modification/change in the attitude, knowledge or skill of the individuals. This objective can be achieved through enriched learning experience to ensure effective participant performance. Another key objective is the development of key skills that will satisfy the current and future needs of the organisation. The training can be imparted to the existing personnel in a particular job role for knowledge/skill enhancement or the personnel who may be chosen to carry a different role, than what they are accustomed to, in order to develop new skills.

The training should fill the gaps in performance of the personnel so that one can deliver effectively. It can be general or specific to a job-role. For example in case of O&M activities personnel have to be trained through special courses or by “on the job training” to ensure that they are thoroughly trained to carry out the required O & M activities. Such a training exercise is essential to ensure that the operating personnel do not “experiment” with equipment due to lack of appropriate skills to effectively carry out maintenance activities. It is always advisable to conduct on-the-job training rather than class room training to develop skills. This ensures that the

key fundamentals are thoroughly entrenched through practical learning rather than class room based theoretical lectures. It is a typical practice to train the supervisors initially and entrusting these trained supervisors with the training of the eventual operators.

Any training programme is expected to have a systematic plan of action to prevent any adhoc approach. The key ingredients of such a programme include:

a. Identification and appraisal of the need for planned training.
b. Well-defined training objectives.
c. Appropriate strategy for training implementation to achieve the designated objectives.
d. A feedback mechanism to assess the effectiveness of proposed training.

3.7 Objective of training needs identification

a. To identify the performance gap in the existing / working employees of the organisation which will yield the training needs requirements.
b. To collect more information on the work culture and communication links at the work place.
c. To make recommendations for a training exercise that would form the strategic basis for the development of employees.

3.8 Identification of training needs

The training needs at an organisation can be identified using the following steps:

- Identify the requirements and expectations of a particular job.
- Determine the degree to which these requirements are being successfully met.
- An assessment of whether the training can bridge the gap between, what is required and the entry behaviour/baseline in terms of the present knowledge, skills, attitudes or behaviour of the employees.

3.9 Data collection and Analysis for training needs

Appropriate data is needed to assess the training needs of an organisation and for a particular job role. Such data set can be collected by using a combination of the following approaches:

a. Direct data collection: through detailed discussions with the stakeholders including, officials, employees, supervisors, and the top management.

b. Indirect data collection:

- Through observing the employees in their routine schedule, their work, work flow and relationships.
- Through a review of the past records and reports, especially details of the consumers' reactions to the services provided by the utility, organization structure, organization policies & records of past trainings, etc.

The data, thus collected, is analysed to carry out an appraisal of the training needs at various levels such as.

a. Corporate needs: training needs for the organization as a single entity.
b. Group Needs: training needs for particular departments/teams, within the organization, that are involved in a particular processor activity.
c. Individual needs: training needs for individual employees to enhance their current level of skills and to prepare them for particular job roles.

The CPHEEO Manual on Sewerage and Sewage Treatment Systems, 2013, details the (a) job analysis to be carried out for a particular job role and contains questions on the why, how, with whom, where, procedure, equipment, etc. and how well (quantity, desired results, quality, etc.) is performed and (b) individual analysis of the employee.

3.10 Mandatory Training

The frequency of training has to be at least once a year as this will help the employee keep in sync with the latest developments and also to refresh his skill set.

3.10.1 Short Term Training

Such training needs are typically met through short-term courses and specialised short-term training programmes as identified for particular job roles. Such short-term training programmes are aimed at enhancing the skillset and the competency level of the existing employees. Short-term training needs are appropriately identified through a comprehensive job analysis and training analysis. It is typically suggested to use in-house competency to conduct such short-term training programmes.

3.10.2 Long-Term Training

Long-term training programmes are conducted to build long-term competency in order to meet the future demands of the organisation and the job roles. Long-term

training programmes are decided upon following the appraisal and success of the various short-term training programmes. Such training programmes typically include formal educational programmes such as certificate courses, as well as specifying recruitment criteria for new entrants. Such formal training programmes, leading to a certification may be available with universities, colleges or public/private sector institutes.

