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GOVERNMENT OF ARUNACHAL PRADESH
DEPARTMENT OF PUBLIC HEALTH ENGINEERING
AND WATER SUPPLY

ITANAGAR

NOTIFICATION

The 7th November, 2023

No.PHED/JJM/O&M/187/2022-23.—Whereas the Operation and Maintenance for Rural and Urban Water Supply System is claimed at ensuring the sustainable management of Water Supply System across the State. The Operation and Maintenance Policy envisages the community participation through Village Water and Sanitation Committee taking ownership of in-Village water supply components, whereas, PHE & WS department shall ensure operation and maintenance of system from intake point to Water Treatment Plant. The Operation and Maintenance Policy, addresses key objectives of sustainability, quality assurance, efficiency, capacity building, community participation and resource management.

Now, therefore, the Operation and Maintenance Policy appended to this notification shall be followed for Operation and Maintenance for Rural and Urban Water Supply System in the State of Arunachal Pradesh.

The notification shall come into effect from the date of its publication in the Official Gazette of the State of Arunachal Pradesh.

A.K. Singh,
Secretary,
Public Health Engineering &
Water Supply Department,
Government of Arunachal Pradesh,
Itanagar.

CHAPTER-1

INTRODUCTION

1.0 Introduction :

Arunachal Pradesh is a vast state in the North Eastern part of India with geographical area of approximately 83743 sq. km and population of 1382611 numbers as per census 2011. Topographically and climatically, the state could be divided into 3 zones. First, the area adjacent to Assam on one side, with altitude up to 300 mtrs. from mean sea level, topographically plain to mild hill slope and climatically tropical. Second, the middle part of the state with altitude ranging from 300 to 1000 mtrs. and climatically sub-tropical with mostly mild to steep hill slope and small plateaus and valleys in between. Third one, comprising of very steep mountainous terrain with altitude beyond 1000 mtrs. upto 4000 mtrs. and temperate climatic condition. This zone has mostly international boundaries on one side with China, Bhutan or Myanmar. Drinking water systems in all these zones have different challenges when it comes to O & M of the assets to keep them sustainable. In case of the first zone, the usual issues of O & M

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faced are mainly related to flooding, landslides, high turbidity, iron content causing problems for pumps and accessories. In case of second zone, the usual issues of O & M faced are mainly related to flooding, landslides, and turbidity. Third zone usually have less turbidity problem but can be affected by flood and landslides.

The water supply system in Arunachal Pradesh, in the days when it was a part of Assam as North Eastern Frontier Tract upto 1954 and all through its existence as North Eastern Frontier Agency (NEFA) upto 1972, was mostly based on the indigenous technology using split bamboo as conveyance and small earthen bunds and embankments as headwork with hardly any financial aid or technical support from government. The villagers used to take up such schemes on community or individual basis. After creation of Rural Works Department in 1977 and later, on attainment of statehood in 1987, the concept of providing piped water supply schemes got impetus. Further, with creation of Public Health Engineering Department in 1995, the subject of drinking water & sanitation got additional importance in the state Government's scheme of things. The state Govt. through its annual plans like AOP, SADA, BE, Water to all, loan under NABARD (RIDF) and CSS programmes like NEC, NLCPR & NESIDS have been trying to meet the fund/project requirements under drinking water sector. Hon'ble Chief Minister, Arunachal Pradesh also announced Arunachal Jal Sankalp on 6th November, 2020, a programme to support drinking water schemes in the state to facilitate the spirit of partnership with GoI in achieving Jal Jeevan Mission (JJM) objectives. Though water is a state subject, the GoI has been supporting and hand holding the states through its programmes like Accelerated Rural Water Supply Programme (ARWSP), National Rural Drinking Water Programme (NRDWP) and Jal Jeevan Mission (JJM) -which aims at providing functional household tap connections (FHTC). Similarly, for urban towns, GoI has been supporting mainly through programmes from MoHUA, DoNER etc. The GoI's programmes have been instrumental in tackling the water supply problems in the state. Creation of huge infrastructures through these programmes have thrown up a challenge to address the sustainability of the assets created. Therefore, the need of operation and maintenance of these assets is very crucial.

1.1 Objectives of Operation and Maintenance :

The objective of an efficient operation and maintenance of a water supply system is to provide safe drinking water as per designed quality and quantity, with adequate pressure at convenient location and time at competitive cost on a sustainable basis. "Operation refers to timely and daily operation of the components of a water supply system such as intake work, treatment plant, machinery and equipment, conveying mains, service reservoirs and distribution system etc., effectively by various technical personnel, as a routine function."

"Maintenance is defined as the act of keeping the structures, plants, machinery and equipment and other facilities in an optimum working order. Maintenance includes preventive /routine maintenance and also breakdown maintenance. However, replacements, correction of defects etc. are considered as actions excluded from preventive maintenance.

1.2 Sector Organization :

Water supply and sanitation is treated as a State subject as per the Constitution of India and therefore, the States are responsible for the planning, implementation, operation and cost recovery of water supply and sanitation projects. At the local level, the responsibility is entrusted by legislation to the local bodies like Gram Panchayat / Village Water & Sanitation Committee (VWSC) in Rural Sector As per the allocation of the business portfolio by the State Government, Public Health Engineering and Water Supply Department (PHE&WS) is the nodal agency at the State level for planning and implementation of water supply program in rural and urban areas of Arunachal Pradesh. The Ministry of Drinking Water and Sanitation, Government of India also formulates policy guidelines in respect of Rural Water Supply & Sanitation Sector and provides technical assistance to the States & Rural Local Bodies (GPs/VWSC) wherever needed. Likewise, Ministry of Housing and Urban Affairs through the Central Public Health & Environmental Engineering Organisation (CPHEEO) issues guidelines for urban towns.

1.3 Operation & Maintenance Scenario :

It has been observed that lack of attention to the important aspect of operation & maintenance (O&M) of water supply schemes in several villages and towns often leads to their dysfunction or deterioration of the useful life of the systems necessitating premature replacement of many components, incurring huge losses. Some of the key issues contributing to the poor Operation & Maintenance (O&M) have been identified as follows:

(a) Lack of finance, equipment, material, and inadequate data on Operation & Maintenance.

(b) Inappropriate system design; and inadequate Workmanship.

(c) Inadequate operating staff.

(d) Illegal tapping of water.

(e) Inadequate training of personnel.

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(f) Lack of performance evaluation and regular monitoring.

(g) Inadequate emphasis on preventive maintenance.

(h) Lack of O & M manual.

(i) Lack of real time field information etc.

Therefore, there is a need for clear–cut sector policies and legal framework and a clear demarcation of responsibilities and mandates for O & M of water supply schemes.

1.4 Necessity for Manual :

The Manual on Operation and Maintenance is a long felt need of the rural as well as urban drinking water sector. At present, there is no compiled technical manual on this subject to benefit the stakeholders and field personnel to take forward the O & M actions strategically in the field.

As per the 73rd Amendment to the Constitution, all the rural water supply schemes are to be operated and maintained by local bodies (V.W.S.Cs./G.Ps./Z.P./civil societies), therefore, this operation and maintenance policy has been prepared to facilitate/institutionalize the operation and maintenance system of rural water supply schemes.

1.5 How Can a Village Improve Its O & M? :

Efficient and effective operation depends upon sound village water supply strategies made up of :

(a) water safety plans to ensure good quality water,

(b) standard operating procedures including who will do what and when, and to identify associated annual expenses and revenues; and

(c) service improvement plans to set out future investments to ensure improved, sustainable service delivery.

1.5.1 Water Safety Plans :

Water safety plans provide a means of prioritizing improvement programme based on health outcomes. Most importantly, water safety plans address bacteriological contamination which is the biggest water quality related threat to public health, especially infant mortality. A water safety plan may consist sanitarily surveying the water supply system from source to storage / treatment to distribution to households (also known as sanitary survey) so as to identify sources /causes of contamination and corresponding operational control measures to reduce the risks. The controls have to be monitored to check that all the components of schemes are working; otherwise remedial action should be taken accordingly.

1.5.2 Standard Operating Procedures :

The Standard Operating Procedure are essential to identify what local operators should do in terms of routine O & M related to water sources, conveying, pumping, storage and treatment units, and distribution systems including household connections. Annual budgets of operating expenses and income, and annual surplus/deficit should be maintained. Someone with good experience and required skills would be needed to train operators and assist them when problems arise. Often the tasks required can overwhelm a local operator who has only basic skills and limited experience, but by providing basic orientation in terms of hands on training and build confidence to do the job well.

1.5.3 Service improvement plans :

It is important to define management and, service delivery improvements and actions to improve accounts, billing and revenue collection.

CHAPTER - 2

RURAL WATER SUPPLY SCHEMES AND SOURCES

2.1. Types of Rural & Urban Water Supply Schemes :

- Surface source-based gravity flow piped water supply schemes.
- Lift water supply schemes based on electric power, DG sets, Solar Power.
- Hybrid of lift and gravity-based schemes.
- Open wells/ Sanitary dug well/ rain water harvesting collections.
- Hand pumps schemes.

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The scheme/project could be for single village/habitation or multi villages/habitations or a town. The sources of water supply schemes/projects may be rivers, streams, reservoir, open wells, bore wells, infiltration wells, infiltration galleries etc.

2.2 Components of Piped Water Supply Scheme (PWSS) :

The Rural Piped Water Supply Scheme comprises of following components, the details of these components will be illustrated separately.

1. Source/ intake works.
2. Raw water storages.
3. Transmission System.
4. Filtration unit.
5. Pumping Machinery.
6. Disinfection.
7. Balancing Reservoir/ Clearwater reservoir.
8. Distribution system.
9. Water testing laboratories /storage facilities
10. Clear water storage/ Reservoir
11. Internet of Things (IoT).

2.3 Types of Sources :

Following are the common water sources:

(I) Surface sources (a) Rivers, canals, (b) streams, (c) reservoir and ponds.

(II) Sub surface sources (a) Infiltration wells, (b) Infiltration galleries, local springs.

(III) Ground water sources (a) Open wells/sanitary wells/bore wells,

2.3.1 Surface Water :

Surface water accumulates mainly as a result of direct runoff from precipitation (rain or snow). Precipitation that does not enter the ground through infiltration or is not returned to the atmosphere by evaporation, flows over the ground surface and is classified as direct runoff. Direct runoff is water that drains from saturated or impermeable surfaces, into stream channels, and then into natural or artificial storage sites or into the ocean in coastal areas. The quantity of available surface water depends largely upon intensity & duration of rainfall and will vary considerably between wet and dry years.

The probability of contamination of surface water is very high. The factors affecting water qualities are waste water, agriculture waste, domestic and Industrial discharge, grazing of livestock, drainage from mining area. The method of treatment of water depends upon raw water quality and range from disinfection only to complete treatment.

2.3.2 Intake Structure :

An Intake is a device or structure placed in a surface water source to permit withdrawal of water from this source and its discharge into an intake conduit through which it will flow into the water works system. Types of intake structures consist oftrench weir drop inlet, impounding cross wall, intake towers, intake pipes or conduits. Trench weir/Drop inlet/Submerged channel inlet twin collection chambers are widely used intake structures in Arunachal Pradesh for surface sources.

2.3.2.1 Problems & Necessary Steps In Operation :

Some of the problems that may arise during the operation of Intakes are given below. Necessary steps should be taken to set right the same

(a) Damages due to flood. Intake structures should be planned to give minimum resistance to a flow and should be designed to stand against sliding, scouring and breakage.

(b) Filling up of trenches and inlet chambers with debris and sedimentations. Enough space to clear the debris should be left and leaves and other matter blocking the trash rack should be cleaned timely. During high flood period usually trenches are filled with debris and cleaning is not possible, to tackle such situations, inverted pores should be left in the wall above the floor but below the flood level, from where, water can be collected through a channel placed behind the guide wall of an intake structure.

(c) Water withdrawal at various depths.

(d) Hydraulic surges, ice, floods, floating debris, boats and barges.

(e) Withdrawal of water of the best available quality to avoid pollution, and to provide structural stability.

(f) Operation of racks and screens to prevent entry of objects that might damage pumps and treatment facilities.

(g) Minimising damage to aquatic life with provision of fish ladder.

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(h) Preservation of space for Equipment cleaning, Removal and repair of machinery, Storing, movement and feeding of chemicals,

(i) Screens should be regularly inspected, maintained and cleaned

(j) Mechanical or hydraulic jet cleaning devices should be used to clean the screens

(k) Intake structures and related facilities should be inspected, operated and tested periodically at regular intervals

(l) Proper service and lubrication of intake facilities is important.

(m) Operation of Gates and Valves

2.3.3 Safety :

When working around Intake Structures, proper safety procedure involving use of electrical and mechanical equipment, precaution against flood and water safety should be observed. Proper safety procedures should be documented and included in the SoP containing the operating procedure.

2.4 Ground Water :

Part of the precipitation that falls infiltrates the soil; water that drains down (percolates) reaches a level at which all the openings or voids in the earth's materials are filled with water. This zone is called as saturation zone and water is called as ground water. Part of precipitation that infiltrates into the unsaturated zone is called sub surface water. This sub surface water is used as source for infiltration wells, infiltration galleries. The ground water sources are used as follows:

(1) Dug well / sanitary well with or without straining wells

(2) Bore well /Tube well

2.4.1 Dug Wells/Sanitary Wells :

Dug wells vary in size, shape, depth, lining and the method of raising water. Typically water is lifted by a simple bucket and rope passing over a pulley. The well may have a diameter of about 1.5 to 6 meters. It may be lined for example with plain concrete/RCC/hollow concrete blocks/stones masonry /brick blocks etc. with headwall with fencing and cover to prevent spilt water, rainfall runoff, debris, people and animals from entering or falling inside. A concrete apron/platform is also critical to prevent polluted water seeping back down the sides of the well and direct water away from the well into drainage channels.

2.4.1.1 O & M Activities for a Dug Well/ Sanitary Well :

Though the dug well and the hand pumps are no more encouraged in the Government scheme of things but in case any individual or an organisation desire to keep them as additional source of water, the following activities can help their operationally.

The daily, monthly and annual activities should include the following O & M activities:

(i) Daily Activities

(a) Check for any debris in the well by regular visual inspection

(b) Clean the concrete apron

(c) Clear the drains

(d) Check that the gate is closed

(e) Check the condition of the rope, pulley, bucket and fence by regular visual inspection

(f) Disinfection

(ii) Monthly activities

(a) Replace the bucket and other parts as needed
(b) Check the concrete apron and well seal for cracks and repair them with cement mortar
(c) Record the water level with a rope-scale
(d) Lubricate the components with grease periodically.
(e) De-silting of dug wells periodically as required
(f) Monthly treatment of existing wells using potassium permanganate.

(iii) Annual activities

(a) Dewater the well and clean the bottom
(b) Inspect the well walls and lining and repair as needed
(c) Check the water level and deepen the well as needed
(d) Check the support posts for the pulley and repair as needed
(e) Record the depth of water level & depth of well with a rope scale

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Note : All open wells (existing/New) should be provisioned invariably with top lid to prevent accidents of child or animals falling into the well. Similarly, for any bore well of dia> 8 inch top cover should be closed during the withdrawal of the submersible pump for repair job.

2.4.2 Hand Pumps :

The Bore hole drilled for the use of Hand Pump is generally of 125 mm diameter size, which may be fitted with variety of Hand Pump instrument. Boreholes may be fitted with a variety of pumps. The India Mark II and the India Mark III are the most common hand pumps implemented by the Public Health Engineers.

The India Mark II is suitable for a depth of upto 50 meters. The pump body parts are extremely durable over the years. The pump achieves high discharges in the range 25-45 meters. To service a Mark II, higher skills and special tools are needed which require help from qualified mechanics. The Mark III - VLOM means that every time the cylinder components need replacement or maintenance, only the valve assemblies can be pulled out without taking out the riser mains. In villages where the resources are scarce, this option can often mean little break-down time. However, the cost of riser pipes may be nearly double in Mark III.

With all hand pumps, the borehole is sealed to prevent the percolation of waste water polluting the borehole. A user friendly designed platform with drains connected to a soak pit/leach pit at least three meters from the borehole is critical. The hand pump should be mounted on top of the casing pipe of borehole (½ meter above GL) so that dirty water cannot enter into the borehole. Following precautions are required to be taken in installation of Hand Pump :

1. In the flood prone area, at least one hand pump platform should be constructed with raised platform above HFL.
2. Washing, cleaning and disinfection of bore wells are to be carried out after the flood recedes.
3. In drought situation, water level monitoring should be done on intensity basis. Use of extra deep Hand pumps should be done. If water level goes below the limits of these hand pumps, then single phase submersible power pumps may be installed, which may operate on Electricity / Diesel Generator/Solar power.
4. Important spare parts in adequate quantities to be kept to meet the emergency situation.
5. As the water table goes down, the assembly pipes of the hand pumps may be lowered down at the depth of at least 15 meter below water table. Also replace damaged pipes so as to have pipes full of water, which will lead to easy operation of hand pumps.

2.4.3 Artificial Re-Charging of Under Ground Source :

The yield in the source can be improved by artificial recharging structures. Artificial recharge of ground water can be achieved by the following:

(i) Stream flow harvesting comprising of

- (a) Anicuts
- (b) Gully plugging /small boulder dams
- (c) Loose stone check dams (LSCD)
- (d) Dams

(ii) Surface flow harvesting

- (a) Tank
- (b) Ponds

(iii) Direct recharge

- (a) Recharge of wells
- (b) Through injected wells
- (c) Through roof top rain water harvesting structures

Note :- The O & M of such structures may be done as per the sustainability practices and manuals.

CHAPTER-3

TRANSMISSION SYSTEM

3.1 General Objective of Transmission System :

The overall objective of a transmission system is to deliver raw water and treated water from the source to the treatment plants and treatment plants to the storage reservoirs respectively for supply into distribution networks. Transmission of raw water can be either by canals or by pipes whereas transmission of treated water is by pipes only. Transmission through pipes can be either by gravity flow or by pumping. In the context of Arunachal Pradesh, canals are used only near the intake works.

The objective of O & M of transmission system is to achieve optimum utilization of the installed capacity of the transmission system with minimum transmission losses and at minimum cost. To attain this objective, operation procedures need to be evolved to ensure that the system can operate satisfactorily, function efficiently and continuously, and last as long as possible at lowest cost.

3.2 Transmission by gravity through channels or canals :

3.2.1 Maintenance of Unlined Canal Transmitting Raw Water :

(a) All grass should be scraped and weed removed from the silted bed.

(b) Silt deposited should be removed.

(c) Bed should be levelled and their gradient regularized.

(d) Berms should be kept straight by trimming.

(e) Flow meters should be installed at the head and tail of canals at important points in between. The reading should be observed and recorded daily.

(f) Both edges of the bank especially the inner one should be neatly aligned and should be free from holes, weeds.

(g) Ensure there is no Seepage through the banks

3.2.2 Maintenance of Lined Canals Transmitting Raw Water :

Cavity or pockets or any activity detected behind the lining should be carefully packed with sand or other suitable material. Care should be taken to ensure that the lining does not get damaged or displaced. Damaged portion of lining should be removed and replaced with fresh lining of good quality by preparing a thoroughly compacted sub-grade before laying fresh sub-grade. The cracks in the lining should be filed with standard sealing compound. An effective sealing may be obtained by cutting 'V' groove along the face of the cracks before filing with sealing compound. Packing with powdered clay upstream of the cracks may seal minor crack on the lining.

(a) Displaced portion of the joint filter should be removed and fresh filter material may be packed.

(b) The chocked pressure release pipes should be cleaned by intermittent application of air and water by ridding.

(c) Subsoil water level should be observed regularly especially after rainy season. If there is rise, adequacy of the pressure release system or other remedial measures like humps, regulators etc. provided for the safety of the lining should be reviewed.