3.10.3 Refresher Training

Any training programme is aimed at equipping the employees with the necessary skills to ensure optimal performance and efficiency. However, many skills often require a shorter-duration refresher courses or training programmes to ensure effective retention of the skills by the employees. The refresher training programmes are typically based on one or more of the following models:

a. Employee creative model

This model defines the training programmes where the primary goal is the personnel skill enhancement and the incentive for the employee is the potential career enhancement.

b. Organizational strategy model

In this model, the key objective is the increased production and work efficiency. This objective is achieved through identifying the basic skillset that is critical to meeting the corporate goals and providing refresher training for the same.

c. Problem centred model

This model is used when training programmes related to some particular skills are needed to tackle a specific issue or difficulty being faced by the organisation or a group/team within it.

3.10.4 Training of Trainers

Training of trainers' programmes is aimed at developing a team of master trainers who can further pass on the necessary skills to other targeted employees. In this programme, the trainers (master) attain a new skills including transfer of knowledge & skills or refresh the skills they already possess. It is expected that the training programmes for the employees would be a regular activity and that sufficient budgetary provisions shall be made by the state governments/ULBs /Municipalities. The master trainers are expected to be deployed appropriately to ensure fulfilment of the long-term interests and foresight of the organisation. Similar trainings can

also be arranged for people working in the O & M sector who may, at some point, be hired by the ULBs through outsourcing.

3.10.5 On-The-Job Training

If the employees receive training at their work/job location, such training is typically called on-the-job training, since the employee is getting trained while doing the assigned job. On-the-job training ensures that the trainee needs very little extra effort in terms of equipment and human resources and is able to put his training into practice immediately. Such a training programme also helps build competency when a new equipment or process is introduced to the workplace. The on-the-job training prepares trainees for providing guidance to their superiors and training to the new recruits.

As an example, a mechanic, plumber, fitter, electrician, supervisor may be given on-the-job training in pump houses to ensure that he learns how to operate and maintain them. This specific training will lead to skill development, attainment of practical knowledge and will provide the hands-on experience to the trainee. After successfully completing the training, the trainee is expected to know the how, when and what of the pump house O & M and will also be able to understand the impact of his work.

3.10.6 Capacity Building of Outsourced O & M Personnel

The typical O & M approach in India is to outsource the unskilled and semi-skilled labour component. The outsourced job role includes the O & M of equipment such as, motors, pumps, valves, electrical switchgears, etc. The process control is not part of their job responsibilities and the ULBs retain the right of overall supervision.

It is essential that extensive capacity building exercise is undertaken to adequately train such outsourced O & M personnel from the private sector so as to ensure quality O & M operation. Industrial Training Institutes (ITIs) and Polytechnic institutes were originally envisaged to provide post-school skill-specific technical training to people. Personnel trained by such institutes can be provided systematic on-the-job training to enhance their skill set and improve the safety and efficiency of the O&M works. ULBs should ideally require all the outsourced staff to undergo relevant on-the-job training to ensure dissemination of essential skills.

To ensure that the O & M contract is awarded to the most deserving contractor firm, the ULBs should make a judgement based on the contractor's previous experience in similar O & M works, as well as, the qualification and experience level of the key O & M personnel mentioned in the bid document. The O & M personnel can be mandated to attend and successfully complete designated training programmes,

offered by training institutes of major utilities/ ULB's in the region, as part of the tender requirements for outsourcing of the O&M work. Additional incentives need to be planned for ensuring adequate skill level of the O & M staff members. These incentives can be in the form of career advancement and/or additional allowances and are necessary to ensure efficient O&M of storm water drainage systems.

3.11 Preparatory Training for Disaster Management

The personnel need to undergo preparatory training related to disaster management in order to equip them for handling any such situations in association with National Disaster Response Force (NDRF). The list of training courses is mentioned in the National Institute of Disaster Management (NIDM) website.

3.12 Exposure Visits to Best Practices

Training can be in the classroom or as part of on-site job training. However, in order for (a) the employee to develop confidence and (b) also to understand the best practice approach exposure visits need to be arranged. It is strongly suggested that the engineers who are concerned with the related works shall alone be sent on these exposure visits.

3.13 Incentives for Efficient Performance

It is human nature that exceptional work / performance get recognised. This will also lead to motivation among other employees to perform better. Hence, there is a requirement to provide for incentives and awards to those employees who have been found to be exceptionally efficient. In order for this to be implemented the budgetary support shall be made.

3.14 Training Institutions

The CPHEEO Manual on Sewerage and Sewage Treatment Systems, 2013, Part C, in Chapter 3 titled Institutional Aspects and Capacity Building details the list of Training Institutions. Hence, the reader is requested to refer to clause 3.11 of the said chapter for guidance there on.

CHAPTER 4: PUBLIC AWARENESS

4.1 General

Creation of awareness among the citizens has now become the new norm related to infrastructure projects wherein the acts of citizens could hamper the functioning of the project in some form or the other thus leading to reduced degree of functioning. This is all the more important when it comes to storm water drains since they are prone to be used as receptacles for dumping of garbage, construction and demolition waste, etc. This has to be prevented to ensure proper functioning of storm water drains. It can be suggested that the SWD should be covered thus preventing dumping of garbage. However, considering the practicality of covering SWD it is generally the norm that drains with width of 4 to 5 m and above remains uncovered. Even the roadside drains which are liable to be covered could become a receptacle for garbage by citizens moving the concrete slab and dumping waste inside. Similarly, the water recharge structures could also be used to dump garbage. This chapter covers the technique of awareness creation through information, education and communication (IEC) which plays a pivotal role in creating awareness, mobilizing people and making participatory approach through advocacy and transferring of knowledge and skill to meet the identified objectives.

4.2 Organising Public Participation

Public Participation is not a onetime task; rather it is a continual exercise with feedback mechanism. Over time, such programmes need to be reviewed, evaluated and, if needed, modifications have to be made and implemented. A functional community outreach office with personnel to handle information, grievance redressal etc. has to be in place. There is a strong need to convey to public the necessity of such systems, costs associated with them and how their participation and behavioural changes can reduce the cost of O & M and enhance the life of the storm water drainage infrastructure and that such participation is not a onetime activity, but rather a way of life.

An action plan indicating the broad IEC strategy and specific activities to be undertaken should be prepared and implemented. Dissemination of information has to be sustained over a period of time and also that, in order to make the communication effective, it has to be in the language and idiom of the target groups. Accordingly efforts should be made during the year through print and electronic media to disseminate information in regional languages and dialects, besides Hindi and English. In addition, the action plan should also envisages IEC activities through other modes of communication, outdoor publicity and other conventional or non-conventional modes of communication for reaching out to the people and target groups. The modes of communication are covered in the following section.

For example, plogging a combination of jogging with picking up litter started in Sweden in 2016 and this had helped raise awareness on plastic pollution. In India, plogging was carried out for the first time in Tiruchirappalli to clean the River Cauvery as shown in Figure 3.1. This is an instance wherein the co-operation between the ULB and public (politicians, lawyers, engineers, students, doctors, common citizen, etc) resulted in launching a movement which is not only replicable but is understood to be continuing every Saturday in keeping the city clean.

Figure 3.1: Public Participation along with ULB to clean the River Cauvery

4.3 Modes of Communication.

4.3.1 Print media

For creating awareness about storm drainage facilities and to enable people to access information, a booklet like ‘storm drainage programme at a glance’ should be brought out in simple language in Hindi, English, as well as, in regional languages and copies are distributed among user groups. Municipal authorities should prepare wall calendar depicting its infrastructure developments and its use, dos and don’ts for distribution in each ward in order to sensitize the people. They may also publish a journal, as and when required, dovetailed to urban programmes, undertaken by them, that could help improve the quality of life of town’s people, if used with caution and care.