(d) Seepage through embankments if any should be observed from time to time and remedial measure should be taken.

(e) Silt deposition if any noticed should be flushed out during non-monsoon period when the water is silt free.

(f) Aquatic weed growth if observed below the supply level should be removed. Land weed growing over the free board should also be controlled.

(g) Canal banks should be inspected for seepage condition at the outer slope and for some distance beyond the toe especially in high fill reaches.

3.3 Transmission through Pipes :

In the case of gravity-based transmission line, where direct feeding in to OHTs is envisaged, it should be ensured that design head is developed. Otherwise, water will be reaching only the OHT at lower elevation at the cost of OHT at higher elevation. This can be ensured by suitably regulating the sluice valves. All valves installed in the transmission main should be inspected daily to ensure that there is no leakage otherwise leakage should be attended. If attending leakage requires stoppage of flow through pipes the same can be attended on a pre-fixed monthly shutdown day.

3.3.1 Types of Pipes which are generally used in Water Supply System :

The various make of pipes is generally used for water supply projects. The selection and specification of pipes should be based on field conditions and used as per the *State Pipe Policy* and *BIS specification*. In case of Arunachal Pradesh DI, GI and HDPE pipes are mostly used.

3.3.2 Problems in Transmission Mains :

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(i) ***Leakage :*** Water is often wasted through leaking pipes, joints, valves and fittings of the transmission system either due to bad quality of materials used, poor workmanship, and corrosion, age of the installations, natural calamities or through vandalism. This leads to reduced supply and loss of pressure. Review of flow meter data will indicate possible leakages. The leakages can be either visible or invisible. In the case of invisible leaks sections of pipeline can be isolated and search carried out for location of leaks.

Most common leaks are through the glands of sluice valves. Leaks also occur through expansion joints where the bolts have become loose and gland packing is not in position. Leaks through air valves occur due to improperly seated ball either due to the damage of the gasket or due to abrasion of the ball, through the gland of the isolating sluice valve or through the small orifice.

(ii) ***Air Entrapment :*** Air in free form in rising main collects at the top of the pipeline and then goes upto higher points. Here, it either escapes through air valves or forms an air pocket which in turn, results into an increase or head loss. Other problems associated with air entrapment are: surging, corrosion, reduced pump efficiency and malfunctioning of valves or vibration. In rare cases bursting of pipes also is likely to occur due to air entrapment. There should always be air valve chamber with cover slabs for the protection of the air valve and it should always be kept leakage free and dry. Frequent inspection should be conducted to check, whether air valves are functioning properly and to ensure that there is no leakage through air valve.

(iii) ***Water Hammer :***

The pressure rise due to water hammer may have sufficient magnitude to rupture the transmission pipe or damage the valves fixed on the pipeline. Water hammer in water supply systems occurs due to rapid closure of valves and sudden shut off or unexpected failure of power supply to the pumps. The care should be taken to open and close sluice valves gradually.

(iv) ***Lack of Records/ Maps etc. :***

Generally, maps showing the actual alignments of transmission mains and location of other pipes & the valves on the ground may not readily be available. The location of pipes and the valves on the ground becomes difficult in the absence of such updated maps and thus, need to be prepared and updated them from time to time. Some minimum information about the location and size of pipes and valves and the direction of opening of valves etc. is required to operate and maintain the system efficiently.

3.3.3 O & M Activities :

3.3.3.1 Operation Schedule :

(i) ***Mapping and inventorying of pipes and fitting :*** An updated transmission system map with location of valves, flow meters and pressure gauges is the foremost requirement of operation schedule. The valves indicated in the map should contain direction to open; number of turn to open, make of valve and date of fixing etc. the hydraulic gradient lines are to be marked to indicate the pressure in the transmission system. They can be used for identifying high pressure or problem areas with low pressure.

(ii) ***System pressure :*** It is essential to maintain a continuous positive pressure in the main at the time of transmission of water in the pipeline. Low pressure locations have to be investigated if necessary, by measuring pressure with pressure gauge.

(iii) ***System Surveillance :*** The maintenance staff of the Department/ Panchayat /VWSC should go along the transmission line frequently so as to accomplish the following objectives.

(a) To detect and correct any deterioration of the transmission system.

(b) To detect if there is encroachment of transmission system failures.

(c) To detect and correct if there is any unauthorized tapping of water.

(d) To detect and correct if there is damage to the system by vandalism.

3.3.3.2 Maintenance Schedule :

A maintenance schedule is required to be prepared to improve the level of maintenance of water Transmission system through improved co-ordination and planning of administrative and fieldwork and through the use of adequate techniques, equipment and materials for field maintenance. The schedule has to be flexible so that it can achieve team action with the available vehicles and tools. Training of maintenance staff shall, apart from the technical skills, include training to achieve better public relations with consumers.

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3.3.3.3 Activities for Preventive Maintenance :

(a) *Servicing of valves :* Periodical servicing is required for valves, expansion joints flow meter and pressure gauges. Corrosion of valves is the main problem in some areas and can cause failure of bonnet and gland bolts. Leaks from spindle rods occur and bonnet separates from the body. Stainless steel bolts can be used for replacement. Manufacturer's catalogues may be referred and servicing procedure should be prepared for the periodical servicing.

(b) *List of spare :* List of spares procured for the transmission system shall be prepared and the spares shall be procured and kept for use. The spares may include check nut, spindle rods, bolt and nuts, gaskets for flanged joints for all sizes of sluice valves, consumables like gland rope, grease, cotton waste, jointing materials like rubber gaskets, spun yarn, pig-lead and lead wool etc.

(c) *List of tools, fittings and specials* : The maintenance staff shall be provided with necessary tools/equipment's/fittings/specials for attending to the repairs in the transmission system. The tools may include key rods for operation of sluice valves, hooks for lifting manhole covers, pipe wrench, DE spanner set, ring spanner set, screw drivers, pliers, hammers, chisels, caulking tools, crow bars, spades, dewatering pumps. The fittings could be sockets, unions, elbows, bends, tees, nipples, end plugs, reducers, flange with gaskets; bib cocks etc and specials could be air release valves, pressure release valves, non-return valves, gate valves etc.

3.3.4 Maintenance of Pipelines :

Pipeline bursts/main breaks can occur at any time and the O& M agencies should have a plan for attending to such events. This plan must be written down, disseminated to all concerned and the agency must always be in readiness to implement the plan immediately after the pipe breaks reported. After a pipe break is located, determine which valve is to be closed to isolate the section where the break has occurred. The consumers have to be informed about the probable interruption in water supply and also the estimated time of resumption of water supply. The damaged pipe if any should be removed and replaced, and the accumulated silt in a pipe that is reusable should be removed from inside the pipe and the line disinfected before bringing into use. A report shall be prepared following every pipe break about the cause of such break, the resource required etc. Scouring of pipe line is also done in a routine manner to clean the transmission lines by removing the impurities or sediments that may be present in the pipe. This is particularly essential in the case of transmission lines carrying raw water.

3.3.4.2. Leakage control :

(i) Visible leaks: The maintenance staff during surveillance operation can report visible leaks found by him to his superiors. Critical areas where leaks often occur have to be identified and appropriate correct measures have to be implemented.

(ii) Invisible leaks: Lead detection equipment have to be procured for detection of non-visible leaks and action to control these leaks should be initiated to control the overall problem of water lost.

3.3.4.3 Chlorine Residual Testing :

A minimum free chorine residual of 0.2 mg/lit at the receiving reservoir of a transmission system is needed to be maintained. Absence of residual chlorine could indicate potential presence of contamination in transmission system.

The following steps which are required to be taken are:

(1) Testing of residual chlorine.

(2) Checking the chlorination equipment at the start of the transmission system.

(3) Searching for source of contamination along the transmission system which has caused the increase in chlorine demands.

(4) Immediate rectification of the source of contamination.

3.3.5. Engaging Contractors for Maintenance :

Due to inadequate trained O & M staff in line department/ PRIs/VWSC, the operation and maintenance of transmission system and other components of the scheme, if required, may be done by out sourcing/awarding Contracts for Comprehensive Annual Maintenance for any specified period e.g.1- 5 years or on case to case basis.

3.3.6. Records and Reports :

Following records and reports should be maintained

1. Updated transmission system maps with alignment plans. Longitudinal sectional plans.

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

CHAPTER-4

FILTRATION AND DISINFECTION

The raw water available from surface water sources is normally not suitable for drinking purposes and needs treatment to produce safe and potable drinking water. Some of the common treatment processes viz. Plain sedimentation, Slow Sand filtration, and Rapid Sand filtration with Coagulation-flocculation units form as essential pre-treatment units. Uses of pressure filters are also becoming common of late. Roughing filters are used, under certain circumstances, as pre-treatment units for the conventional filters.

4.1 Types of Filtration Plants :

The types of Filtration Plants are as follows:

(A) Slow Sand Filter Plant

(B) Rapid Sand Filter Plant

(C) Other types of Filter Plants, whose uses are gaining grounds are:

- (1) Pressure filters-used as treatment plants in Industries and in habitations.
- (2) Roughing filters-may be used to reduce load on the treatment plants. Small streams of water in the catchment areas may carry large particles and floating matter, RF can entrap such undesirable material prior to the storage structures of the treatment units.

4.1.1 Slow Sand Filtration-Plant :

Slow sand filtration plant is most widely used in rural water supply schemes and is an effective, low-cost system of water treatment if operated and managed correctly. A slow sand filter is usually in a rectangular shape with inlet and out let chambers and filter unit in between and made of concrete or masonry.

Typically, there may be two rectangular slow sand filters operating in parallel, one filter unit is kept in operation and other for maintenance. The filter unit contains supernatant water layer, a bed of filter media, an under-drainage system and a set of control valves and appurtenances.

The filter units also comprise graded gravel to support the filter's sand bed. The filter units are operated by a combination of valves, inlet, inlet drainage, back-filling, emptying, filter regulation, clear water drainage, and distribution. A flow indicator is used for checking the flow rate. The turbidity of the inlet water is checked to ensure the water is of an acceptable turbidity to prevent rapid blocking of the filter. Turbidity is also measured at the outlet to check the filter is functioning properly. Time to time bacteriological tests on the filtered water should be carried out.

4.1.1.1 Filter Cleaning :

While the filter is in operation, a stage comes when the bed resistance increases forcing the operator to open the regulating valve fully and at this stage, the operator should plan the cleaning of the filter bed otherwise the filtration rate may reduce further. Indicators may be installed showing the inlet and outlet heads, from which the head loss can be regularly checked; this gives a clear picture of the progress of choking and the nearness of the end of the filtration. Without any measurement of the head loss the only true indicator of build-up of resistance is the extent of opening of the regulating valve and the experienced operator may be able to recognize, preliminary visual warnings by the filter bed surface condition. A slight deterioration in the treated water quality may also be an indication for cleaning needs. To clean a filter bed, the raw water inlet valve is to be closed first, allowing the filter to discharge to the clear water reservoir or clear well as long as possible (usually overnight). As the head in the supernatant reservoir drops, the rate of filtration rapidly decreases, and although the water above the bed would continue to fall until, it reaches the level of the weir outlet, it would take a very long time to do so. Consequently, after a few hours, the effluent delivery to the clear water valve is closed, and the supernatant water outlet is run to waste through the drain valve provided. When the supernatant water has been drained off (leaving the water level at the surface of the bed) it is necessary to lower the water within the bed still further, until it is lower down to 100 mm or more below the surface. This is done by opening the waste valve on the effluent outlet pipe. As soon as the Schmutzdecke is dry enough to handle, cleaning should start. The cleaning of the bed may be carried out by hand or with mechanical equipment.

Working as rapidly as possible, they should strip off the Schmutzdecke and the surface sand adhering to it, stack it into ridges or heaps, and then remove the waste material by barrow, hand cart, basket, conveyor belt or any other device. After removal of the scrapings, the bed should be smoothed to level surface. Before the filter unit is refilled, the exposed walls of the supernatant water reservoir should be well swabbed down to discourage the growth of adhering slimes and algae, and the height of the supernatant water drain and of the outlet must be adjusted. The water level in the bed is then raised by charging from below with treated water from the clear water well or from one of the other filters. As soon as the level has risen sufficiently above the bed surface to provide a cushion, the raw water inlet is gradually turned on. The effluent is run to waste until analysis shows that it satisfies the normal quality standards. The regulating valves on the effluent line will be substantially closed to compensate for the reduced resistance of the cleaned bed, and the filter will then be ready to start a new run.

During the cleaning operations precautions must be taken to minimize the chances of pollution of the filter bed surface by the labourers themselves. Such measures as the provision of boots that can be disinfected in a tray of bleaching solution should be taken. Hygienic personal behaviour must be rigidly imposed, and no labourers with symptoms that might be attributable to water borne or parasitic diseases should be permitted to come into direct or indirect contact with the filter medium.

4.1.1.2 Re-Sanding :

After several operation say, twenty or thirty scrapings, the depth of filtering material will have dropped to its minimum designed level (usually 0.5 to 0.8 m above the supporting gravel, according to the grain size of the medium). The filter bed consists of natural sand with an effective size (E.S.) of 0.25mm to 0.35 mm and uniform coefficient (U.C.) of 3 to 5.For best efficiency, thickness of filter bed should not be less than 0.4-0.5 meter. As a layer of 10-20 mm sand will be removed every time the filter is cleaned, a new filter sand layer should be provided with an initial depth of 1.0 meter. Re-sanding will then become necessary only once in 2-3 years. During the long period of the filter use/run some of the raw water impurities and some products of biochemical degradation may be carried into the sand-bed to a depth of some 0.3 to 0.5 m according to the grain size of the sand. To prevent cumulative fouling and increased resistance, this sand layer is required to be removed for re-sanding. However, it can be reused after proper washing, if desired. Usually, it is moved to one side and the new sand is added to the filter and thereafter, the old sand replaced on the top of the new one. Thus, this retains much of the active material to enable the re-sanded filter to become operational with the minimum re-ripening. This process (of replacing old sand on the top of the new) known as "throwing over" is carried out in strips. Excavation is carried out on each strip in turn, making sure that it is not dug so deeply as to disturb the supporting gravel layers below. The removed material from the first strip is stacked to one side in a long ridge, the excavated trench is filled with new sand, and the adjacent strip is excavated, throwing the removed material from the second trench to cover the new sand in the first. When the whole of the bed has been re-sanded, the material in the ridge from the first trench is used to cover the new sand in the last strip.

In areas where sand is expensive or difficult to obtain, the surface scrapings may be washed, stored and used for re-sanding at some future date. These scrapings must be washed as soon as they are taken from the filter, otherwise, being full of organic matter, the material will continue to consume oxygen, quickly become anaerobic, and putrefy, yielding taste and odour producing substances that are virtually impossible to remove during any washing process. Sand Washing Machines should be provided for the bigger plants. Wherever provided, these should be operated regularly to prevent accumulation of sand and also to keep the machine in working condition. It should be kept in mind that it may be adapted to water, low in colour, turbidity and bacterial count. Under such circumstances, provision of roughing filters as a pre-treatment unit gives a good result

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4.1.1.3 O & M Activities for Slow Sand Filter :

(a) ***Daily activities***

(a) Check the rate of filtration on the flow indicator where ever installed – adjust the rate of filtration as needed by turning the filtered water valve.

(b) Check the water level in the filter – adjust the inlet valve as needed to maintain a constant water level.

(c) Remove scum and floating material by further opening the inlet valve for short time.

(d) Check the water level in the clear well.

(e) Sample and check water turbidity – if the inflow turbidity is too high close the intake; if the outflow turbidity is too high report to the supervisor.

(f) Testing water quality

- Complete the log book
- Testing Water Quality: Daily monitoring of water quality may be done whether it is slows and filter or rapid sand filter. If the water supply scheme is having laboratory at the water treatment plant site, water quality testing both the raw water and treated water may be carried out daily.

(b) ***Weekly activities***

(i) Clean the water treatment plant site.

(c) ***Monthly activities***

(i) ***Shut down the filter unit*** – remove scum and floating material; brush the filter walls; close the inlet, filtered water and distribution valves; drain water to 20 cm below the sand level; increase the filtration rate in the other filter to 0.2 m/h.

(ii) ***Clean the drained down filter bed*** – wash boots and equipment before use; scrape upper 2-3 cm in narrow strips and remove scrapings from filter; check and service exposed inlet and drain valves; remove cleaning equipment and level sand surface; check and record depth of sand bed; adjust inlet box to the new sand level.

(iii) ***Re-start the filter*** -- open the recharge valve; check sand surface and level as needed; when water is 20 cm above the sand, open the inlet valve; open the filtered water valve and stop when filtration rate reaches 0.02 m/h; open waste valve for outflow water to flow to waste; open filtered water valve to increase filtration rate every hour by 0.02 m/h until a rate of 0.1 m/h is reached; adjust and check flow daily until safe to drink; close waste valve and open distribution valve to pass filtered water into the supply; decrease filtration rate of other filter to 0.1 m/h.

(iv) Wash the filter scrapings and store the clean sand.

(d) ***Annual activities***

(i) Check if filter is water tight: close all valves and fill filter box from inlet valve until it overflows – close valve; leave for 24 hours and check if water level reduces; if filter box leaks, report for repair; open filtered water valve to fill outlet chamber and when full, close valve; leave for 24 hours and check if water level reduces; if chamber leaks, report for repair; open drain valve to empty filter; clean the clear well in the outlet chamber; restart filter as per the month clean.

(e) ***Every two years, activities***

(i) Re-sand the filter units – clean the filter as in a monthly filter clean; open drain valve to empty water from the sand bed; remove strip of old sand to one side; place new clean sand on top of exposed gravel, and level; place old sand on top of the new sand to the correct depth of 0.8 m in total, and level the surface; continue in strips until filter is rescinded; adjust inlet box to new sand level. Re-start the filter as per the monthly clean plan.

(f) ***Random checks***

(i) Checks on the functioning of the plant by supervising staff including turbidity tests through a turbidity meter, and bacteriological tests of the filtered water.

(g) ***Record keeping***

Records have to be kept for the following activities.

(i) Daily Source water quality.

(ii) Daily Treated water quality.

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(iii) Names of chemicals used.

(iv) Rates of feedings of chemicals.

(v) Daily consumption of chemical and quality of water treated.

(vi) Dates of cleaning of filter feds, sedimentation tank and clear water reservoir.

(vii) The date and hour of return to full service (end of re-ripening period).

(viii) Raw and filtered water levels (measured each day at the same hour) and daily loss of head.

(ix) The filtration rate, the hourly variations, if any.

(x) The quality of raw water in physical terms (turbidity, colour) and bacteriological terms (total bacterial count, E. Coli.) determined by samples taken each day at the same hour.

(xi) The same quality factors of the filtered water.

(xii) Any incidents occurring e.g. plankton development, rising Schmutzdecke, and unusual weather conditions.

4.1.2 Rapid Sand Filtration Plant :

The pre-treatment units which form essential parts of a Rapid sand filtration unit and include:

(a) Aeration /Pre-sedimentation (optional),

(b) Coagulation and flocculation with rapid mixing facilities and

(c) Sėdimentation unit

(d) Filtration unit

4.1.2.1 Aeration /Pre-sedimentation :

Aeration

Aeration is a unit process in which air and water are brought into intimate contact. Turbulence increases the aeration of flowing streams. Aeration is used for the following purposes :

(a) carbon dioxide reduction (de-carbonation)

(b) oxidation of iron and manganese of many well waters (oxidation tower)

(c) ammonia and hydrogen sulfide reduction (stripping)

(d) Effective method of bacteria control.

Two general methods may be used for the aeration of water. The most common in use is the water-fall aerator. Through the use of spray nozzles, the water is broken up into small droplets or a thin film to enhance counter current air contact. In the air diffusion method of aeration, air is diffused into a receiving vessel containing counter-current flowing water, creating very small air bubbles. This ensures good air-water contact for "scrubbing" of undesirable gases from the water.

Pre-sedimentation

Sedimentation without coagulation and flocculation as part of the pre-treatment process is known as pre-sedimentation and removal of coarse suspended matter (such as grit) depends merely on gravity. This type of sedimentation typically takes place in a reservoir, grit basin, debris dam, or sand trap at the beginning of the treatment process.

While sedimentation with coagulation/flocculation is meant to remove most of the suspended particles from the water before the water reaches to the filters, pre-sedimentation removes most of the sediment from the water at the pre-treatment stage and it reduces the load on the Coagulation/flocculation basin and on the sedimentation chamber, as well as reducing the volume of coagulant chemicals required to treat the water.

4.1.2.2 Coagulation and Flocculation :

The term coagulation and flocculation are often used to describe the process of removal of turbidity caused by fine suspension, colloids and organic colours i.e. non-settle able particles from water. *Coagulation* is the process by which particles become destabilized and begin to clump together. It is an essential component in the water treatment operation.
Flocculation is the second stage of the formation of settle able particles (or flocs) from destabilized colloidal sized particles and is achieved by gentle and prolonged mixing.

The processes of coagulation-flocculation are required to precondition or prepare non settle-able particles present in the raw water for removal by sedimentation and filtration. Small particles (particularly colloids), without proper coagulation-flocculation are too light to settle out and will not be large enough to

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be trapped during filtration process. Since the purpose of coagulation–flocculation is to accelerate particle removal, the effectiveness of the sedimentation and filtration processes, as well as overall performance depends upon successful coagulation - flocculation.

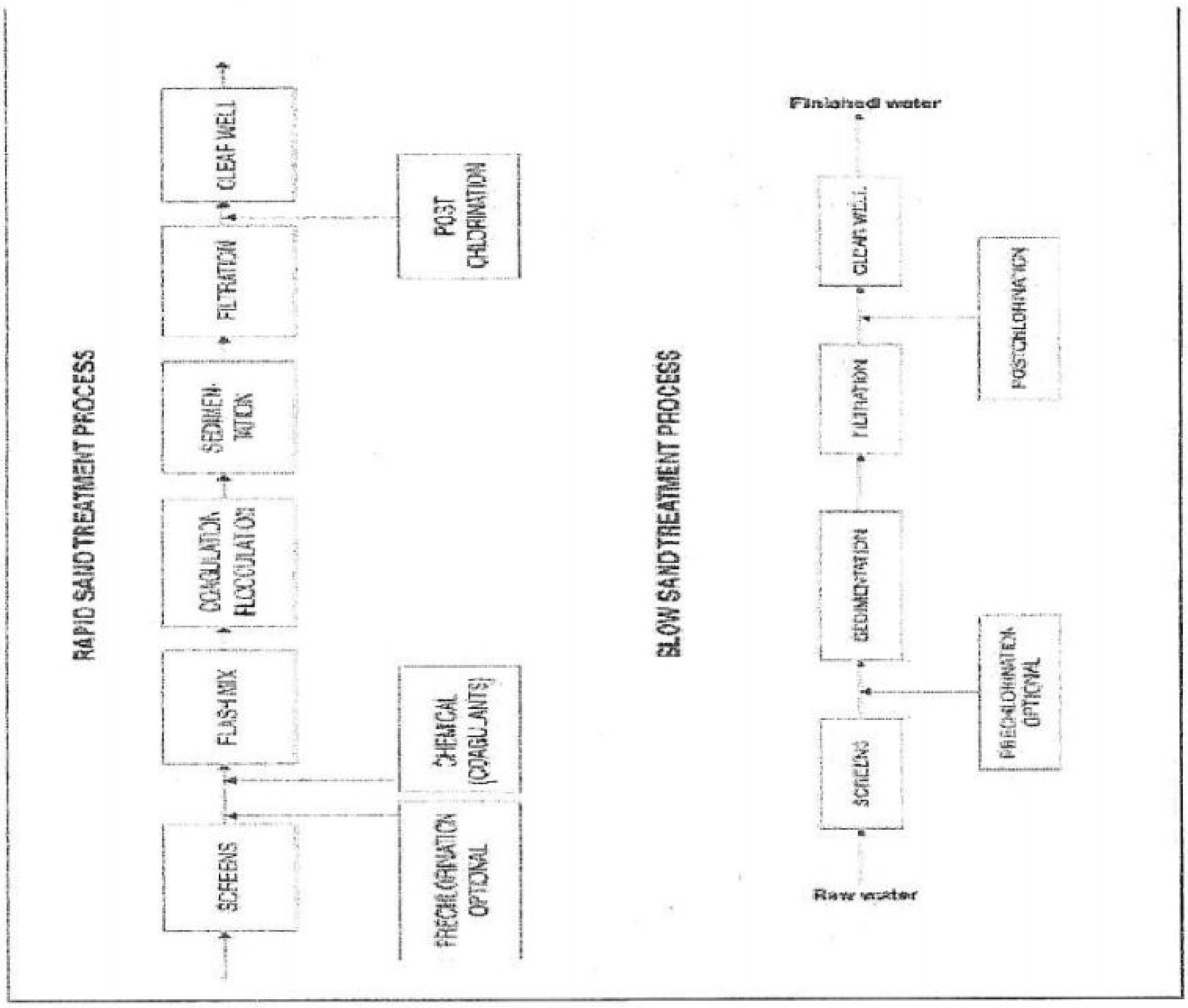

Fig 4.1 : Conventional Filtration Process

4.1.2.3 Sedimentation :

The purpose of sedimentation process is to remove suspended particles so as to reduce load on Filters. If adequate detention time and basin surface area are provided in the sedimentation basins, solids removal efficiencies can be achieved more than 95%. However, it may not always be the cost-effective way to remove suspended solids.

In low turbidity source waters (less than about 10 NTU) effective coagulation, flocculation and filtration may produce satisfactory filtered water without sedimentation. In this case, coagulation-flocculation process is operated to produce a highly filterable tiny floc, which does not readily settle due to its small size; instead the tiny floc is removed by the filters. There is, however, a practical limitation in applying this concept to higher turbidity conditions. If the filters become overloaded with suspended solids, they will quickly clog and need frequent back washing. This can limit plant production and cause degradation in filtered water quality. Thus the sedimentation process should be operated from the standpoint of overall plant efficiency. If the source water turbidity is only 3 mg/l, and the jar tests indicate that 0.5 mg/l of coagulant is the most effective dosage, then one cannot expect the sedimentation process to remove a significant fraction of the suspended solids. On the other hand, source water turbidity in excess of 50 mg/l will probably require a high coagulant dosage for efficient solids removal and the suspended particles and alum floc should be removed by sedimentation basin.

4.1.2.3.1 Sedimentation Basins :

The Basin can be divided into four zones viz. Inlet; Settling; Sludge and Outlet zone. The basins may be of the following types:

- Rectangular basins.
- Circular and square basins.
- High Rate Settlers (Tube Settlers).
- Solid Contact Units (Up-flow solid-contact clarification and up-flow sludge blanket clarification).

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4.1.2.3.2 Operating Procedures :

From a water quality point of view, filter effluent turbidity is a good indication of overall process performance. However, monitoring the performance of each of the individual water treatment process including sedimentation is must in order to check water quality or performance changes. Operations are considered to be normal within the operating ranges of the plant, while unusual or difficult to handle condition is abnormal operating condition. In normal operation of the sedimentation process one must monitor.

(a) Turbidity of inflow and out flow of water in the Sedimentation Basin: Turbidity of inflow water indicates the floc or solids loading to the sedimentation basin while turbidity of outflow water of the basin indicates the effectiveness or efficiency of the sedimentation process. Low levels of outflow water turbidity to be achieved to minimize the floc loading on the filter.

(b) Temperature of inflow water is important as the water becomes colder, the settling of particles become slow. To compensate for this change, jar tests should be performed and accordingly, the coagulant dosage is to be adjusted to produce a heavier and thus a settle-able floc. Another possibility is to provide longer detention times when water demand decreases.

(c) Visual checks of the sedimentation process should include observation of floc settling characteristics, distribution of floc at the basin inlet and clarity of outflow settled water spilling over the weirs. An uneven distribution of floc or poorly settling floc is an indication of a raw water quality change or there is operational problem.

4.1.2.3.4 Sludge Handling and Disposal :

(a) Sludge characteristics

Water treatment sludge is typically alum sludge, with solid concentrations varying from 0.25 to 10% when removed from a basin. In gravity flow sludge removal systems, the solid concentration should be limited to about 3%.If the sludge is to be pumped, solids concentrations should be high as 10% for readily transportation. In horizontal flow sedimentation basins preceded by coagulation and flocculation, over 50% of the floc will settle out in the first third of the basin length. Operationally, this must be considered when establishing the frequency of the operation of sludge removal equipment.

(b) Sludge Removal Systems

Sludge which accumulates on the bottom of the sedimentation basins must be removed periodically for the following reasons:

(a) To prevent interference with the settling process (such as re-suspension of solids due to scouring).

(b) To prevent the sludge from becoming septic or providing an environment for the growth of microorganisms that create taste and odour problems.

(c) To prevent excessive reduction in the cross sectional area of the basin (reduction of detention time).

In large-scale plants, sludge is normally removed on an intermittent basis with the aid of mechanical sludge removal equipment. However, in smaller plants with low solid loading, manual sludge removal may be more cost effective.

In manually cleaned basins, the sludge is allowed to accumulate until it reduces settled water quality. High levels of sludge reduce the detention time and floc carries over to the filters. The basin is then dewatered (drained), most of the sludge is removed by stationary or portable pumps, and the remaining sludge is removed with squeegees and hoses. Basin floors are usually sloped towards a drain to help sludge removal. The frequency of shutdown for cleaning will vary from several months to a year or more, depending on source water quality (amount of suspended matter in the water).

In larger plants, a variety of mechanical devices can be used to remove sludge including

- Mechanical rakes.
- Drag-chain and flights.
- Travelling bridge.

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Circular or square basins are usually equipped with rotating sludge rakes. Basin floors are sloped towards the centre and the sludge rakes progressively push the sludge toward a centre outlet. In rectangular basins, the simplest sludge removal mechanism is the chain and flight system.

(c) Sludge Disposal

Disposal of waste from the water treatment plants has become increasingly important with the availability of technology and the need for protection of the environment. Treatment of waste solid adds to the cost of construction and operation of treatment plants.

Waste from the Water treatment plants comprise of:

(i) Sludge from sedimentation of particulate matter in raw water, flocculated and precipitated material resulting from chemical coagulation, or residuals of excess chemical dosages, plankton etc.

(ii) Waste from rinsing backwashing of filter media containing debris, chemical precipitates, straining of organic debris and plankton and residual of excess chemical dosages etc., and

iii) Wastes from regeneration processes of ion exchange softening treatment plant containing caption of calcium, magnesium and unused sodium and anion of chlorides and sulphates originally present in the regenerate.

(d) Disposal Method

In continuous sludge removal, the feasibility of discharging of water treatment plant sludge to existing sewer nearby should be considered. For lime softening plant sludge, the reclamation by claiming and reuse can be explored. These sludge from clarification units using irons and aluminium coagulant can be dewatered by vacuum filtration. However, the method of waste disposal shall conform to the pollution control norms.

4.1.2.4 Filter unit :

Rapid Sand Filter comprises of bed of a sand serving as a single medium granular matrix supported on gravel overlying on under drainage system. The distinctive features of rapid sand filtration as compared to slow sand filtration include careful pre-treatment of raw water to effectively flocculate the colloidal particles, use of higher filtration rates with coarser uniform filter media to utilize greater depths of filter media to trap influent solid without excessive head loss and also back washing of filter bed by reversing the flow direction to clean the entire depth of filter.

4.1.2.4.1 Filter Sand :

Filter sand is defined in terms of effective size and uniformity coefficient. Effective size is the sieve size in mm that permits 10% by weight to pass. Uniformity in size is specified by the uniformity coefficient which is the ratio between the sieve sizes that will pass 60% by weight and the effective size.

Check shape size and quantity of filter sand to the followings:

(a) Sand shall be of hard and resistant quartz or quartzite and free of clay, fine particles, soft grains and dirt of every description.

(b) Effective size shall be 0.4 to 0.7 mm.

(c) Uniformity coefficient shall not be more than 1.7 nor less than 1.3.

(d) Ignition loss should not exceed 0.7 per cent by weight.

(e) Soluble fraction in hydrochloric acid shall not exceed 5.0% by weight.

(f) Silica content should be not less than 90%.

(g) Specific gravity shall be in the range between 2.55 to 2.65.

(h) Wearing loss shall not exceed 3%.

4.1.2.4.2 Interaction with Other Treatment Processes :

The purpose of filtration is to remove particulate impurities and floc from the raw water. In this regard, the filtration process is the final step in the solids removal process which usually includes the pre-treatment processes of coagulation, flocculation and sedimentation. The degree of treatment applied prior to filtration depends on the quality of water.

***Filter Operation and* Backwashing** : A filter is usually operated until just before clogging or breakthrough occurs or a specified time period has passed (generally 24 hours). After a filter
Clogs /breakthrough occurs, the filtration process is stopped and the filter is taken out of service for *cleaning or backwashing.*

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Surface Wash : In order to produce optimum cleaning of the filter media during backwashing and to prevent mud balls, surface wash (supplemental scouring) is usually practiced. Surface wash systems provide additional scrubbing action to remove attached floc and other suspended solids from the filter media.

(A) Operational Procedures

(a) **The *indicators of Normal Operating Conditions:*** The filter influent and effluent turbidity should be closely watched with a turbid-meter. Filter Influent turbidity levels (settled turbidity) can be checked on a periodic basis at the filter or from the laboratory sample tap.

(b) However, the filter effluent turbidity is best monitored and recorded on a continuous basis by an on-line turbidity-meter.

(B) Process Actions: Follow the steps as indicated below :

(i) Monitor process performance.

(ii) Evaluate turbidity and make appropriate process changes.

(iii) Check and adjust processes equipment (change chemical feed rates).

(iv) Backwash filters.

(v) Evaluate filter media condition (media loss, mud balls, cracking),

(vi) Visually inspect facilities.

(C) *Important process activities and Precautions*.

Process performance monitoring is an on-going activity. Check for any treatment process changes or other problems which might affect filtered water quality, such as a chemical feed system failure. Measurement of head-loss built up in the filter media may give a good indication of how well the solids removal process is performing. The total designed head loss from the filter influent to the effluent in a gravity filter is usually about 3 meters. At the beginning of the filtration cycle the actual measured head-loss due to clean media and other hydraulic losses are about 0.9 m. This would permit an additional head-loss of about 2.1 m due to solid accumulation in the filter.

The rate of head-loss build up is an important indication of process performance. Sudden increase in head loss might be an indication of surface sealing of the filter media (lack of depth penetration).Early detection of this condition may require appropriate process changes such as adjustment of chemical filter, aid feed rate or adjustment of filtration rate.
Monitoring of filter turbidity on a continuous basis with an on-line turbidity-meter may be adopted for obtaining continuous feedback on the performance of the filtration process. In most instances it is desirable to cut off (terminate) filter at a predetermined effluent turbidity level. Preset the filter cut-off control at a point where breakthrough occurrence is noticed/ tested.

In the filter process, time for completion of normal filter process may be calculated on the basis of the following parameters :

(a) Head-loss.

(b) Effluent turbidity level.

(c) Elapsed run time.

(d) A predetermined value established for each of above parameter as a cut off point for filter operation may be checked and when any of the selves is reached, the filter should be removed from service and backwashed.

(e) At least once a year, the filter media must be examined and its overall condition evaluated. Measure (i) the filter media thickness for an indication of media loss during the back-washing process, (ii) mud ball accumulation in the filter media to evaluate the effectiveness of the overall back-washing operation.

(f) Routinely observe (i) the backwash process to qualitatively assess process performance, (ii) for media boils (uneven flow distribution) during backwashing, media carry over in to the wash water trough, and (iii) clarity of the waste wash-water near the end of the backwash cycle.

(g) Upon completion of the backwash cycle, observe (i)the condition of the media surface, (ii) check for filter sidewall or media surface cracks (iii) routinely inspect physical facilities, equipment as part of good house-keeping and maintenance practices (d) correct or report the abnormal equipment conditions.

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4.2 Special Treatment :

4.2.1 Algal Control :

Algae are unicellular or multi-cellular chlorophyll bearing plants without any true root, stem or leaves. They may be microscopic unicellular colonial or dense mat-forming filamentous forms commonly inhabiting surface waters. Their growth is influenced by a number of factors, such as mineral nutrients, availability of sunlight, temperature and type of reservoir. During certain climatic conditions there is an algal bloom which creates acute problems in treatment processes and production of potable water. The algae commonly encountered in water purification plants are diatoms, green algae, and blue green algae and algal flagellates. Algae may be seen floating (plankton) in the form of blooms. The problems caused by algae are as follows:

1. Many species of algae produce objectionable taste and odour due to characteristic coil secretions. These also impart colour ranging from yellow-green to green, blue, red or brown.
2. Profuse growth of algae interferes with chemical treatment of raw water by changing water pH and its hardness.
3. Some algae act as inhibitors in process of coagulation carried out for water purification.
4. Some algae clog filters and reduce filter run.
5. Some algae produce toxin sand. Their growth in drinking water reservoirs is harmful for humans and livestock.
6. Some algae provide shelter to a large number of bacteria, some of which may be pathogenic.
7. Some algae corrode metal tanks, forming pits in their walls.
8. Algae may also cause complete disintegration of concrete in contact with them.
9. Prolific growth of algae increases organic content of water, which is an important factor for the development of other organisms.

Remedial Measures :

(A) Preventive Measures

Preventive measures should, therefore, be based on control of factors such as :

(a) Reduction of food supply.

(b) Change of the environment or exclusion of sunlight though they are not always practicable.

(c) Clear water reservoir, service reservoirs and wells may be covered to exclude sunlight, but such a remedy is obviously inapplicable in the case of large reservoir of raw water.

(d) Turbid water prevents large penetration and thereby reduces algal population.

(e) Activated carbon reduces algal population by excluding sunlight but disappearance of activated carbon in the raw water may support algal growth again.

(B) Control Measures

Adequate records of number, kind and location of algae becomes handy for algal growth control. *Algaecide* dose used should be harmless to humans, have no effect on water quality, should be inexpensive and readily available and easy to apply. The most commonly used algaecides are copper, sulphate and chlorine/ bleaching powder.

CHLORINE TREATMENT

Chlorine treatment is relatively cheap, readily available and provides prolonged disinfecting action. Though chlorine is generally used for disinfecting potable water it can also be used as an algaecide. Pre-chlorination has specific toxic effect and it causes death and disintegration of some of the algae. It also assists in removal of algae by coagulation and sedimentation. It prevents growth of algae on basin walls and destroys slime organisms on filter sand thus prolonging filter and facilitating filter washing. ***Dosage :*** Effective chlorine dose should be such that sufficient chlorine is there to react with organic matter, ammonia, iron, manganese and other reducing substances in water and at the same time leave sufficient chlorine to act as algaecide. Dose required for this purpose may be over 5mg/l. With chlorine treatment essential oils present in algae as well as organic matter of dead algae are liberated this may lead to development of odour and color and taste. In such cases break point - chlorination is required. Post chlorination dose can be adjusted to obtain minimum 0.2mg/ L residual chlorine in potable water at consumer end.

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Method of Application :

Chlorine is preferably applied as a strong solution of chlorine from chlorinator. Slurry of bleaching powder can also be used. For algal growth control, generally, chlorine is administered at the entry of raw water before coagulant feeder.