4.3.2 Electronic media

An intensive IEC campaign in the electronic media should be undertaken through Prasar Bharti for optimum dissemination of information on urban infrastructure projects and programmes. In order to meet the specific communication needs 15-20 minutes audio-video programme should be produced and broadcast / telecast over local and primary stations of All India Radio and Regional Kendra of Doordarshan. The song and dance division, a media unit of Ministry of Information and Broadcasting, disseminate information on development issues among target groups through medium of performing arts, traditional arts, puppet shows, folk media,

mythological recitals and the like. As the medium of transmission is rooted in the local ethos and traditions, the development messages are more easily grasped by the target groups.

4.3.3 Social Media

With the extensive coverage of internet and popularity of social media, much of our population has access to some social media platform (such as, Face book, Pinterest, Twitter, etc.) and millions of people actively use these services daily. Short instructional videos / messages can be widely and quickly circulated through these platforms and their reach can be tracked easily, as well.

4.3.4 Cinema Halls

It is customary to have instructional and promotional videos before and during a movie and such time slots can be effectively utilised to spread the message to the audience. In fact, the same advertisement may be used on TV and in cinema halls.

4.3.5 Street plays

NGO's and/or school/college students can be roped in to create short street plays targeted at spreading awareness related to storm water drainage system maintenance and protection by the public. Street plays are appropriate for target audience and capture the attention of people through simple messages relayed through Play or Skits.

4.3.6 Poster, pamphlets & hoardings

Posters and hoardings displayed at prominent locations such as bus stands, railway stations, highways, etc. capture the attention of a large number of people on daily basis and can be effectively used for raising the awareness level of public. Pamphlets can also be distributed at such prominent locations or door-to-door along with newspapers for attaining an even higher level of information dispersal.

4.3.7 Public transportation system

Public Transportation system such as buses and trains are used by crores of commuters every day and can act as a good medium for display of advertisements containing information related to public role in maintenance of civil infrastructure typically, in the form of Do's and Don'ts.

4.3.8 Educational institutes

Educational institutes such as schools and colleges can spread the information and instructions through a large number of students they enrol and the same can thus be spread over to their families and friends. Educational institutes may also participate in public awareness campaigns by organising street plays & skits etc. for public awareness. Such institutions can also incorporate the awareness message in their talks, seminars and coursework.

4.3.9 Voluntary organization

Voluntary organisations should employ educated volunteers who can develop and organize street plays, seminars, door-to-door campaigns, demonstration activities, etc. for raising the awareness level of public.

4.3.10 Door-to-door campaigns

An effective method of communication is door-to-door awareness campaign with clear and easily understandable content, in which volunteers - students, NGO members, women, etc. approach and communicate individually to people at their homes and create awareness of the necessity and the public role in maintaining civic infrastructure.

4.3.11 Corporate social and environmental responsibility campaigns etc.

Industry can be roped into awareness campaigns as part of their CSR initiatives. Not only can the industries provide funding for awareness campaigns, they can also provide training and information to their own staff, as well as, provide volunteers for effectively running such campaigns.

4.3.12 Mobile Phones

Short messages can be sent to people through SMS and/or informational pre-recorded calls of short duration. It is suggested that SMSs should contain the website links if any particular websites have been created, with detailed information for public awareness.

4.3.13 Sanitation Volunteers

The ULB shall endeavour to create a group of enthusiasts called as sanitation volunteers from all walks of life. These volunteers could be students, members of residential welfare associations, lawyers, doctors, engineers, shop keepers, etc. The city / town are already divided in terms of wards for easy management. Each

ward / group of wards has their own officer. This officer shall identify such interested sanitation volunteers and form a WhatsApp group for exchange of messages. These sanitation volunteers shall be the extended arm of the ULB in that they shall be monitoring the infrastructure such as SWD, storm water harvesting infrastructure in their vicinity and inform the ULB of any broken cover slab, dumped garbage, siltation of drains, etc which may have not been noticed as part of regular monitoring. On receipt of these alerts, the ULB shall address these effectively.