4.2.2 Iron Removal Plants :

Two types of such plants are described below :

Compact type plant

The process comprises of :

(a) Spray aeration through a grid of pipes to flush out CO_2, H_2S and to improve pH level.

(b) Trickling of aerated water through a contact catalytic media viz., limestone of 20 mm size or a combination of MnO_2 (Manganese dioxide) and lime; or hard coke, $MnO_2$and limestone.

(c) Sedimentation.

(d) Filtration through Slow or Rapid Gravity Filter.

(e) Disinfection.

The structure consists of ordinary masonry or concrete. The aerator with contact media maybe placed at the top of the sedimentation tank. Sedimentation tank may be rectangular with a length to breadth ratio of 3:1. The detention time may be around 3-5 hours. The surface loading may be around 25 m^3/day / m^2. Filter media shall consist of sand with effective size 0.5-0.7 mm and a depth of 750-1000 mm over a 450-600 mm deep gravel 3 to 50 mm size.

Operation and Maintenance

1. The nozzles/orifices attached to the aeration pipe grid shall have their angles so adjusted as to ensure maximum aeration and to prevent loss of water. These nozzles/orifices shall require regular manual cleaning to remove incrusted iron. The residual iron deposits from inside the pipe grid shall be flushed out by opening end plugs or flanges. These operations should be repeated at least once in 2 months.
2. The limestone and other contact media require manual cleaning and washing at least once in 45-60 days.
3. The contact media bed should not remain exposed to sun for a long time to prevent hardening of bed by iron incrustation.
4. The sedimentation tank inlet baffle wall opening shall be cleaned of iron slime at least once in 45-60 days.
5. Sedimentation tank bed should be regularly scoured for removal of sludge.
6. Floc forming aid (coagulant aid) may be used for better coalescing and agglomeration.
7. The rapid gravity filter should have a water depth of about 1.2-1.5 m.
8. Since iron deposits create incrustation of filtering media, at least 100-150 mm of tops and layer of sand shall be scrapped and replenished with fresh sand at least once on 60 days. The whole bed may require replacement once in 2 years or so.
9. The characteristics of iron flocs are different from those of surface (river) water flocs. Due to the aeration process and contact of water with air, there may be incrustation of filter bed by residual oxidized deposits. To avoid this, common salt may be mixed with standing water and after 1-2 hours, the filter may be backwashed for better results and longevity of sand bed.

Package Type IRP (Iron removal plant)

The process incorporates the following steps :

(1) Dosing of sodium aluminates solution to the raw water pumping line, to raise pH up to the optimum level and to ensure subsequent coagulation, as it is an alkaline salt.

(2) Injection of compressed air for oxidation of dissolved iron.

(3) Thorough mixing of raw water, sodium aluminates and compressed air for proper dispersion in a mixing chamber of M.S. welded cylindrical shell equipped with one M.S perforated plate fitted inside through which the mixture flows upward.

(4) Passing the mixture through an oxidation chamber of M.S. shell, in which a catalytically media of MnO2 (Manganese dioxide) is sandwiched between two M.S. perforated circular plates. (Through which the mixture flows).

(5) Passing the above mixture in to a M.S. welded cylindrical shell type of filter in which dual media comprising of Anthracite Coal or high graded bituminous coal, 3-6 mm size, is placed at the top and finer sand of 0.5-1.00 mm size with 98% silica content is placed at the bottom, over a gravel supported bed. At the bottom is the under drainage system. Backwashing is done by air agitation followed by backwash with water.

(6) Disinfection.

Operation and Maintenance

(1) Sodium aluminates should be so mixed as to raise the pH up to 8.5-9.5.

(2) The quantity of compressed air should be so regulated as to achieve the optimum oxygen level.

(3) The MnO_2 (Manganese dioxide) may need replacement every 6-9 months.

(4) The inside of both the mixing chamber and oxidizing chamber should be coated with epoxy resin to avoid corrosion and incursion.

(5) The filtration rate should be controlled within a range of 100-125 lpm /m2.

(6) The inlet pipe at the top should be fitted with a cylindrical strainer to obviate the possibility of loss of anthracite coal during washing.

(7) After backwashing, rinsing of filtering media for at least 5 minutes has to be done to resettle the filtering media before normal functioning.

(8) Where the iron content is very high the whole media like MnO_2 (Manganese dioxide), anthracite coal, sand, gravel, strainers etc. require replacement and replenishment at least once a year for effective functioning and performance. The interior epoxy painting should also be done simultaneously.

4.2.3 Treatment technologies for removal of turbidity :

Turbidity in water is caused by any suspended matter which interferes with the clarity of the water. This may include clay or silt, algae and other organic or inorganic compounds. The BIS limit of turbidity for drinking purpose is 0-5 NTU. Due to unavoidable dependency on surface sources, Turbidity in hilly region is a huge concern. The prolonged monsoon season and erosion prone earth surfaces especially in young Himalayan mountains contributes to very high turbidity level to the extent of 400 NTU and beyond on most days of the rainy months. Supplying drinking water without treating the turbidity is rationally not possible. The sources of turbidity in drinking water include the following:

(a) Run off from disturbed or eroding catchment areas/watersheds

(b) Algae or aquatic weeds and products of their breakdown in water reservoirs, rivers or lakes.

(c) Humic acids and other organic compounds resulting from decay of plants, leaves etc. in water sources.

(d) High iron concentration which gives water a rust red coloration.

(e) Waste water discharge into drinking water sources.

Excessive turbidity in drinking water is not only unsightly, but also may be a health hazard :

(a) Turbidity can provide food for microbes, promoting their regrowth in the distribution system.

(b) Turbidity interferes with ion exchange and carbon adsorption processes, and may interfere with laboratory analysis of water quality.

(c) Disinfection by oxidants or UV is limited as colloid particles safeguard the micro organisms.

(d) Turbidity causing suspended particulate matter can absorb toxic substances, providing a medium to concentrate and transport these substances.

(e) Drinking water supply is jeopardized due to prolong settling time of suspended particles and use of excess alum during purification process.

The treatment processes for removal of turbidity involve the following:

1. **Pre-settling Tank or Desalting Tank :** Detention period of ½ hour to 3 hours and surface loading of 20 to 80 cum/sqm/day for removal of coarse and rapidly settling silt is recommended for the Pre-sedimentation tank. In hilly areas, where silt/debris carried in the surface sources is more all through during monsoon, provision of a pre-settling tank designed with the floor inclining from both the longitudinal ends towards the hopper shaped bottom located at 1/3d of the length from inlet with bleeding arrangement at one end of the hopper to

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allow continuous discharge of settled sediments and with inverted angled baffle wall near the inlet to break the velocity of the flow, is found to be efficient performance wise. It generally does not require workers to track through the tough terrain upto intake points to wash it. It works on gravity based self-cleansing system. The process helps in reducing erosion of pipe (raw mains) walls due to rolling pebbles as they are mostly sucked out along with other larger suspended particles and debris etc. and also thereby results in increased carrying capacity of water in the pipes with reduction of turbidity load.

2. **Chemical Treatment :-** The commonly used metal coagulants fall into two general categories; those based on aluminium and those based on iron. The aluminum coagulants include aluminum sulfate, aluminum chloride and sodium aluminate. The iron coagulants include ferric sulphate, ferrous sulphate, ferric chloride and ferric chloride sulphate. Other chemicals used as coagulants include hydrated lime and magnesium carbonate. Coagulation mostly happens in a rapid mixing tank for a few minutes. During coagulation, the coagulant (alum) is added to destabilize the surface charge of particles in order to promote the formation of micro flocs during the collision. The dose of coagulant varies from 5 to 40 mg/L depending on turbidity, colour, pH value of raw water etc.

3. **Flocculation :** - Flocculation is a process by which individual particles of clay aggregate into clot like masses or precipitate into small lumps. Flocculation occurs as a result of a chemical reaction between the clay particles and another substance, usually salt water. Flocculation unit can be independent of clarifier unit or can be combined as a clariflocculator unit.

4. **Settling :-** Sedimentation in water treatment system is used to reduce the concentration of particles in suspension before the application of coagulation to reduce the amount of coagulating chemicals needed or after coagulation and flocculation. When sedimentation is applied after coagulation, its purpose is usually to reduce the concentration of solids in suspension so that the subsequent filtration can function most effectively. The range of surface loading and detention period for average design flow for different types of sedimentation tank are as follows:

Sl. No.	Tank type	Surface loading (cum/sqm/ day)	Detention period (hour)	Particles normally removed
1	Plain sedimentation	15-30	3 – 4	Sand, silt and clay
2	Horizontal flow, Circular	30-40	2 - 2.5	Alum and iron floc
3	Vertical flow (up flow) Clarifiers	40 – 50	1 – 1.5	Flocculent

In order to enhance efficiency of settling tanks, tube settlers can also be used.

5. **Filtration :** There are primarily three types of filters. Slow sand filter, Rapid sand filter & Pressure filter. In order to enhance efficiency of these filters mainly slow sand filter, a horizontal roughing filter can also be employed in high turbid water.

Slow sand filter has filter bed consisting of natural sand of effective size of 0.25 to 0.35 mm with uniform coefficient of 3 to 5. The depth of initial sand bed should be about 1 meter. Below the sand bed, 3-4 layers of gravels of about 30 cm is provided. The depth of supernatant water should be about 1 meter. The washing of filter is done through scrapping of top layer of about 15-20 cm and replacing it. The SSF operates on gravity with a rate of filtration of about 100 to 250 L/SqM/Hr.

The Rapid sand filter has sand grains of 0.4 to 07 mm placed upto a bed depth of 1 mtr. The sand bed rests on a graded gravel layer of about 30-40 cm. The depth of water over the sand bed is 1-1.5 mtr. The filtration rate of RSF is 4800 to 6000 L/SqM/Hr. The filter is washed through back wash system operated on electricity or DG set or even on solar power.

6. **Pressure Filter :**

In Pressure filters, water is passed through a cylindrical shaped tank made of cast iron or steel or FRP (Fibre reinforced Plastic) etc under pressure through gravity or using pump. Filter media like katalox, purolite, activated carbon, gravel, sand and anthracite etc are used. The pressure filters are usually engaged for smaller capacities. Since, it is a ready-to-install system; therefore, it is less time consuming for commissioning. Multiport valve-based backwash system is present in pressure filter to keep the filter media active.

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Most important cleaning operation of pressure filter is backwash. The backwash reverses water flow, lifts up and flushes the media expelling dirty water via a dedicated waste line upstream to the system. It can be carried out by rotating the multiport valve in certain direction and fixing it. To assist in cleaning the bed, the backwash operation is sometimes preceded by scouring by way of agitation through the under-drain system. The air scouring agitates sand with a scrubbing action, which loses intercepted particles. After this operation the filter is ready to put back into services. Filter media must be periodically replaced because of their saturation. Back wash operations are often automated; particular attention should be paid in backwash water and its recirculation in wastewater plant. Valves, PLC, pipes, pumps, etc. require normal maintenance.

Table 4.1 : Details of pressure filter media and the O & M schedule

Sl. No.	Particulars	Content
1	Absorbent media - Katalox, Purolite (MZ10 Plus)	1. Removal of Iron, Manganese, Hydrogen Sulphide, Turbidity, Suspended Solids 2. Balancing of PH
2	Absorbent Resins	1. Removal of Alkaline, Iron, Manganese
3	Activated Carbon	1. Removal of chlorine, foul smell, turbidity 2. Improves taste & colour
4	Replacement of media	After 5 years (45% of the volume of the FRP Vessel)
5	Backwashing	1. Depends on the turbidity/iron/other suspended solids 2. Backwashing to be carried out until we get clear water through the backwashing channel 3. Frequent Backwashing to be done during monsoon season 4. Backwashing time may vary from 20 - 40 minutes for FRP (10"x54" to 24'x72") and from 40 - 90 minutes for FRP (30"x72" to 48"x72")
6	For High Iron Content areas	At times, recharging of absorbent medias to be done by using chlorine dosing system for proper functioning and regeneration of media (quality)

7. Roughing Filter

Roughing filters; vertical (upward & downward) and horizontal roughing filters are employed to effectively separate fine solid particles. They are usually placed at the treatment plant site and operated in combination with other pre-treatment units such as sedimentation tank. Roughing filters precede final treatment processes, such as slow sand filtration and chlorination.

4.3 Lamella Clarifier Filter :

In a simple term, a LAMELLA is a gravity type separator with a series of parallel, shallow, straight line settling channels. The plates forming channels present a multiple of available settling area for a given water surface area.

The Lamella Separator provides a means of water clarification at a large saving of plant surface area. The separator consists of a series of inclined overlapping plates, which are arranged to form a separate sedimentation chamber or the cells between each pair of adjacent plates. The overlapping additive projected area of the several plate is a factor of increased surface settling area proportioned to the number of plates used. Inlet flow is divided and allowed to enter the lower part of each sedimentation cell from its two opposite sides. As the water is displaced upward in smooth, gentle flow, suspended solids coalesce to form precipitates which settle out in the cells on the lower portion of each lamella plate. Influent water flows upwards over the plates. Deposited precipitates grows in size until they slide or roll down the incline and are deposited in the hopper at bottom of the separator. Near top of each plate, water leaves each cell through a pair of circular openings in the adjustable weir plate located along each side of separator tank. The weir plate should be set horizontally to provide a design water level below top of the tank.

4.3.1 Operation of Lamella Filter :

A Flash mix and Flocculation Tank is provided which is divided internally into two compartments. Water to be treated is fed to the bottom of the flash mix compartment where it is intimately mixed with chemicals. The partition plate, dividing the tank compartments, allows water to pass over to the flocculation compartment. In this compartment, formation of flocs continues and flocculation is completed. Water containing the floc, passes into the lamella separator. The flow is divided after it enters the lamella, to enter the lower part of each sedimentation cell from its two opposite sides. As the water moves upward

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along the plate, suspended solids coalesce to form precipitates which settles at the bottom of the lamella plate. The clarified water then flows to the top of the plates, over the adjustable weird outlet to the outlet of the clarifier. The deposited precipitates slides into the hopper bottom of the lamella clarifier.

4.3.2 Maintenance of lamella filter :

The Lamella plate should be removed for cleaning periodically. The frequency depends on specific application and should be determined by operating experience. Any deposits present are then removed by appropriate methods depending upon the type of deposit. A relatively inclined clean surface increase ease with which settled precipitates slide or roll down the plates to the collection hopper. Plates are removed from their slots by lifting the above. Three or four plates can be removed at a time for cleaning, while in service, allowing separator operation to continue uninterrupted. Draining of the lamella should be avoided if possible until the plates are removed.

The FRP plates associated with lamella should not be installed until the unit is filled with the water. FRP is a flammable material (in various degrees depending upon the resin used) and therefore, care must be taken against accidental ignition. This is especially true before plates are installed in the unit or when the unit is drained for more than twenty four hours, removal of plates is recommended. The liquid fill helps to support and wet the plates. Upon receipt of the lamella plates care should be given as to how they are handled, especially if they are constructed of FRP. They should not be thrown, stepped on, allowed to fall etc. Particularly the support channels are sensitive, since they are mechanically and chemically joined to flat plate. When the plates are installed in the unit, they should be slided down easily into the tank. Stepping on the plates once they are installed should be avoided. For the operators to walk on as per need basis, a wide board may be placed across the steel walls of the unit.

4.4. Disinfection :

Drinking water is disinfected to kill bacteria, viruses and parasites, which may exist in the water and may cause illness and disease like *Campylobacter, cholera, amoebic dysentery, Giardia* (beaver fever) and *Cryptosporidium*. These organisms usually get into drinking water supplies when source of waters such as lakes or streams, community water transmission pipes or storage reservoirs are contaminated by animal waste or human sewage. Generally deep wells are safer than shallow wells if chemical contamination is absent. In fact, shallow dug wells are often as contaminated as lakes or streams. The disinfection of potable water is almost universally accomplished by the use of gaseous chlorine or chlorine compounds. Chlorine is easy to apply, measure and control. It persists reasonably well and it is relatively inexpensive. Other methods of disinfection are also available viz. ozone, ultra-violet light, chlorine dioxide, silver ionization etc.

4.4.1. Chlorination :

The primary objectives of the chlorination process are disinfection, taste and odour control in the system, preventing the growth of algae and other micro-organisms that might interfere with coagulation and flocculation, keeping filter media free of slime growths and mud balls and preventing possible built up of anaerobic bacteria in the filter media, destroying hydrogen sulphide and controlling sulphurous taste and odour in the finished water, removing iron and manganese, bleaching of organic colour.

Dosage : Effective chlorine dose should be such that sufficient chlorine is there to react with organic matter, ammonia, iron, manganese and other reducing substances in water and at the same time leave sufficient chlorine to act as algaecide. Dose required for this purpose may be over 2mg/L. Post chlorination dose can be adjusted to obtain minimum 0.2 to 0.5 mg/l residual chlorine in potable water at consumer end.

Methods : Disinfection is carried out by applying chlorine or chlorine compounds. The methods of application are as follows :

1. Preparing weak solution by bleaching powder.
2. Preparing weak solution by electrolysing brine solution.
3. By adding chlorine either in the form of gas or solution prepared from dissolving chlorine gas in small feed of water.

   (a) Disinfection by Bleaching Powder Bleaching powder or calcium hypochlorite is a chlorinated lime, which contains about 25 to 34% of available chlorine by weight. Chlorine being a gas is unstable and as such it is mixed with lime to retain its strength for a longer period, as far as possible. The bleaching powder is hygroscopic in nature. It loses its chlorine strength rapidly due to poor storage and hence should not be stored for more than three months. The method of chlorination by bleaching powder is known as hypo-chlorination. The combined action of hypochlorous acid and hypochlorite ion brings about the disinfection of water.

Preparation of Solution :

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(1) The concentrated solution of bleaching powder is prepared in one or two tanks of *capacity* suitable for 24 hours requirement.

(2) The tank inside should be of glazed tiles or stoneware and should be covered.

(3) The powder is first put on a perforated slab placed longitudinally inside the tank at higher level, with respect to bed level of tank.

(4) Water is sprinkled on the powder through a perforated pipe above this perforated slab.

(5) The solution of bleaching powder & water now enters the tank. The solution isrotated for thorough mixing of powder with water by a hand driven/motor-reduction gear operated slow speed stirrer is now ready for use as disinfectant.

(6) The precipitates of calcium hydroxide settle at the bottom of the tank. The supernatant water, which contains OCl, Cl- plays the important role in disinfection.

(7) For effectiveness of chlorination, contact period of at least 4 hours shall be maintained.

Dosing of Solution :

The solution is discharged to a small measuring tank at a lower level through PVC pipe or any other material resistant to chlorine. The level of water in this tank is maintained constant through a float valve. A micrometer orifice valve discharges the solution at any pre-set rate, by adjustment on the scale fitted on it. The solution is dosed to the clear water channel by gravity at the time of entry to clear water reservoir. The dose has to be monitored properly, depending on the desired residual chlorine required in clear water reservoir. The waste precipitates at the bottom of tanks are taken out occasionally by scour valve.

Precautions :

1. The operating personnel should use hand gloves, aprons and other protective apparel, while handling and mixing.
2. The valves, stirrer, tanks, plumbing arrangements require renovation at every 6 months or so.

(b) Chlorination by Gaseous Chlorine Elemental chlorine at a normal pressure is a toxic, yellow green gas, and is liquid at high pressure. Chlorine gas is released from a liquid chlorine cylinder by a pressure reducing and flow control valve operating at a pressure less than atmospheric pressure. The gas is injected in the water supply pipe where highly pressurized water is passed through a venture creating vacuum that draws the chlorine in to the water stream. Adequate mixing and contact time must be provided after injection to ensure complete disinfection of pathogens. It may be necessary to control the PH of water. A basic system consists of chlorine cylinder mounted with vacuum regulator, chlorine gas injectors, and a contact tank or pipe. Prudence or state regulation would require that a second cylinder and gas regulator be provided with a change-over valve to ensure continuity of disinfection. Additional safety and control system may be required.

Chlorine is very effective for removing almost all pathogen and is appropriate for both a primary and secondary disinfectant. The limitation with this is, it is dangerous gas that is lethal at concentrations as low as 0.1 per cent air by volume.

4.4.2 Electro-chlorinator :

Chlorine is instantly produced by electrolyzing brine solution. Common salt is mixed with water to prepare brine solution. This solution is passed through an Electrolyser of electrodes comprising of anodes & cathodes, which are energised by D.C. current to produce Na OCl. This solution of sodium hypo chlorite is used as disinfectant.

The electro chlorinator set basically comprises of two compartments one comprising of Brine solution tank, electrolyser, cooler, etc. and the other comprising of compact panel board (rectifier). Normal life of electro-chlorinator is 12 years provided reconditioning of the electrodes at regular interval of four years is carried out. These chlorinators are available at various capacities ranging from 50 gm. /hr. to 18 kg/h of active chlorine production. The electrolyser consists of a number of electrodes as required. For 500 gm. /hr. capacity plant, there are 6 nos. of electrodes comprising of anodes and cathodes. The rectifier is having facilities for auto tripping if there is variation in certain set conditions.

4.4.3 Other Disinfectant :

The other chemical-based disinfectants generally in used are ionized silver coating, gaseous chlorine, ozone, Chloramines, potassium permanganate and hydrogen peroxide. A number of Commercially available alternative processes, such as membrane processes, are able to remove bacteria, viruses and protozoa as well as a range of chemical contaminants. These are coming into use but generally only on a small scale. It may be possible to operate these processes with no chemical disinfection or at least to reduce the amount of chemicals used for final disinfection. Alternatives to chemical disinfection, such as UV irradiation, are also being used for disinfection of drinking water. Such 'non-conventional' processes and disinfection methods could in principle be used to replace, or at least greatly reduce, the use of chemical disinfection of drinking water.

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CHAPTER-5

STORAGE OF WATER

The main function of Reservoirs and Service Reservoirs (SR) is to cater for daily demands and especially peak demands of water. Operator checks the amount of water in the storage reservoir and the corresponding water levels at particular times of the day. Procedures for operating the Service Reservoir will depend upon the design of its storage capacity and on the water demand.

5.1 Procedures for Operation of Service Reservoir (S.R.) :

Service Reservoirs have to be operated as per the design requirements. Generally, the service reservoirs are constructed at elevated place to supply water during periods of high-water demand and hence the SRs are filled in low water demand period. At times pumps may be used only for filling the SR before the next supply timing or can be used also during supply hours to maintain the levels in the SR. Normally, small changes in the distribution system such as pipeline extensions or the addition of few more connections will not require additional storage requirement. Major system changes such as addition of larger size of main pipelines and increase in large number of connections may require additional storage.

5.1.1 Operation of SRs during Abnormal Conditions :

Abnormal operating conditions arise:

(i) Whenever demand for water goes up suddenly due to fire demand, or due to excessive demand on one command area/zone of a system.

(ii) Due to failure or breakdown of water supply of another zone of the distribution system.

(iii) Breakdown or out of service pumps or pipelines or power breakdowns or out of service SRs.

The operator must have a thorough knowledge of the distribution system emanating from the SRs. Closure or adjustment of valves at strategic points in the distribution system can focus or divert the flow of water towards the affected areas. Emergency plans must be developed in advance to cope with such situations.

5.1.2 Storage Level & Capacity :

Most of the distribution systems establish a pattern of levels for assuring the required supplies at the required pressures. The maximum water levels to be maintained in the SR at each morning should be known to ensure that the system demands are met for the day. It is also desirable to have an indication of levels of SR in the pump house. Usually water levels are read at the same time each day and the readings recorded. Checks of water levels at other times of the day will enable to determine if any unusual consumption conditions have occurred. If any significant increase in consumption is anticipated the operations should ensure a corresponding increase in supply into the SR.

In case of intermittent supply, timings for supply of water in the areas are fixed in advance in large command areas. The water can be supplied to sub-zones during particular fixed hours by operation of the necessary valves. Routine valve operations are normally done at the SRs. Problems in operation of valves in SRs can also be caused by valve seat getting jammed, and hence cannot be opened, or non-seating of valves, and hence cannot be closed properly. Sometimes two valves are fixed in series on the outlet and the downstream valve only is usually operated. Whenever the valve under operation is jammed the upstream valve is closed and the jammed valve is repaired. Such an arrangement enables repair of valves without emptying the SR.

In some SRs a bypass line is provided direct from the inlet line to the outlet line for drawing water without feeding the SR. Identification of the valves as to their intended purpose such as inlet, outlet, scour, bye-pass etc. and their direction of opening are to be prominently marked. The operator/manager shall ensure that all valves in a SR are in good working condition and are operated as per the schedule for such operation

5.1.3 Water Quality at SR :

Water from all SRs should be periodically sampled to determine the quality of water that enters and leaves the SR. Sampling data can help in setting up periodic cleaning of SR. Common cause of physical water quality problems includes collection of sediment, rust and chemical precipitates. Water quality in a SR may also deteriorate due to excessively long periods of stagnant conditions. Whenever seasonal demand rises, residual chlorine has to be maintained properly.

5.2 Plans for O&M of Service Reservoir :

The plan for O&M of the service reservoirs shall contain operational procedures, maintenance procedures and the manufacturer's information in respect of the instruments/gauges.

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5.2.1 Procedures for Operations :

The operational procedures inter-alia will contain:

(i) Information of design details for the reservoir such as: capacity in liters, size and depth of storage; size of piping/locations of control valves of inlet, outlet, scour and overflow; source of feeding the reservoir; hours of pumping or gravity feeding into the reservoir; rate of flow into the reservoir; hours of supply from the reservoir and quantity to be supplied from the reservoir; areas to be served/ supplied; highest and lowest elevations to be commanded from the SR and the water levels to be maintained in the SR for command of the entire area.

(ii) Key plan showing the alignment of pipe connections, by pass lines, interconnections and location of valves, flow meters, pressure gauges and alignment of out-fall drain to lead off the scour and overflow water from the reservoir.

(iii) Step by step operating instructions indicating how to operate and control various valves located on the inlets and outlets, so as to ensure the required quantity of water is supplied to the command areas at the desired pressures during the period required to be displayed.

(iv) A record sheet for each valve showing direction for turning, number of turns, inspections, repairs and whether opens or closed. The direction of operation of valves shall be clearly marked as "open" or "close".

(v) The name of the valve and piping such as washout, inlet, outlet, by pass, overflow etc. shall be painted clearly and repainted regularly. In the case of mechanized operation of valves, the steps to include starting, running and stopping the operations.

5.2.2 Maintenance of Service Reservoirs :

(i) Service Reservoirs (SRs) have to be inspected regularly and the line department can prescribe frequency of inspections.

(ii) Leakage from structure of SR and through the pipes and valves has to be attended to on priority. It is advisable to resort to pressure grouting to arrest leaks from structures and sometimes an additional coating of cement mortar plastering is also done using water proof compound to arrest leaks from the structure.

(iii) Maintenance is concerned with mainly protection against corrosion both externally and internally. Corrosion of roof slab of RCC reservoirs due to the effect of chlorine is also common. Internal corrosion is prevented by cleaning and painting at regular intervals. Quite Toxic paints should not be used for painting interior surface of SRs. food grade epoxy painted shall only be used for internal surface of SRs. Anticorrosive painting (epoxy) is also done to the interiors when corrosion due to chlorine is expected. Painting of steel tanks once in a year and external painting with waterproof cement paint for exteriors of RCC Tanks once in 5 years is usually done. The inside of painted SR shall be disinfected before putting into use for a period sufficient to give chlorine residuals of at least 0.2 mg/l. Manhole covers & vent pipes shall always be properly placed and maintained

(iv) The maintenance procedures shall include step by step procedure for every piece of equipment in SRs such as pipes inside the tank (In-let, out-let, wash-out, over-flow) valves, specials and flow meters following the procedures as per the manufacturers' catalogues.

(a) Pipes (In-let, out-let, wash-out, over-flow) and specials

(i) All the pipe fittings should be leak proof, any leakage nearby reservoir may affect the safety of reservoir.

(ii) Overflow pipe should be connected with the distribution system after the sluice valve installed on delivery pipeline.

(b) Valves

All valves should be inspected regularly in specified frequency of inspection and following activities shall be undertaken.

(i) Lubrication is required to be done regularly.

(ii) Spindles that develop leaks should be repacked.

(iii) Rust and sediment in the valve is removed by shutting the disc hard in the seat, then opening about a quarter way and closing tightly several times; the increased velocity usually flushes the obstructions away.

(iv) Valve chambers of the SR also require maintenance to ensure that the interiors of chambers are not silted up and also ensure that the covers are in good condition and are in position.

(v) Sluice valve chamber shall not be water logged.

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(c) CLEANING OF RESERVOIRS

Routine inspection is the best way to determine when a tank requires maintenance and cleaning. A visual inspection can be made from the roof manhole with water level lowered to about half full or less. Alternatively, a detailed inspection can be made after draining the tank and then cleaning or washing. Best time of the year to take up cleaning of SRs is during the period of lowest water consumption.

The following activities are normally involved in cleaning of a tank/SR:

(i) Make alternate arrangement for water supply to consumers served by the SR.

(ii) Close the inlet line before commencing cleaning of SR.

(iii) Do not empty S.R. and always keep minimum water level at 200-300 mm in the SR.

(iv) Close the outlet valve so that no water will be used while the tank is being cleaned.

(v) Drain and dispose of the remaining water and silt.

(vi) Wash the interior of tank walls and floor with water hose and brushes.

(vii) Inspect the interior of walls and ceiling of tank for signs of peeling off or deterioration.

(viii) Apply disinfectant (Supernatant of Bleaching powder) to the walls and floor before start of filling the tank/SR.

(ix) The higher frequency of cleaning of SR depends on the extent of silting, development of bio films and results from water quality monitoring. Generally cleaning of Service Reservoir may be periodically done.

5.3 Record System :

A record system has to be developed which should be realistic and apply to the operating problems involved at the particular SR site. The most efficient way to keep records is to plan what data is essential and then prepare the formats followed by the persons to fill the data, frequency and to whom the record is to be sent for review and report. Sample records to be maintained at a SR site are given below for guidance.

The following details shall be recorded:

5.3.1 Records of Maintenance :

The records on each of the following maintenance/repair works along with the cost of materials and labour shall be maintained along with date

(i) Water levels.

(ii) Time and relevant operation of control valves with time of opening and closure or throttling position of the valves.

(iii) Daily flow meter readings both on the inlets and outlets.

(iv) At least once a day Residual chlorine readings of inflow water and outflow water.

(v) Gland ropes of the valves/Spares at the SR were changed.

(vi) Manhole covers were changed/replaced.

(vii) Water level indicator was repaired or replaced.

(viii) Reservoir was cleaned.

(ix) Out-fall drain for scour and overflow was last cleaned.

(x) Ladder was changed, when the structure of the reservoir was last repaired to attend to structural defects or arrest leakage.

(xi) Reservoir/Pips was last painted

(xii) Total cost of repairs and replacements at the SR in previous year along with breakup of material cost and labor cost with amount spent on outside agencies for repairs and replacements.

5.4 Zincalume Tank :

One of the new tanks that have been used in drinking water schemes is Zincalume steel water storage tanks. They are manufactured from steel sheet which has been continuously coated with zinc and aluminium. Aluminium in the coating provides barrier protection to the steel while the zinc element provides sacrificial cut edge protection.

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5.4.1 Operation & Maintenance of Zincalume tank :

- Periodic maintenance of liner
  1. Cleaning with utmost care, no acidic/high potent alkaline to be used.
  2. Sediment/Foreign particles deposit to be removed.
  3. Placement of ladder inside the groove of Tank has to be done with utmost care.
  4. Any leakages of liner should be rewarded with the same quality (GSM) liner by professionals
- Periodic maintenance of inlet/outlet Flange
  (1) Leakage check should be done to ascertain the cause which may be mainly due to the improper clamping of the inlet/outlet pipe
- Periodic inspection of Level Gauge
  (1) During cleaning or other work near the tank/ESR, the level gauge should not be disturbed. In case there is any intervention, the weight and the connected GI rope should be checked.
- Periodic check of quality of GI/Aluminium Materials installed.
  1. GI Nut & Bolt – rusted ones to be replaced.
  2. Aluminium/GI Ladder - rusted ones to be replaced.
  3. GI L-Clamp - rusted ones to be replaced.
  4. Aluminium Manway - rusted ones to be replaced.
  5. GI Truss & Top Angle - rusted ones to be replaced.
  6. GI/Aluminium Level Gauge Assembly – rusted one to be replaced.

5.5 Glass Reinforced Plastic (GRP) Tank :

GRP Water tanks, or Glass Reinforced Plastic water tanks, are now the leading standard water containment unit currently found on the market. Given their lightweight, sturdy yet workable fibreglass design, GRP tanks provide safe storage for water without the risk of corrosion or contamination from bacteria. Furthermore, given the materials the water tanks are made from, they are also resistant to external temperatures and adverse weather, meaning the tanks will not degrade over time. These materials also make the water tanks pliable, meaning they can be adapted at the manufacturing level for any specific access or locational needs.

Given the materials they are inherently made of, GRP water tanks are fully customisable units; they can be manufactured to almost any shape and size, depending on the consumer's requirements. With pre-insulated GRP Tanks, the water can be kept within a maintained temperature margin, meaning this microbiological growth can be prevented at source. Insulation can be provided at a variety of thicknesses depending on the needs of the consumer, but generally it ranges from around 25 – 100mm of insulation.

5.5.1 O & M of GRP Tanks :

GRP tanks are claimed to be zero maintenance water storage tanks. The reasons given for the claim are as follows:

- Made with composite materials GRP (Glass Reinforced Polymer) a mixture of unsaturated Polyester Resin with impregnating augmentation materials and Glass Fibre which results no decay in materials, no algae or bacteria formation.
- Due to external supporting Structure, No Metal parts are in touch with water, so No corrosion and gives more life.
- Due to Convex type mirror finish Bottom panel and Concave type Mirror finish drain panel, impurities coming with water easily drained out from panel, requirement of cleaning is in longer duration.

CHAPTER-6

DISTRIBUTION SYSTEM

The overall objective of a distribution system is to deliver safe drinking water to the consumer a adequate residual pressure in sufficient quantity at convenient points and achieve continuity and maximum coverage at affordable cost. Normally, the operations are intended to maintain the required supply and pressure throughout the distribution system. Critical points are selected in a given distribution system for monitoring of pressures by installation of pressure recorders and gauges.

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6.1 Issues Causing Problems in the Distribution System :

(A) Intermittent System

The distribution system is usually designed as a continuous system but often operated as an intermittent system in rural areas. Intermittent supply creates doubts in the minds of the consumer's about the reliability of water supply. During the supply period the water is stored in all sorts of vessels for use in non-supply hours, which might contaminate the water. Often, when the supply is resumed, the stored water is wasted and fresh water again stored. During non-supply hours polluted water may enter the supply mains through leaking joints and pollute the supplies. Further, this practice prompts the consumers to always keep open the taps of both public stand posts and house connections leading to wastage of water whenever the supply is resumed. Intermittent systems and systems which require frequent valve operations are likely to affect equitable distribution of water mostly due to operator negligence.

(b) Non-Availability of Required Quantity of Water Failure of source or failure of power supply may cause reduced supplies. Normally, the distribution affected reservoirs are designed for filling in about 8 hours of pumping and whenever the power supply is the pumping hours are reduced and hence the distribution reservoirs are not filled up leading to reduced supply hours and hence reduced quantity of water.

(c) Low Pressure at Supply Point Normally peak demand is considered ranging from 2 to 3, whereas the water supply is given only for a different duration, leading to large peak factors and hence affecting the pressures in the distribution system. This is a common with most water supply systems.

(d) Leakage of Water Large quantity of water is wasted through leaking pipes, joints, valves and fittings of the distribution systems either due to bad quality of materials used, poor workmanship, and corrosion, age of the installations or through vandalism. This leads to reduced supply, loss of pressure and deterioration in water quality.

Maintenance of appropriate positive pressure at all times to all consumers is the main concern of O &M. Negative pressure can cause contamination of water and very high pressure damages the pipelines. Low pressure may be avoided by taking the following steps.

(a) Purposefully or accidently a line valve is left closed or partly closed or blockage due to any material causing loss of pressure.

(b) Too high velocities in small pipelines

(c) Low water level in S.R.

(d) Failure of pumps/Booster pumps (either due to power failure or mechanical failure) feeding the system directly.

(e) Unauthorized Connections Illegally connected users will contribute to the reduction in service level to authorized users/ consumers and deterioration of quality of water. Sometimes, even legally connected users draw water by sucking through motors causing reduction in pressures

(f) Extension of Service Area

(g) Due to extension of service area without corresponding extension of distribution mains, the length of house connections will be too long leading to reduction in pressures.

(h) Age of the System With age there is considerable reduction in carrying capacity of the pipelines due to incrustation, particularly unlined CI, MS and GI pipes. In most of the places the consumer pipes get corroded and leaks occur resulting in loss of water reduced pressure and pollution of supplies

(i) Lack of Records Record of replacement of fittings/pipes/valves, scouring of entire distribution system, system maps, designs of the network and reservoirs and historic records of the equipment installed in the distribution system are often not available, whereas some minimum information is required to operate and maintain the system efficiently.

6.2 Operational Schedule :

6.2.1 Mapping and Inventory of Pipes and Fittings in the Water Supply System :

Availability of updated distribution system maps with contours, location of valves, flow meters and pressure gauges or taping points is the first requirement for preparation of operation schedule. The agency should set up routine procedures for preparing and updating the maps and inventory of pipes, valves and consumer connections. The maps shall be exchanged with other public utilities to contain information on other utility services like electricity, communications etc.

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6.2.2 Field Survey :

Existing maps are used or conventional survey is employed for preparation and up-dating of maps. As an alternative to traditional survey and map preparation, 'total station method' is gaining popularity. Total station instruments can be used for survey and mapping of villages where data is not readily available.

6.2.3 Routine Operations of the Water Supply Distribution System :

The efficiency and effectiveness of a water supply system depends on the operating personnel's knowledge of the variables that affect the continuity, reliability, and quantity of water supplied to consumers. The operational staff should be able to carry out changes in the hydraulic status of the system as required depending on those variables promptly and effectively. Routine operations shall be specified which are activities for adjusting the valves and operation of contain procedures for operating the distribution system. It should contain procedures to obtain, process, and analyse the variables related to water flows, pressures and levels as well as the consequences of manipulating control devices, such as operation of valves and or pumps so that the hydraulic status of the system can match the demand for water. When operators change their shifts, information on valve closure and opening must be exchanged.

6.2.4 Operations in Break Downs and Emergencies :

Operations other than routine viz. during breakdowns and emergencies have to be specified and should be carried out in specific circumstances when normal conditions change i.e. when flows, pressures and levels and operation of pumps change

6.2.5 Measurement of Flows, Pressures and Levels :

It will be necessary to monitor regularly operational data concerning flows, pressures and levels to assess whether the system is functioning as per requirements. Analysis of data may reveal over drawl of water to some reservoirs and or bulk consumers. At such places appropriate flow control devices may be introduced to limit the supplies to the required quantity. A list of priority points in water supply system have to be identified such as installation of meters to measure flows, pressures and levels. A detailed map showing location or each measuring point has also to be prepared. The degree of sophistication of the devices used at each measuring point with regard to indication, integration, recording, transmission and reception of data depends mainly on the skills of the O&M personnel available with the agency and affordability of the agency.