4.4 Importance of Water Harvesting Structures

The public have to be made aware of the water harvesting structures since they serve as a source control and helps in reducing storm water runoff. In certain instances, it could also be a structure in the public domain on certain identified stretches and which need to be protected. By applying the methods mentioned in clause 3.3, effective public communication shall be promoted to emphasize the importance of water harvesting structures.

4.5 No sewage in storm water Drains

The importance of not allowing sewage in the storm water drains has to be effectively communicated to the citizens. This becomes more important wherein insitu harvesting in the SWD is planned to be implemented. Even in the case of harvesting the storm water outside the SWD, the storm water shall not be mixed with sewage. This requires proper planning and mapping of certain areas of the city / town wherein separate sewers have been laid and chances of mixing sewage with storm water is not possible. However, the ULB shall follow the methods mentioned in clause 3.3 to ensure effective public communication in order to emphasize the importance of not discharging sewage into storm water drains.

4.6 No Dumping in Storm Water Drains

People should be dissuaded from habit of indiscriminate littering and dumping of debris, solid waste, Construction & Demolition waste either on open ground or nearby rivers/ streams/lakes/drains. In many urban towns and cities street children and even adults have been found defecating in open drains and nallas in secluded part of the town and cities. Indiscriminate littering and defecation has led to many adverse physical and biological effects on population inhabiting the area such as blockage of drains, pollution of rivers/ streams/ lakes. Information, education and communication plays a pivotal role in creating awareness, mobilizing people and making participatory approach through advocacy and transferring of knowledge and skill. The importance of not dumping waste in the storm water drains has to be effectively communicated to the citizens.

CHAPTER 5: FINANCIAL MANAGEMENT AND SUSTAINABLE OPERATION & MAINTENANCE

5.1 Background

It is important that a storm water drainage system works efficiently as per design objectives throughout its design life. To achieve this objective, the financial management of project becomes of paramount importance and so does its sustainable operation and maintenance. Often large projects are implemented availing government grants and also borrowing from financial institutions/bilateral assistance. What is important is cost effective design of storm water drainage system maintaining adequate recharge of ground water and minimizing the built up concrete structures. In several cases although projects are designed and implemented but their sustainable operation and maintenance is lacking due to poor revenue generation and high cost of operation and maintenance because of its way of design. Lack of adequate institutional setup and poor capacity building/training the operation and maintenance of such created assets do not get adequate priority resulting in its poor performance.

In this chapter, the aspects like financing of projects, O&M, capacity building and adequate revenue generation etc. are covered which are important ingredients for successful implementation and sustainable operation and maintenance of storm water drainage system.

5.2 Financing of Projects

Formulation, construction and maintenance of urban storm water drainage projects is a mandatory responsibility of Urban Local bodies. However, when it comes to devolution of finances to meet the revenue needs of ULBs for fulfilling these functions, they are often dependent on state governments. Further, ULBs have only limited powers to levy taxes and duties and they are often dependent on state government for levying/raising of taxes.

Storm water drainage systems are often designed following natural gradients involving pumping at several locations according to varied topography. Rampant paving and concretization in urban areas has increased storm run-off requiring wider storm drainage sections to handle to run-off rendering such projects highly capital intensive. Poor enforcement of regulations results in people connecting their waste water outlets in storm water drainage course rendering its routine operation and maintenance a costly affair.

To minimize the capital intensive design of storm drainage systems, various countries are increasingly integrating pervious storm drainage sections with rainwater harvesting to minimize storm run-off on one hand and replenish

groundwater enhancing water security and reduction in water supply cost to its citizens.

Similarly, to minimize operation and maintenance cost, preventing dumping of solid waste including construction and demolition debris as well as wastewater will go a long way in reducing cost of O&M on one hand and improving performance of such drains at the time of need.

In the present setup ULBs get financial support from the government of India and state governments to perform the tasks assigned to them by constitution and state legislatures. Also, in many states/UTs, a number of partner institutions like water supply and sewerage boards are involved in the delivery of such services either independently or on behalf of the ULB. Quite often, they are not accountable to ULB and therefore are not able to address local priorities. However, these functions are being gradually assigned to ULB. Various types of funding available from central government/state governments are as under.

5.2.1 Government of India (G.O.I) Level

The Ministry of Housing and Urban Affairs (MoHUA) has taken several initiatives to motivate states and ULBs to upgrade services as per requirement. The Government of India launched two massive urban infrastructure renewal programme namely 'JNNURM' which ended in 2014 and a new massive investment programme for urban development namely 'AMRUT' which was launched in 2015 to meet the growing requirements of urban services in cities and towns of India which includes storm water drainage as eligible component. External aid is also procured through the G.O.I. for major projects fulfilling certain norms.

5.2.2 State Government Level

The stage Governments offer to assist the local bodies in planning and implementation of storm water drainage schemes through Grant-In-Aid, part funding to centrally sponsored schemes, and loan etc. for capital investment. In special circumstances, State Governments assist the local bodies in operating and maintaining their storm water drainage schemes through their own departments or through the statutory boards. Trained Engineers and skilled workmen are often deputed to local bodies on request to plan, implement and operate the systems. The State Governments monitor general progress of schemes of local bodies in respect of planning, implementation, operation and maintenance.

5.2.3 Local Body Level

It is obligatory responsibility of every local body to collect, transport and properly dispose storm water run-off in the area under their respective jurisdictions. Depending upon financial status of each local body, the State/Central Governments come to the help of these local bodies to meet a part/whole of their capital investment cost on schemes in the form of Grant-In-Aid and/or loan. The expenditure on annual operation and maintenance of these schemes has however to be met by the local body out of its own revenue to be generated from taxes. As per the respective acts of local bodies, in many cases, they have been empowered to levy and recover tax from the community to whom wastewater disposal facility is provided by the local body.

5.2.4 Bilateral Assistance and Financial Institutions

To finance storm water projects, ULBs can avail loan assistance from bilateral assistance and financial institutions like JICA, World Bank and ADB etc.

5.3 Public Private Partnerships

The basic intent of the PPP is to encourage the private sector, to dedicate its capacity to raise capital investments and ability to complete projects on time with in the budget for the welfare of the community, without having to compromise the profit motive. At the same time the public sector would retain its responsibility to provide goods and services to the public at large, at affordable rates. The arrangement indeed calls for judicious approach to decision making and underscores the need for a framework that enables the private sector partner to make reasonable returns on investment without diluting the standards and quality of service provided. The key to success of PPP projects is a balanced and fair sharing of risks and benefits between the partners, transparency and accountability in all transactions relating to the award and management of the contract.

A typical PPP Process has four stages namely; Identification Stage, Development Stage, Procurement Stage, Contract management and monitoring stage. A PPP Model is often confused and used interchangeably with privatization. While PPPs involve private management of public service through a long term contract between an operator and a public authority, privatization involves outright sale of a public service. In PPP Models, investments are made by and/or management is undertaken by the private sector entity.

The typical structure of a PPP Model has the Special Purpose Vehicle (SPV) at its core with other important stakeholders such as the government, financer, customers/community, knowledge experts, etc.

Predictability and risk mitigation are key to successful PPPs. Unlike public projects where prices are generally determined competitively and Government resources are not involved, PPP infrastructure projects typically involve transfer of public assets, delegation of public authority for recovery of user charges, private control of monopolistic services and sharing of risks and contingent liabilities by the government. Protection of user interest and need to secure value for public money as such demand a more thorough treatment of the project.