6.2.6 Sampling for Quality of Water :

The agency operating the water supply system is charged with the primary responsibility of ensuring that the water supplied to the consumer is of an appropriate quality. To achieve this objective it is necessary that the physical, chemical and bacteriological tests are carried out at frequent intervals. Samples should be taken at different points on each occasion to enable overall assessment. In the event of epidemic or danger of pollution more frequent sampling may be required, especially for bacteriological quality. For each distribution system a monitoring programme has to be prepared showing the location of sampling points. Based on historic records of a system it will be possible for the manager of the system to decide locations for bacteriological sampling and residual chlorine testing.

6.3 Management in Times of Water Shortage :

The objective of developing a programme for managing in times of shortage of water is to reduce the excessive use of water particularly when the source is limited due to adverse seasonal conditions. Basically, it involves that a water conservation policy is developed and implemented among water consumers. The following activities can be considered while formulating such a water management project:

(a) Enforcement of restrictions on use of treated water for watering lawns, cooling, construction, washing of vehicles etc.

(b) Encouragement and/or enforcement of the reuse of treated industrial effluents and wastewater.

(c) Development and implementation of public education programmes to encourage water conservation.

6.4 System Surveillance :

Surveillance of distribution system is done to detect and correct.

(a) Sanitary hazards.

(b) Deterioration of distribution system facilities, [to detect].

(c) Encroachment of distribution system facilities by other utilities such as sewer and storm water lines, power cables, telecom cables etc. And

(d) Damages of the system facilities by vandalism. [Detecting and correcting].

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6.5 Leakage Control :

Wastage of water in the system and distribution network occurs by way of leakage from pipes, joints & fittings, reservoirs and overflow from reservoirs & sumps. The objective of leakage control programme is to reduce the wastage to a minimum and minimize the time that elapses between the occurrence of a leak and its repair. The volume of water lost through each leak should be reduced by taking whatever action is technically and economically feasible to ensure that the leak repaired as quickly as possible. To achieve this, the organization shall prescribe procedures for identifying, reporting, repairing and accounting for all visible leaks. It will be beneficial for the agency if the procedures involve the conscious and active participation of the population served by the agency apart from its own staff. The Management has to process the data and evaluate the work on detection and location of leaks and for dissemination of the results and initiate actions to control the overall problem of water loss. Interim measures for reduction/control of leakage can be initiated by controlling pressures in the water distribution system where feasible.

6.5.1 Leakage through House Connections :

Leakage can be controlled at the point of house connection and in the consumer pipe by adopting correct plumbing practices and improving the methods used for tapping the main and giving house connection and strict quality control on the pipe material used for house connection. An analysis of leaks in house connections and investigation of reasons for leaks in the house connections shall be carried out to initiate action on reducing the leakage through house connections.

6.5.2 Procedures for reporting Visible Leaks :

The water supply agency has to establish procedures whereby the population served by the agency can notifies the visible leaks. The agency staff can also report visible leaks found by them while carrying out other works on the water supply system. Critical areas where leaks often occur have to be identified and appropriate corrective measures have to be implemented.

6.6 Cross Connections :

Contaminated water through cross connections of water supply lines with sewers and drains is a problem prevailing widely. Intermittent supply further aggravates the problem since, during non-supply hours polluted water may reach the supply mains through leaking joints, thus polluting the supplies. In certain instances, when there are extremely high water demands, the pressures in the supply mains are likely to fall below atmospheric pressure, particularly when consumers start use of pumps with direct suction from supply mains. Regular survey has to be undertaken to identify potential areas likely to be affected by cross connections and back-flow. All field personnel should be constantly alert for situations where cross connections are likely to exist. After identifying the cross connections, remedial measures are taken up which include: providing horizontal and vertical separation between the water main and the sewer/drain, providing a sleeve pipe to the consumer pipes crossing a drain, modifying the piping including changing corroded piping with non-corrodible piping, providing double check/non return valves at the consumer end etc. The various types of material of pipe &specials are being used in distribution system, namely CI,GI, DI,MS,PVC, HDPE, GRP RCC, AC, etc. and specific requirement of maintenance are to be followed as per the CPHEEO Manual/ Manufacturer's recommendations.

6.7 Plumbing Practices for Drinking Water Supply :

The internal plumbing system of the consumer shall conform to the National Building Code and also particularly to the bye laws of concerned water utility/local authority. The various types of plumbing materials are being used, namely GI MDPE &PVC, etc. and require different maintenance practices. Hence specific requirement of maintenance are to be followed as per the CPHEEO Manual/ Manufacturer's recommendations

6.7.1 Quality of Pipe Material for House Connection :

PHED shall ensure that the connection pipe from the street main up to the consumer premises is laid as per correct plumbing practices and adopt improved methods for tapping the main. Strict quality control is required on the pipe material used for house connection.

6.7.2 Contamination through House Connection :

While laying the consumer connection pipes there are a need to avoid contamination of water supplies. This can be achieved by maintaining horizontal and vertical separation between the water supply communication pipe and the sewer/drain. In some instances, a sleeve pipe may be required to be provided to the consumer pipes crossing a drain. It is always recommended to provide a non-corrodible pipe material for the consumer connection. Contamination by possible back flow can also be prevented by ensuring provision of double check/non-return valves at the consumer end.

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6.7.3 Rules for Consumer Connections :

In case of urban towns, new connections to the consumers shall be governed by 'The Arunachal Pradesh Water Supply Act, 2015' passed by the State Govt. whereas, in the rural areas, the responsibility shall rest with the VWSC.

6.8 Chlorine Residual Testing at Consumer End :

A minimum chlorine residual of about 0.2 -0.5mg/l at the selected monitoring point/ consumer's end is often maintained to ensure that even a little contamination is destroyed by the chlorine. Hence, absence of residual chlorine could indicate potential presence of heavy contamination. If routine checks at a monitoring point are carried out, required chlorine residuals and any sudden absence of residual chlorine should alert the operating staff to take up prompt investigation. Immediate steps to be taken are:

(a) Re-testing for residual chlorine,

(b) Checking chlorination equipment,

(c) Searching for source of contamination, which has caused the increased chlorine demand, and

(d) Immediate stoppage of supplies from the contaminated pipelines.

CHAPTER-7

PUMPING MACHINERY

7.1 Introduction

Pumping machinery and pumping station are very important components in water Supply system. Pumping machinery is subjected to wear, tear, erosion and corrosion due to their nature of functioning and therefore is vulnerable for failures. Generally, a greater number of failures or interruptions in water supply are attributed to pumping machinery than any other component. Therefore, correct operation and timely maintenance and upkeep of pumping stations and pumping machinery are of vital importance to ensure uninterrupted water supply. Sudden failures can be avoided by timely inspection, follow up actions on observations of inspection and planned periodical maintenance. Downtime can be reduced by maintaining inventory of fast-moving spare parts. Efficiency of pumping machinery reduces due to normal wear and tear. Timely action for restoration of efficiency can keep energy bill within reasonable optimum limit. In case there is no standby pump provision, suitable water pumps identical duty condition shall be provided 100% standby in case of single pump set, and two or more pumps with 50% standby along with all necessary accessories like cables, control panels, safety equipment, valves and fittings etc. Providing 50% standby pump set will help in operating the schemes in initial stage until stabilization is achieved.

In case of depletion of sources during summer/ monsoon failure, the schemes can be operated partially without throttling of pumps. While replacement of motors/ pumps is done, it may be insisted to provide star rated motors to have energy savings. Generally, as the pumps are scheme specific, (i.e. Discharge & head fixed depending upon the requirement) the question of standardization with regard to minimizing the inventory does not arise. To ensure better performance/ for effective cost savings energy audit and water audit need to be done for every scheme. Annual monitoring of handed over schemes must be done by the department who executed the scheme. Proper record keeping is also very important. A log book should be maintained covering the following items.

(i) Timings 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 hours duration, and

(xi) Any specific problem or event in the pumping installation or pumping system e.g. burst in pipeline, tripping or fault, power failure.

7.2 Components in Pumping Stations :

The components in pumping station can be grouped as follows.

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(i) Pumping machinery

(a) Pumps and other mechanical equipment, i.e. valves, pipe work, vacuum pumps Motors, switchgears, cable, transformer and other electrical accessories

(ii) Ancillary Equipment

(a) Lifting equipment

(b) Water hammer control device

(c) Flow meter

(d) Diesel generating set

(iii) Pumping station

(a) Sump/intake/well/tube well/bore well

(b) Pump house

(c) Screen

(d) Penstock/gate

7.2.1 Type of Pumps :

Following types of pumps are used in water supply systems:

(a) Centrifugal pumps

(b) Vertical turbine pumps

(c) Oil lubricated

(d) Self-water (pumped water) lubricated

(e) Clear water lubricated

(f) Submersible pumps

(g) Vertical bore well type pump-motor set

(h) Mono bloc open well type pump-motor set

(i) Jet pumps

(j) Reciprocating pumps

7.2.2 Important Points for Operation of the Pumps :

Various types of pumps are in use and the specification of O&M schedule provided by manufacturers shall be followed. However, the following points shall be observed while operating the pumps :

(a) Dry running of the pumps should be avoided.

(b) Centrifugal pumps have to be primed before starting.

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

(i) If pump is operated at point away from duty point, the pump efficiency normally reduces.

(ii) Operation near the shut off should be avoided, as the operation near the shut off causes substantial recirculation within the pump, resulting in overheating of water in the casing and consequently, overheating of the pump.

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

(e) Whether the delivery valve should be opened or closed at the time of starting should be decided by examining shape of the power-discharge characteristic of the pump. Pump of low and medium specific speeds draw lesser power at shut off head and power required increases from shut off to normal operating point. Hence in order to reduce starting load on motor, a pump of low or medium specific speed is started against closed delivery valve. Normally the pumps used in water supply schemes are of low and medium specific speeds. Hence, such pumps need to be started against closed delivery valve. The pumps of high specific speed draw more power at shut off. Such pumps should be started with the delivery valve open.

(f) The delivery valve should be operated gradually to avoid sudden change in flow velocity which can cause water hammer pressures. It is also necessary to control opening of delivery valve during pipeline - filling period so that the head on the pump is within its operating range to avoid operation on low head and consequent overloading. This is particularly important during charging of the pumping main initially or after shutdown. As head increases the valve shall be gradually opened.

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

(h) When the pumps are to be operated in series, they should be started and stopped sequentially, but with minimum time lag. Any pump, next in sequence should be started immediately after the delivery valve of the previous pump is even partly opened. Due care should be taken to keep the air vent of the pump next in sequence open, before starting that pump.

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

(j) The running of the duty pumps and the standby should be scheduled so that no pump remains idle for long period and all pumps are in ready-to run condition. Similarly unequal running should be ensured so that all pumps do not wear equally and become due for overhaul simultaneously. If any undue vibration or noise is noticed, the pump should be stopped immediately and cause for vibration or noise be checked and rectified.

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

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

Additional Points for Operation of the Pumps

(a) Submersible pumps :

(a) Correct rotations

(b) Pump is below static water level before starting, and continues to be below draw down level throughout the operation.

(b) Centrifugal pumps :

(a) Correct rotations

(b) Pump is properly primed before starting if pump suction is negative.

(c) Vertical turbine pumps :

(a) Pumps properly primed before starting

(b) Air vent to be fully opened before starting

(c) Correct rotation of pump.

(d) Pump should not be operated, if ratchet pins are missing

(e) Bowl assembly is completely submerged

(d) Inventory of materials for pumps

(a) Submersible pumps: Impellers

(b) Centrifugal pumps: Impellers, diffusers, bearings, gland packing's

(c) Vertical turbine pumps: thrust bearings, gland packing, head shaft, intermediate shaft, bearing spider, bowl assemble, impeller etc.

(d) Motors: Bearings

(e) MCC: Relay, tripping circuit, fuses.

(f) Transformer : Oil

7.2.2.1 Undesirable Operations :

Following undesirable operations should be avoided :

(1) Operation at Higher Head-The pump should never be operated at head higher than maximum recommended. Such operation results in excessive recirculation in the pump, overheating of the water and the pump. Another problem, which arises if pump is operated at a head higher than the recommended maximum head, is that the radial reaction on the pump shaft increases causing excessive unbalanced forces on the shaft which may cause failure of the pump shaft. As a useful guide, appropriate marking on pressure gauge be made. Such operation is also inefficient as efficiency at higher head is normally low.

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(2) Operation at Lower Head-If pump is operated at lower head than recommended minimum head, radial reaction on the pump shaft increases causing excessive unbalanced forces on shaft which may cause failure of the pump shaft. As useful guide, appropriate markings on both pressure gauge and ammeter are made. Such operation is also inefficient as efficiency at lower head is normally low.

(3) Operation on Higher Suction Lift-If pump is operated on higher suction lift than permissible value, pressure at the eye of impeller and suction side falls below vapour pressure. This results in flashing of water into vapour. These vapour bubbles during passage collapse resulting in cavitations in the pump, pitting on suction side of impeller and casing and excessive vibrations. In addition to mechanical damage due to pitting, discharge of the pump also reduces drastically.

(4) Throttled operation-At times if motor is continuously overloaded, the delivery valve is throttled to increase head on the pump and reduce power drawn from motor. Such operation results in inefficient running as energy is wasted in throttling. In such cases, it is preferable to reduce diameter of impeller which will reduce power drawn from motor. Installation of variable voltage &variable frequency (VVVF) drive as a remedial measure is recommended

(5) Operation with Strainer/Foot Valve Clogged-If the strainer or foot valve is clogged, the friction loss in strainer increases to high magnitude which may result in pressure at the eye of the impeller falling below water vapor pressure, causing cavitations' and pitting similar to operation on higher suction lift. The strainers and foot valves should be periodically cleaned particularly during monsoon.

(6) Operation with Occurrence of Vortices-If vibration continues even after taking all precautions, vortex may be the cause. All parameters necessary for vortex-free operation should be checked.

7.2.2.2 STARTING THE PUMPS :

Following points should be checked before starting the pump.

(a) Power is available in all 3 phases.

(b) All connections are properly thimble

(c) Trip circuit for relays is in healthy state\ Check voltage in all 3 phases.

(d) The voltage in all phases should be almost same and within + 10% of rated voltage, as per permissible voltage variation.

(f) Check functioning of lubrication system specifically for oil lubricated and clear water lubricated VT pumps and oil lubricated bearings

(g) Check stuffing box to ensure that it is packed properly.

(h) Check and ensure that the pump is free to rotate.

(i) Check over current setting if the pump is not operated for a week or longer period.

(j) Before starting it shall be ensured that the water level in the sump/intake is above low water level and inflow from the source or preceding pumping station is adequate.

7.2.2.3 Stopping the Pump :

(a) Stopping the Pump under Normal Condition

Steps to be followed for stopping a pump of low and medium specific speed are as follows:

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

(b) Stopping after Power Failure/Tripping

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

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eventuality, if the pumps start automatically on resumption of power supply, there will be sudden increase in flow velocity in the pumping main causing sudden rise in pressure due to water hammer which may prove disastrous to the pumping main. Secondly, due to sudden acceleration of flow in the pumping main from no-flow situation, acceleration head will be very high and the pumps shall operate near shut off region during acceleration period which may last for few minutes for long pumping main and cause overheating of the pump. Restarting of all pumps simultaneously shall also cause overloading of electrical system. Hence, precautions are necessary to prevent auto-restarting on resumption on power.

Following procedure should be followed.

(a) Close all delivery valves on delivery piping of pumps if necessary, manually as actuators cannot 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 shall be operated to open i.e. off-position.

(d) Open air vent in case of V.T. or submersible pump and close lubricating oil or clear water supply in case of oil lubricated or clear water lubricated V.T. pump. Information about power failure should be given to all concerned, particularly to upstream pumping station to stop pumping so as to prevent overflow.

7.3 Pumping Machinery Maintenances :

(a) Daily

(a) Clean the pump, motor and other accessories.

(b) Check coupling bushes/rubber spider.

(c) Check stuffing box, gland etc.

(i) Routine observations of irregularities

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

(b) Changes in sound of running pump and motor

(c) Abrupt changes in bearing temperature.

(d) Oil leakage from bearings

(e) Leakage from stuffing box or mechanical seal

(f) Changes in voltage

(g) Changes in current

(h) Changes in vacuum gauge and pressure gauge readings

(i) Sparks or leakage current in motor, starter, switch-gears, cable etc

(j) Overheating of motor, starter, switch gear, cable etc.

(II) Record of operations and observations

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

(a) Timings when the pumps are started operated and stopped during 24 hours.

(b) Voltage in all three phases.

(c) Current drawn by each pump-motor set and total current drawn at the installation.

(d) Frequency.

(e) Readings of vacuum and pressure gauges.

(f) Motor winding temperature.

(g) Bearing temperature for pump and motor.

(h) Water level in intake/sump.

(i) Flow meter reading.

(j) Daily PF over 24 hour's duration.

(k) Any specific problem or event in the pumping installation or pumping system e.g. burst in pipeline, tripping or fault, power failure.

(b) Monthly Maintenance

(a) Check free movement of the gland of the stuffing box; check gland packing and replace if necessary. Clean and apply oil to the gland bolts.

(b) Inspect the mechanical seal for wear and replacement if necessary. Check condition of bearing oil and replace or top up if necessary.

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(c) Quarterly Maintenance

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

(b) Clean oil lubricated bearings and replenish with fresh oil. If bearings are grease lubricated, the condition of the grease should be checked and replaced/replenished to the correct quantity. An anti-friction bearing should have its housing so packed with grease that the void space in the bearing housing should be between one third to half. A fully packed housing will overheat the bearing and will result in reduction of life of the bearing.

(c) Tighten the foundation bolts and holding down bolts of pump and motor mounting on base plate or frame.

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

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

(d) Annual Inspections and Maintenance

A very thorough, critical inspection and maintenance should be performed by trained operator/Engineer once in a year. Following items should be specifically attended.

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

(b) Clean bearing housing and examine for flaws, e.g. wear, grooving etc. Change oil or grease in bearing housing.

(c) Examine shaft sleeves for wear or scour and necessary rectification. If shaft sleeves are not used, shaft at gland packing's should be examined for wear.

(d) Check stuffing box, glands, lantern ring, and mechanical seal and rectify if necessary.

(e) Check clearances in wearing ring.

(f) Check impeller hubs and vane tips for any pitting or erosion.

(g) Check interior of volute, casing and diffuser for pitting, erosion, and rough surface

(h) All vital instruments i.e. pressure gauge, vacuum gauge, ammeter, voltmeter,

(i) Check performance test of the pump for discharge, head efficiency.

7.3.1 MAINTENANCE SCHEDULE FOR MOTORS :

(A) *Daily*

(a) Clean external surface of motor.

(b) Examine earth connections and motor leads.

(c) Check temperature of motor and check whether overheated. The permissible maximum temperature is above the level which can be comfortably felt by hand. Hence temperature observation should be taken with RTD or thermometer. (Note: In order to avoid opening up motors, a good practice is to observe the stator temperature under normal working conditions. Any increase not accounted for, by seasonal increase in ambient temperature, should be suspected).

(d) In case of oil ring lubricated bearing.

o Examine bearings to check whether oil rings are working.

o Note bearing temperature.

o Add oil if necessary.

(e) Check for any abnormal Bearing noise.

(B) Monthly

(a) Check belt tension. In case where this is excessive it should immediately be reduced.

(c) Blow dust from the motor.

(d) Examine oil in oil lubricated bearing for contamination by dust, grit, etc. (this can be judged from the colour of the oil).

(e) Check functioning and connections of anti-condensation heater (space heater).

(f) Check insulation resistance by mongering.

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(C) Quarterly

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

(b) 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 half. A fully packed housing will overheat the bearing and will result in reduction of life of the bearing.