A major deterrent to the entry of private firms in the urban services in India is the commercial non viability of the projects. This is clearly linked to the inability of ULBs to generate a strong internal revenue base.

To create an enabling environment for the delivery of service through PPP the state government either amend the municipal acts or enact overarching acts to facilitate PPP. This must be supplemented by a robust regulatory environment. State financial intermediaries should take on the role of guiding ULB on PPP initiatives. Financial planning and transparency become important as ULBs acquire greater autonomy in the management of their resources and reach out to private capital.

5.4 Estimate for Operation & Maintenance and Capacity Building

Proper budget estimate for operation and maintenance and capacity building is key for performance of created storm water drainage infrastructure. In India, not much work done to institutionalize the earmarking the fund for operation & maintenance and capacity building as far as storm water drainage is concerned. Funds are allocated based on need and availability particularly before and during monsoon season. Normally, the budget estimate should entail the fund requirement towards routine cleaning and repairing of drainage way, pumping stations, fuel and energy costs, consumables and cost towards social and managerial aspects etc.

Operation & Maintenance consists of activities such as:

a) Execution of general affairs related to storm water drainage,
b) Budget execution,
c) Asset management,
d) Coordination of service charges,
e) O&M of drainage systems,
f) O&M of pumping station,
g) Environmental conservation,
h) Establishment costs,
i) Fuel and consumables,
j) Energy,
k) Seed capital and depreciation,

l) Debt servicing,
m) Taxes, duties and cess,
n) Landscaping.

The normal budget provision may be made on case to case basis according to existing drainage system which varies widely. However, the energy costs can be calculated based on average running KW, number and hours of operation of electrical equipment. Further, the estimated consumption of fuel requirement may be estimated as per local requirement including operation of regular pumps as well as those for engaging in emergency situations. For repair and renewals of civil works, anything between 2-5% may be sufficient carrying out repairs and periodic cleaning and maintenance of drains before and during monsoon considering the size of drainage system and its age. Budget estimate for establishment can be worked out by ULB in accordance with their existing setup and roles and responsibilities assigned to the personnel for operation and maintenance of storm water drainage system. It is recommended that cities having population of 1 lac and above may have a dedicated cell/wing for management of storm water drainage system.

5.5 Revenue Generation

At present there are no separate taxes or fee are charged for storm water drainage in almost all the Urban Local Bodies. The Municipal Acts in many States talk about Sewerage and Drainage Tax due to the fact that earlier in those states combined systems were there in big towns/cities. Where separate systems are there, no charges in shape of Taxes or user charge is levied for Storm water Drainage. For using any infrastructure user charges must be levied for their efficient O & M according to the present approach. Taxes and User fee can be imposed by the ULB under the Municipal Act. Some revenue generation models are discussed here in brief:

I. Flat Storm water fee

A uniform storm water fee can be charged for all the properties in a use category. Many communities, for instance, can employ a flat rate for residential properties in which all homeowners are charged the same amount.

II. Storm water Drainage Tax

Storm water drainage tax can be levied as a percentage as decided by ULB within the maximum capping for Municipal Tax.

III. Storm water Fee based on impervious area

The fee may be categorized on similar lines as mentioned below:

- Storm water fee can be charged for every parcel of land in the city, including residential, commercial, institutional and public properties. Residential customers can pay a standard amount based on the average surface area of impervious cover of all residential properties throughout the city.

- For non-residential properties, the charge is based on the specific square meter of impervious area covering the property and the total square meter of the property. Suitable reduction in tax can be provided in case large-scale in-situ storm water management projects across multiple properties are built. These practices reduce storm water load on city drainage infrastructure and minimize the incidence of flooding on one hand and replenishing groundwater on other hand.

- Further, if a property owner can prove that their property does not drain surface rainwater into the public drains, they may be entitled to an exemption from future storm water charges.