(c) Wipe brush holders and check contact faces of brushes of slip-ring motors. If contact face is not smooth or is irregular, file it for proper and full contact over slip rings.

(d) Check insulation resistance of the motor.

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

(f) Check and tighten foundation bolts and holding down bolts between motor and frame.

(g) Check vibration level with instrument if available; otherwise by observation.

(D) Half Yearly

(a) Clean winding of motor, bake and varnish if necessary.

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

(E) Annual Inspections and Maintenance

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

(b) Clean bearing housing and examine for flaws, e.g. wear, grooving etc. Change oil or grease in bearing housing.

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

(d) Clean and varnish dirty and oily windings. Re-varnish motors subjected to severe operating and environmental conditions e.g., operation in dust-laden environment, polluted atmosphere etc.

(e) Check condition of stator, stamping, insulation, terminal box, fan etc.

(f) Check insulation resistance to earth and between phases of motors windings, control gear and wiring.

(g) Check air gaps.

(h) Check resistance of earth connections.

7.3.2 History Sheet :

Similar to history sheet of pump, history sheet of motor should be maintained. The history sheet should contain all important particulars, records of periodical maintenance, repairs, Inspections and tests. It shall generally include the following

(a) Details of motor, rating, model, class of duty, class of insulation, efficiency curve, type test result and type test certificate etc.

(b) Date of installation and commissioning.

(c) Addresses of manufacturer & dealer with phone & fax number and e-mail addresses.

(d) Brief details of monthly, quarterly, half yearly and annual maintenance and observations of inspections about insulation level, air gap etc.

(e) Details of breakdown, repairs with fault diagnosis.

(f) Running hours at the time of major repairs.

7.3.3 L.T. Starters, Breakers and Panel :

Note: Circuit diagram of starter/breaker should be pasted on door of switch gear and additional copy should be kept on record.

(A) Daily

(a) Clean the external surface.

(b) Check for any spark or leakage current.

(c) Check for overheating.

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(B) Monthly

(a) Blow the dust and clean internal components in the panel, breaker and

(b) Check and tighten all connections of cable, wires, jumpers and bus-bars. All carbon deposits shall be cleaned.

(c) Check relay setting.

(C) Quarterly

(a) Check all connections as per circuit diagram.

(b) Check fixed and moving contacts and clean with smooth polish paper, if necessary.

(c) Check oil level and condition of oil in oil tank. Replace the oil if carbon deposit in suspension is observed or colour is black.

(d) Check insulation resistances.

(e) Check conditions of insulators.

(D) Yearly

(a) Check and carry out servicing of all components, thoroughly clean and reassemble.

(b) Calibrate voltmeter, ammeter, frequency meter etc.

7.3.4 H.T. Breakers, Contactors and Protection Relays :

Note : Circuit diagram of breaker/relay circuit should be pasted on door of switch gear and additional copy should be kept on record. Maintenance schedule specified for L.T. breakers are also applicable to H.T. breakers and contactors. In addition, following important points shall be attended for H.T. breakers and contactors.

(A) Monthly

(a) Check spring charging mechanism and manual cranking arrangement for operation.

(b) Clean all exposed insulators.

(c) Check trip circuit and alarm circuit.

(d) Check opening & closing timing of breaker.

(B) Quarterly

(a) Check control circuits including connections in marshalling boxes of breakers and transformer.

(b) Check oil level in MOCB/LOCB/HT OCB and top up with tested oil.

(c) *Yearly / Two yearly*1 Testing of protection relay with D.C. injection shall be carried out once in year.

(d) Servicing of HT breaker and contactor shall be carried out once in 2-3 years.

(e) Check dielectric strength of oil in breaker and replace if necessary.

(f) Check male & female contacts for any pitting and measure contact resistance.

7.3.5 Transformer & Transformer Substation :

Maintenance schedule as follows shall be applicable for transformer and sub-station equipment's e.g. Lightening arrestor, A.B. switch, D.O. or horn gap fuse, sub-station earthling system etc. This Para is particularly useful for the large schemes. Instructions of state electricity department and chief electrical inspector shall be followed.

(a) Daily Observations and Maintenance

(i) Check winding temperature and oil temperature in transformer and record. (For large transformers above 1000 kV, the temperature should be recorded hourly).

(ii) Check leakages through CT/PT unit, transformer tank and HT/LT bushings.

(iii) Check colour of silica gel. If silica gel is of pink colour, change the same by spare charge and reactivate old charge for reuse.

(b) Monthly

(i) Check oil level in transformer tank and top up if required.

(ii) Check relay contacts, cable termination, connections in marshaling box etc.

(iii) Check operation of AB switch and DO fuse assembly.

(iv) Clean radiators free from dust and scales

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(v) Pour 3-4 buckets (6 to 8 buckets in summer) of water in earth pit. Watering shall be increased to once in a week in summer season. Watering shall be increased to once in a week in summer season. shall preferably contain small amount of salt in solution.

(vi) Inspect lightning arrestor and HT/LT bushing for cracks and dirt.

(c) Quarterly

(i) Check dielectric strength of transformer oil and change or filter if necessary.

(ii) Check insulation resistance of all equipment's in sub-station, continuity of earthlings and earth leads.

(iii) Check operation of tap changing switch.

7.3.6 Pre-Monsoon and Post-Monsoon Checks and Maintenance :

(i) Check insulation resistance of transformer.

(ii) Test transformer oil for dielectric strength, sludge etc. If necessary, filtration of oil shall be carried out before monsoon.

(iii) Oil shall be tested for dielectric strength after monsoon.

(a) Half-Yearly

(i) Check dielectric strength of transformer oil in CT/PT and filter or change oil if necessary.

(ii) Check contact faces of AB switch and DO/HG fuse; apply petroleum jelly or grease to moving components of AB switch.

(b) Annual

(i) Measure resistance of earth pit. Resistance shall not exceed 1 ohm.

(ii) Check bus bar connections, clean contact faces, change rusted nut bolts.

(iii) Calibrate the protection relay for functioning. Check relay setting and correct if necessary.

(iv) Ensure that sub-station area is not water-logged. If required necessary earth fillings with metal spreading at top shall be carried out once in a year. Check drainage arrangement to prevent water logging in substation area and cable trenches.

(v) Test transformer oil for acidity test.

(c) Special Maintenance

(i) Painting of transformer tank and steel structure of sub-station equipment's shall be carried out after every two years.

(ii) The core of transformer and winding shall be checked after 5 years for transformer up to3000 kVA and after 7–10 years for transformers of higher capacity.

7.4. Solar Pumping :

A solar water pump is an application of photovoltaic technology which **converts solar energy into electricity** to run the pumping system thereby, replacing grid supply which at times is erratic and pollution-causing diesel-powered options. The solar water pump is powered by solar modules that helps draw surface or ground water out for different purposes. Key advantages of solar pumps are:

- No dependency on unreliable distribution system, diesel & kerosene pumps.
- Green and renewable mechanism
- No carbone mission, environnent friendly
- Zero running cost as runs directly on sunlight
- Flexible to operate hence easy to operate in remote areas

7.3.1 Components of Solar Pump :

The main components of solar pump system are:

1. Solar Photovoltaic (PV) Modules
2. Solar Controller/Inverter
3. Solar Pump-set
4. Array Structure
5. Plumbing, Electrical Accessories, Cables, earthing.
6. Remote Monitoring Unit (RMU)

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7.3.2 Basics of Solar Pump Selection and Unit Sizing :

1. The selection of solar pump is very similar to normal pump selection.
2. In the same HP range, there can be different pump models which can deliver different discharge at different dynamic heads.
3. In order to select a solar pump, the exact duty point which includes total dynamic head (TDH) and water requirement (**in Liters Per Day**); are necessary.
4. The pipe sizing has to be done carefully, so as to have minimum frictional losses.
5. The cables also have to be selected, such that the voltage losses are minimum. The solar modules sizing also has to be done as per the site conditions and solar insulation available at the site. For all practical conditions the solar modules always produce less power than the rated Wp.
6. Solar module sizing also depends upon the type of technology being used (like Poly crystalline, Thin film, etc) based on space constraint, weather constraint at site, etc.

7.3.3 Basic Maintenance :

1. Cleaning modules (solar panels) at regular intervals. Clean bird dropping, dust, etc. Modules may be cleaned bi-monthly. However, the interval entirely depends on the surrounding and weather.
2. Keeping track of trees growth, solar panels should be placed to avoid tree shades. Preferably the direction of solar PV array should be towards the southern pole.
3. Closing the controller door immediately after switching ON-OFF to avoid insects inside the controller and thereby avoiding short-circuit/ fan clogging, etc.

7.3.4 Do's and don'ts for submersible solar pump :

- Do fill the motor with clean drinking water before Use.
- Check physical damage before installation.
- Read the installation manual before Use.
- Ensure proper assembly of motor and pump before starting.
- Do Always Disconnect motor From Power source before handling
- Don't run the motor without sufficient quantity of water.
- Don't operate the motor without sand-guard and seal.
- Don't handle or lift the motor by its power cord.
- Don't use hard objects to turn the motor shaft.

7.3.5 Do's and don'ts for submersible solar pump :

- The horizontal length of the suction pipe should be straight to avoid air trapping in pipe.
- A check valve should be installed in the pipe line for delivery pressure more than 20 meters

CHAPTER-8

IoT AND SCADA SYSTEM

Normally O&M of water scheme involves monitoring the levels in Service reservoirs, pressures and flows in a distribution system and on operation of pumps such as hours of pumping and failure of pumps and monitor water quality by measuring residual chlorine. The line department usually uses the telephone line or wireless unit to gather the data, uses his discretion gained with experience and takes decisions to ensure that the system is operating with required efficiency. Manual collection of data and analysis may not be helpful in large undertakings if water utilities have to aim at enhanced customer service by improving water quality and service level with reduced costs. This is possible if the management acquires operational data at a very high cost.

8.1 Internet of Things (IoT) :

Internet of Things (IOT) is all about collecting information from the world with the help of network devices connected and are capable of sensing and collecting the information and then sharing them on cloud where several people can access that information for different purposes. Network devices include sensors, actuators, and any other physical devices. IOT implementation is considered to consist of two stages where in the first stage the devices or sensors are connected to send and receive data. The IoT application areas include home automation, water environment monitoring, and water quality monitoring etc.

Smart water management requires the integration of systems and a complex of measures to monitor, control and regulate the usage and quality of water resources as well as maintain the associated equipment (pipes, pumps, etc.).

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There's a wide range of hardware and software instruments, including sensors, meters, data processing and visualization tools, actuators and web and mobile controls connecting people with water systems. This category includes IoT devices for water management, systems and software tools that help optimize production, distribution and consumption of water and enable smart water treatment practices.

8.1.1 Sensors :

Sensors have broad applications in smart water management due to their great diversity and purposes. In a very basic water supply chain, sensors measure:

- the quality of raw water, the chemical composition in the water after treatment and wastewater, etc.
- changing quantity in the storage reservoir,
- pressure on the pipes in the distribution pipeline,
- wear of the equipment and machinery that process and distribute water to end-users, and more.

Using the data collected by IoT water sensors, service provider at different points of the water supply chain receives key insights into the changing conditions of water resources and equipment and can take data-driven corrective measures on demand.

8.1.2 Data for collection by IoT :

The data includes levels in Service reservoirs, pressures and flows in a distribution system, Flows/quantity of delivered into a SR and data on operation of pumps such as Voltage, amperes, energy consumed, operating times and down times of pumps and chlorine residuals. In IoT system up-to the minute real time information is gathered from remote terminal unit located at the water treatment plant, reservoir, flow meter, pumping station etc. and transmitted to a central control station where the information is updated, displayed and stored manually or automatically.

(ii) Processing data from IoT

The meter readings from reservoirs are useful information for managing the distribution system and helps in preventing overflow from reservoirs. However, the effectiveness of IoT in pumping operations is dependent on reliability of instrumentation for measuring flows, pressures, KWh meters, etc. Standard practice is to calculate pump efficiency and water audit calculations on amonthly basis. IoT can also be used to supervise water hammer protection system wherein the pump failures are linked to initiate measures to prevent occurrence of water hammer.

O & M of IoT is basically a task of skilled person. It is to be performed on the basis of O & M manual provided by service provider. Basic activities like observing any anomaly or receiving absurd data may be noted. In such cases service engineer should be informed immediately to look into the matter.

8.2 SCADA Systems (Supervisory Control and Data Acquisition) :

Supervisory Control and Data Acquisition (SCADA) systems provide control functionality and alarms at rural water supply scheme sites which in many cases are very remote. These systems were often used to solve single problems such as reducing power cost, or improving control of a particularly complex operation. The installation of SCADA has subsequently been seen as a means to satisfy a variety of increasing pressures such as consumer demands, regulatory requirements, and to also satisfy the need to reduce operational costs. The deployment of SCADA systems has been extended to cover large rural water supply schemes and has been found very effective.

8.2.1 Remote Terminal Units (RTU) :

A Remote Terminal Unit (RTU) is a microprocessor-controlled electronic device that interfaces objects in the physical world to a SCADA by transmitting telemetry data to the system and/or altering the state of connected objects based on control messages received from the system. Modern RTUs are usually capable of executing simple programs autonomously without involving the host computers of SCADA system to simplify deployment, and to provide redundancy for safety reasons. An RTU in a modern water management system will typically have code to modify its behaviour when physical override switches on the RTU are changed during maintenance-by-maintenance personnel. This is done for safety reasons; a miscommunication between the system operators and the maintenance personnel could cause system operators to mistakenly enable power to a water pump when it is being replaced.

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CHAPTER-9

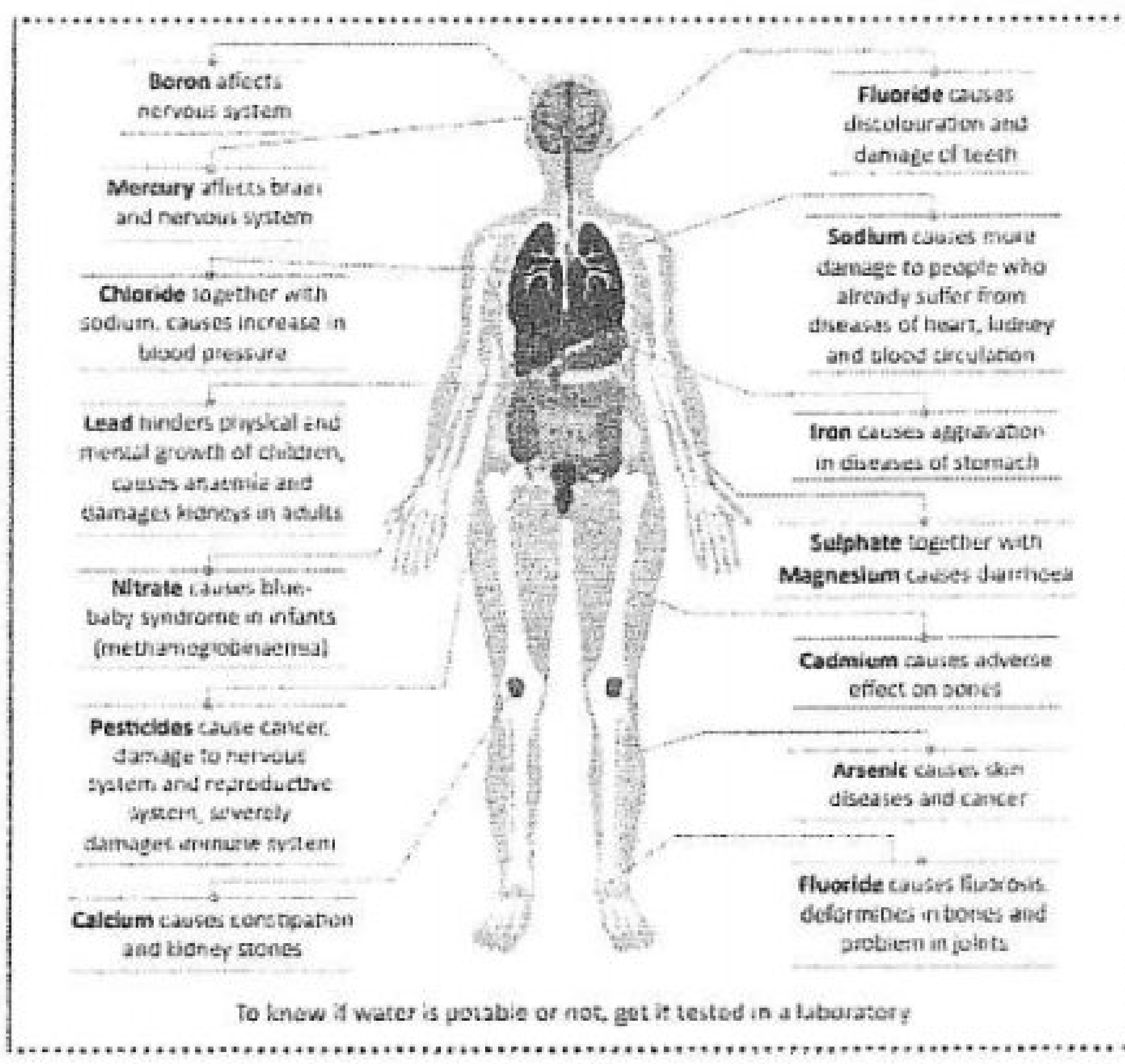
WATER QUALITY MONITORING AND SURVEILLANCE

9.1 Introduction :

Potable water is essential for human consumption and socio-economic development. The quality of drinking water is a powerful environmental determinant of the health of a community. Hence, it is of utmost importance to ensure that the quality of drinking water supply meets the prescribed standards. With the growing population and expanding economic activities, there is an increase in demand for water in various sectors, *viz.* agriculture, industry, domestic, recreation, infrastructure development, etc., whereas the source of water is finite. Thus, finite availability and competing demands make drinking water management a complex issue. Further, the widening demand-supply gap is compounded by other challenges, *viz.* depletion of groundwater caused by over-extraction, poor recharge, low storage capacity, erratic rainfall due to climate change, presence of contaminants, poor Operation and Maintenance (O&M) of water supply systems, etc. leading to rise in water quality issues.

Based on the reports 'Ground Water Quality in Shallow Aquifers in India, 2018' and 'National Compilation on Dynamic Ground Water Resources of India, 2017' published by Central Ground Water Board (CGWB), only about 50% of the total assessment units (blocks/ firkas/ manuals) have ground water in sufficient quantity and of prescribed quality (as per BIS standards). Consumption of contaminated water has adverse health impacts on human (as shown in **Figure 9.1**)and livestock population.

Figure 9.1: Adverse effects of drinking contaminated water



The newly launched Jal Jeevan Mission (JJM) focuses on service delivery at household level, i.e. water supply on a regular basis in adequate quantity and of prescribed quality. This emphasis on water quality began with the erstwhile NRDWP through its Water Quality Monitoring & Surveillance (WQM&S) component which is now being strengthened through JJM.

Under JJM, WQM&S aims to enable PHE & WS department to monitor quality of water supply and empower local community to keep surveillance on quality of water supplied, Water Quality Monitoring and Surveillance (WQM&S) programme is under implementation. The activities include setting up and up-gradation of state, district and sub-division level water quality testing laboratories, provisioning of mobile laboratories (for outreach and to be used during calamity), procurement of Field Test Kits (FTKs), periodic monitoring of water quality of various drinking water sources and capacity building of grass-root level workers for basic water quality tests.

9.2 Emphasis on water quality standards :

Water supplied by PHE & WS department is considered to be of potable only when it adheres to standards prescribed as per Indian Standards on Drinking Water-Specification IS 10500:2012 and its amendments from time to time.