5.6 Green Infrastructure Retrofit Financing

A fee for storm water, regardless of how it is calculated, could create a new incentive for property owners to implement green infrastructure. The key to creating such an incentive is for utilities to allow property owners to receive a reduced fee or rate by implementing qualifying onsite storm water management retrofits. Two case studies are presented in boxes below:

CASE STUDY - I

CHESTER WATER AUTHORITY (CWA), AMERICA (SOURCE: USEPA)

The Stormwater Authority of Chester has created a Community-Based Public- Private Partnership (CBP3) to plan, finance, build and maintain up to $50 million in green stormwater infrastructure over the next 20- 30 years on approximately 350 acres to address significant pollution and flooding issues; improve neighbourhood quality of life; assist small, minority-owned businesses; drive economic growth, including significant job creation and cost savings to water and other public and private capital improvement efforts (e.g., streets, housing, economic development, education) in the region.

Partners:

- US EPA: providing more than $150,000 in technical and planning assistance.
- PENNVEST, Pennsylvania's infrastructure investment authority: $1 million planning/pre-construction grant.
- The Chester Water Authority (CWA): $50,000 grant.

The Program:

- A uniquely innovative Design Build Finance Operate Maintain (DBFOM) Model, utilizing a Triple Bottom Line (TBL), Community-Based performance approach to ideally create a long-term 30-year contract, establishing a "Community-Based Public-Private Partnership" (CBP3) - to accomplish procurement goals.
- Reduction in costs by 30-50% as compared to traditional approaches, while engaging broad local community participation, including training and creation of hundreds of local jobs.
- Creation of an excellent opportunity for local economic development that improves property values, provides contracts to local employers, and creates workforce opportunities.
- The program complements and enhances the jurisdiction's existing programmatic, procurement delivery capacity, to finance and deliver faster, cheaper, greener results,

CASE STUDY - II

VICTORIA, BC, CANADA

The City of Victoria, B.C., has some of the oldest storm water infrastructure in Canada, dating back to the early 1900's. The city administration decided to roll-out the storm water drainage utility in 2014 and subsequently adapted user-fee billing based model from 2016.

The storm water utility for every property is calculated based on the following four factors:

1. **Impervious Surfaces Factor:** this is based on the total area of all impervious surfaces on a parcel;
2. **Street cleaning factor:** this is based on the street frontage of the parcel and the type of street the parcel fronts on to;
3. **Intensity code factor:** this is based on the property classification (i.e. low density residential, multifamily residential, civic/ institutional, and commercial/ industrial); and
4. **Codes of Practice Factor:** if a certain business type is listed (construction, auto operation, recreation facility, etc.) an additional factor is calculated.

Low-density residential properties can obtain up to a 10% discount, while other properties can obtain a maximum 40% discount or 50% if they include an educational component. The discount expires after 5 years; upon which time it must be renewed.

One of the main goals of the storm water management program is to encourage green infrastructure projects on private properties. As such, one of the focus areas of the implementation of the storm water utility for the City has been to make it as easy as possible for residents to install green infrastructure.

Significance of the timeframe provided to the community: The year and a half that the City gave property owners to adjust to the fee allowed issues, including those properties not connected to the stormwater system to be brought forward and amendments to the bylaw made.

5.7 Summary

Often storm water drainage systems get choked during monsoon and cause localized flooding due to poor cleaning of drainage ways and also dumping of solid waste/C&D waste into drains. The problem is aggravated in absence of routine operation and maintenance of storm drainage system which is often a result of not giving much importance to storm drainage system. The situation is further compounded due to non-earmarking of dedicated funds for routine operation and maintenance of storm water drains and pumping stations etc. The above problem of cost intensive designs and O&M may be minimized by adopting best storm water management approaches of integrating storm water drainage system with rainwater harvesting/drinking water supply system of the city. Citizens' involvement is key to efficient service delivery and would minimize the cost of service delivery to ULB.