The IS:10500 standard specifies the **acceptable limits** and the **permissible limits** in the absence of alternate source. Acceptable limits are the values in excess of which the water is not suitable for drinking purposes. Such a value may, however, be tolerated in the absence of an alternative source. However, if the value exceeds the limits indicated under 'permissible limit in the absence of alternate source', the water from such sources will have to be rejected.

9.3. Water, health and nutrition :

WHO estimates 50% of malnutrition is associated with recurrent diarrhea/ worm infection caused by contaminated water/poor hygiene/sanitation. Stunting, another strong indicator of malnutrition, can stem from enteropathy and poor cereals diet. Children exposed to open defecation and poor accesses to safe water are the most vulnerable.

Drinking water is also a vehicle for carrying essential micronutrients. Globally, it is estimated that 2 billion people, mostly in the low- and mid-income countries, rely on groundwater as the potable supply. Using data from three Asian deltas (Bengal, Mekong, and Red River) the observed chemical content of groundwater is such that in some areas, individuals obtain up to 50% or more of the Recommended Daily

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Intake (RDI) of certain nutrients e.g., calcium, magnesium and iron from just two liters of drinking water. It has also been observed that nutrition plays a significant role in fighting water-borne diseases. The work carried by !NREM foundation focusing on the water-health-nutrition linkages resulted in fluoridise reversal in young kids. Convergence with Poshan Abhiyan at district level is the immediate logical step in order to fight water-borne diseases.

9.4. Water and disaster :

Climate change driven extreme weather events like droughts and floods are unpredictably altering the current and future availability of freshwater. North Eastern states, hilly regions suffer every year landslides affecting drinking water assets. The adverse impacts resulting from uncertain availability of adequate and quality water, in turn affect availability of food, health parameters, nutrition and livelihood security. Also, the increasing instances of landslides, earthquakes, etc. at times damage water supply infrastructure resulting in disruption of drinking water supply. This poses a challenge for urban and rural planners working for providing safe drinking water to communities and hence, JJM will strengthen the efforts of States/ UTs in implementing their disaster management plan including disaster resilient drinking water infrastructures.

The key challenges in a disaster situation are:

(i) advance planning and preparedness to mitigate/ minimize the impact of disaster;

(ii) rapid response at time of disaster; and

(iii) restoration of the services with a robust and resilient supply system post disaster.

Thus, the plan has to address the above challenges in the context of drinking water supply. While the operational guidelines for implementation of JJM specify the above, efforts are to be made to further issue advisories on disaster preparedness.

9.5 Definition :

While describing water quality, certain terms are frequently used, which are to be clearly understood and correctly used. Some of the definitions are given below:

(a) ***Pollution*** is the introduction in to water of substance in sufficient quantity to affect the original quality of water, make it objectionable to sight, taste, smell or make it less useful.

(b) ***Contamination*** is the introduction into water of toxic materials, bacteria or other deleterious agents that make the water hazardous and therefore unfit for human use.

(c) *Potable* ***Water*** that is satisfactory for drinking purposes from the standpoint of its chemical, physical and biological characteristics. Palatable Water that is appealing to the sense of taste, sight and smell. Palatable water need not always be potable.

(d) ***Parts per million (ppm) or milligrams per liter (mg/l)*** these terms are used to express the concentrations of dissolved or suspended matter in water. The parts per million (ppm) is aweigh to weight or volume to volume relationship. Except in highly mineralized water, this quantity would be same as milligram per liter. This is preferable, since it indicates how it is determined in the laboratory.

(e) ***pH of water is*** an expression of the Hydrogen ion concentration. Alkaline water is with pH of above 7 and acidic water has pH of below 7 whereas water with pH 7 is neutral. *Physiological effect - having* effect on the normal functions of the body. *Pathogens* disease-producing organisms.

(f) ***Bacteria*-a** group of universally distributed, essentially unicellular microorganisms lacking chlorophyll.

(g) ***Virus*** - the smallest form capable of producing infection and diseases in human beings.

(h) ***Coliform Bacteria***-group of bacteria predominantly inhabiting the intestine of human being sand animals, but also occasionally found elsewhere. Used to indicate presence of fecal pollution.

(i) ***Enteric***-having its normal habitat in the intestinal tract of human beings or animals.

(j) ***Chlorine Residual***-chlorine remaining in the water at the end of a specified period.

(k) ***Chlorine Demand*** -the difference between the amounts of chlorine added to water and amount of residual chlorine remaining in the water at the end of a specified period.

9.6 Water Supply and Surveillance Agencies :

PHE & WS department is responsible for safe water supply to consumers. The main objectives of water quality monitoring are:

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(1) To determine the quality of water in its natural state in view of its present and future needs

(2) To assess the suitability of water for required use

(3) To find out the pathways for pollution, if any

Monitoring of water quality by water supply agency involves laboratory and field testing of water samples collected from various points in the water supply system, including the source, water purification plants, service reservoirs distribution systems and consumer end, representative of the condition of water at the point and time of collection. Continuous water quality monitoring involves good operating practices and preventive maintenance, as well as the regular routine testing, and monitoring of water quality to ensure compliance with standards. Surveillance is an investigative activity undertaken by a separate agency, to identify and evaluate factors posing a health risk to drinking water. Surveillance requires a systematic program of surveys that combine water analysis and sanitary inspection of institutional and community aspects, and reporting system. Sanitary inspection of water supply system should cover the whole system including water sources, rising mains, treatment plants, storage reservoirs, and distribution systems; to identify most common risks and shortcomings in the water supply. Moreover, surveillance is concerned with all sources of water used for domestic purpose by the population, whether supplied by a water supply agency or collected from other individual sources. So it is important to inspect and analyse all sources of water used and intend to be used for human consumption.

Surveillance agency should communicate to the water supply agency and pinpoint the risk areas and give advice for remedial action. It should also maintain good communication and cooperation with water supply agency for detection of risk areas and remedial action for betterment of water supply.

9.7 Planning and Implementation :

Systematic planning, keeping in view the fundamental objectives, is necessary for successful implementation of drinking water quality control program.

9.7.1 General Consideration and Strategies :

Quality control activities should be initiated as per the norms of national guidelines for each water supply system on a continuous basis. Surveillance agency should carry out periodic surveillance of all aspects of water quality safety including sanitary inspection and spot checks and result should be reported to the concerned water supply agency to implement remedial action when and where necessary. Water supply surveillance can be planned in progressive manner considering the availability of resources. It should start with a basic program, which could generate useful data to plan advanced surveillance as resources, and conditions permit. The initial pilot scale program should cover minimum basic strategies including fewer water quality parameters that provide reasonable degree of public health protection and should be widely applicable. Careful planning of training and resource provision is very essential right from the beginning of the project.

9.7.2 Surveillance Program :

Surveillance activities differ from region to region; between urban and rural communities; and according to the types of water supply. They should be adapted to local conditions; availability of local finances, infrastructure and knowledge. Water supply provider and surveillance agencies, depending on resources available with tem, will develop the program for monitoring and surveillance of drinking water quality. Following factors should be taken into consideration while implementation of surveillance activities.

- The type and size of water supply systems.
- The existing and available equipment.
- Local employment practices and the level of training.
- Opportunities for community participation.
- Accessibility of systems keeping in view of geographical and climatologically conditions
- Communication and transport facilities available.

9.8 Information Management :

The flow of information between and within the water supply and surveillance agencies is necessary to maximize the quality of service to consumer and protection of public health. The report provided by the surveillance agency to water supply provider should include :

1. The summary reports of condition of water supply and water quality analysis.
2. Highlight those aspects, which are considered inadequate and needs action.
3. Recommendation of remedial action in case of emergency.

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The report should not be limited to complain about failures but the water supply and surveillance agencies should coordinate their activities to ensure good quality of water to consumers. Such a report should specify actions in order of priorities for intervention based on public health criteria. If consistently, unsatisfactory results are reported in a particular area, 'the cause for the same should be investigated and remedial measures taken, such as repair of leakage, replacement of corroded and leaking consumer pipes etc. Inspections and water analysis of all water supplies available in the area. It should include the results of all inspections and analysis. The local surveillance office should report to the relevant supply agency as soon as possible after field visits. The information should also be passed on to regional authorities to allow follow-up; if recommendations for remedial action are not implemented. However, there must be a rapid means of reporting in case of emergency.

The consumers have the right to know about the quality of water being supplied to them. Therefore, the agencies responsible for monitoring should develop strategies for informing public the health-related results obtained by them along with recommendations for action (e.g. boiling during severe fecal contamination, household water storage education etc.) through publicity, Pani-Panchayats etc. Local government should ensure that the agency that supplies drinking water to the area complies with the quality standards.

9.9 Support Structure :

Monitoring and surveillance program require laboratory network, offices, transport, financial support and adequate staffing.

9.10 Community Based Monitoring and Surveillance :

Community participation is an essential component of the monitoring and surveillance framework. As the primary beneficiaries community can play an important role in surveillance activity. They are the people who may first notice the problems in water supply and report it to concerned agency or take remedial action if possible. Establishing a genuine partnership with the community creates a climate of trust and understanding, which generates interest and enthusiasm. It also provides a good foundation for other educational activities such as promotion of good hygiene practices. The community based monitoring and surveillance can be carried out in two ways:

1. Selection of community volunteers, including women, to undertake surveillance activities after training.
2. Providing encouragement to local worker to carry out certain jobs pertaining to surveillance.

In both the cases, preliminary training is necessary for field workers to identify sanitary hazards associated with the water supply, as well as regarding reporting system. Health department or water supply agency should help in providing necessary training while community water committee or health committee can supervise the work. The community participation includes:

(i) Assisting field workers in water sample collection, including sample location points, existing damaged networks, causing/likely to cause contamination of drinking water.

(ii) Assisting in data collection.

(iii) Monitoring water quantity, quality, and reporting findings to surveillance staff regularly.

(iv) (iv) Ensuring proper use of water supply.

(v) (v) Setting priorities for sanitation and hygiene and educate community members.

(vi) (vi) Under-take simple maintenance and repair work. Refer problems which require special attention.

(vii) (vii) Disseminate results and explain the implications with respect to health with the objective to stimulate involvement in actions to keep water clean, safe and wholesome.

9.11 Surveillance Action :

Surveillance action comprise of :

(i) Investigative action to identify and evaluate all possible factors associated with drinking water, which could pose a risk to human health.

(ii) Ensure preventive action to be taken to prevent public health problem.

(iii) Data analysis and evaluation of surveys.

(iv) Reporting to concerned authorities.

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9.12 Sanitary Survey :

Sanitary survey is periodic audit of all aspects of all water supply system. Systematic program of sanitary survey includes sanitary inspection, water quality analysis, and evaluation of data and reporting.

9.12.1 Nature and Scope :

Sanitary survey is an on-site inspection and evaluation of all conditions, devices and practices used in water supply system, which pose an actual or potential danger to the health and well-being of consumer by trained persons. It is a fact-finding activity, which identifies actual sources of contamination as well as point out inadequacies in the system that could lead to contamination.

The two important activities of sanitary survey are sanitary inspection and water quality analysis; which are complementary to one another. The inspection identifies potential hazards, while analysis indicates actual quality of water and intensity of contamination.

9.12.2 Work Chart for Sanitary Survey :

For collection of adequate information and follow-up work, proper work chart should be prepared considering local requirement. Following should be taken care of :

(i) Prior knowledge of source, and type of water supply; and map of distribution system.

(ii) Notify the visit in advance, where the assistance of community members is needed.

(iii) Carry prescribed forms and necessary accessories, like sample bottle, sample carry box, analysis kit etc.

(iv) Verify basic data with community.

(v) Interview community members for drinking water supply quality.

(vi) Verify information gathered by observation during survey.

(vii) Inspection and water sampling should not be haphazard, should follow specific guideline.

(viii) Water samples should be analyzed immediately for residual chlorine and thermo tolerant coliform, or transported quickly to laboratory in iced boxes.

(ix) Complete the sanitary report on site, and send it immediately to appropriate authority for follow-up remedial action if necessary.

(x) Undertake appropriate small repairs at the time of survey in remote areas such as washer changing for leaking taps.

(xi) For pictorial forms, each risk point should be circled and given to member of water committee for follow-up action.

9.13 Water Sampling and Analysis :

Periodic drinking water analysis is necessary to ensure safe quality water supply. Water samples should be analyzed for various microbiological and physic chemical contaminants. However, the authenticity of water analysis greatly depends on the sampling procedure.

The objective of sampling is to collect a small portion of water which can be easily transported to laboratory, without contamination or deterioration and which should accurately represent the water being supplied. It should cover locations which are most venerable in the supply system.

9.14 Data Analysis, Interpretation and Reporting :

Data analysis and interpretation are fundamental components of surveillance process. It aims at generation of data, which contributes to protect public health by promoting adequate, safe, potable water supply to communities.

9.14.1 Data Analysis

Evaluation of community water supply requires consideration of number of factors, such as quality, quantity, coverage, continuity of water supply and never the least, its production cost.

Quantity *Along with quality* of supplied water to the community plays an important role for maintenance and improvement of public health. Personal and domestic hygiene greatly depends on per capita quantity of water supply to the consumers. In case of inadequate quantity of water supply, community may use alternate source of water, some of which may not be safe and affect the public health.

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9.15 Use of Field Water Testing Kit (FTK) :

The field water testing kit is a simple device, which can be used for testing some critical water quality parameters in the field as it gives first-hand information on the quality of water. Whenever 100% accuracy is needed then laboratory test shall be carried out. This water testing kit can be used for regular Water Quality Monitoring Programs to be conducted at Village level. Panchayat level functionaries, NGOS and students of even 7th and 8th standards can easily do the experiments using this kit. The details of water sources and the quality of water in many villages can be collected and the data computerized at Panchayat level. The data will be much useful in planning and formulating various water supply schemes and will be useful for proper maintenance of rural water supply schemes. The kits can be used in Schools to promote the knowledge on water quality and help to develop a good practice and scientific culture among the students.

Water Testing Methodology

For testing the water in the field, the following aspects have to be clearly understood.

(a) Sampling procedures.

(b) Testing procedures.

(c) Reporting.

I. Sampling Procedure: **(to be included as annexure)**

(a) Before sampling, the source should be flushed adequately.

(b) For hand pump sources, before collecting the water, the water should be pumped for at least three to five minutes to clear all dirt, turbidity and slime.

(c) Water from wells should be taken in the middle at mid depth.

(d) For lakes, rivers and dams, the water should be collected near the off take point.

(e) The water should be collected after clearing the suspended and floating matter.

(f) Water for chemical examination should be collected in a clean white 250 ml capacity leak proof polythene container.

(g) Before collection of sample the container should be washed, rinsed with the water to be sampled for at least two to three times.

(h) The water should be then filled completely in the container without leaving any air space.

(i) Place a polythene sheet (10x10cm) over the cap and tie it with a rubber band or twine thread to avoid any leak

(j) Write the field code number (sample ID) on the container. The field code number and related source details should be separately recorded in a note book.

(k) The testing of sample should be completed within 12 hrs. From the time of collection.

II. Water Testing Procedure :

(a) Pour 10-20 ml. of water into the 100 ml polypropylene/titration cup.

(b) Conduct water testing as described in manual provided with FTKs.

(c) Find the result with the help of colour given.

III. REPORTING :

VWSC has to check the quality of the water at both source(s) and delivery points at regular intervals. Water quality testing is to be done at least twice a year for bacteriological contamination and once a year for chemical contamination. This register will have the details of source/ delivery point tested, type of test, quality of water tested, date of testing, name of the person who conducted the test etc. The names and contact numbers of the five women members trained to handle the Field Test Kit (FTK) from village responsible for water quality surveillance activities shall be maintained and they will be responsible for the testing the water samples.

Sl. No.	Date of testing	Sample from source or delivery points	Parameters tested	Result of testing	Safe/unsafe	Testing done by (Name to be given)	Remarks	Signature

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CHAPTER-10

WATER TARIFF

Revenue management system is an important aspect of any Water supply System as it governs the financial sustainability to it. Besides fixing a tariff structure, billing and collection of revenue play an important part.

10.1 Tariff Fixation :

- In case of rural areas, the VWSC through Gram-sabhas attended by minimum 80% of the household shall decide the rate of water tariff to be collected. Minimum tariff shall be decided by the Gram Sabha to be convened by VWSC.
- If heavy volume of water is being consumed by a family or household, different set of rates may be decided by Gram-sabha.
- Likewise, there could be exemption of water tariff for a widow or widower left without any dependable earner in the family.
- VWSCs may take a call if SHGs/rural societies are to be engaged for water tariff collection.
- Water tariff collection in urban areas would be governed by 'The Arunachal Pradesh Water Supply Act, 2015' and subsequent amendments if any.
- In case a rural water supply scheme facilitates water to urban/semi urban/Government quarters and adjacent rural villages, water tariff for rural villages shall be as per VWSC initiated Gram Sabha decision whereas that of urban/semi-urban/Government quarters shall be as per the Arunachal Pradesh Water Supply Act, 2015 and subsequent amendments if any.

10.2 Methods of Water Charges :

The methods of levying water charges can be any one or more of the following :

(1) Metered consumption of water.

(2) Non-Metered System :

(a) Fixed charge per house per month (depending upon the size of the house) or per connection per month or

(b) Fixed charge per family per month or per tap per month/per house or

(c) Percentage of ratable value of the property.

10.3.1 Payment of Bills by Consumer :

The payments can be accepted at any one or more ways of the following:

(a) Counters at G.Ps. / VWSC office.
(b) At bank / banks authorized for accepting payments.
(c) Door to door/on the spot recovery by authorized person.
(e) By advance e-pay system (Optional)

10.3.2 Related Accounting:

The billing section also carries out the accounting related to these receipts such as posting of receipts, generation of demand registers or ledgers on periodic basis. The complete accounting related to the billing may also be more efficiently carried out by the computerized system.

10.3.3 Delayed Payments :

Since water is being treated as a commodity consumed, the advance billing is generally not carried out. It is therefore 'a must' to levy penalty/interest on the delayed payments of the bills. Computerization overcomes many of the defects in the manual system, it is fast and gives control on the system.

10.3.4 Registers to be maintained by VWSCs :

A. Complaint register :

Sl. No.	Name of the consumer	Date of complaint	Address with phone number	Nature of the complaint	Name of the trained person deployed	Date of resolution to the problem	Signature of the trained person put on the job

Chairperson VWSC may engage one of the member of the VWSC to maintain the complaint register in which the date-wise details of the complaint are recorded and which is seen daily.

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B. Meeting Register :

After constitution of VWSC, all details of the meetings held by the members like date of the meeting, place, time, members present with signature on the attendance sheet, agenda of the meeting, decisions taken, actions taken on earlier plan, etc. shall be maintained.

Sl. No.	Name of the participants	Designation	Decision Taken	Signature/Thumb Impression

C. Contribution Register:

This register should contain details of all the contributions received from the community and any other sources. The name of the family member should be written against the cash contribution received. The signature of the family members should be taken with their consent on the register.

Sl. No.	Name of the contributor	Designa tion	Particulars of contribution (water Tariff/ service charge/ donation/other)	Date of contribution	Amount	Signature/Thum b Impression

D. Cash-Book Register :

In this register, VWSC shall keep record of the water tariff collection and expenditure incurred during O&M through the official Bank Account.

Receipt			
Date	Receipt No.	Particulars	Total Receipt amount

Payment			
Date	Particular/ Paid to whom	Paid amount	Signature of approval of Member Secretary/ Treasurer/VWSC Chairperson

E. Material/ Stock Register :

In this register, all the materials (Fittings, T&P and other items) purchased for water supply scheme shall be recorded. The register shcuid also have the details of the material used/issued and remaining stock available. The materials donated by individual and well-wishers should also be maintained properly.

(a) Stock register from purchases

Sl. No.	Date of Purchase	Purchase		Particulars of suppliers			Location of store where assets are kept	Signature of Member Secretary
		Particulars of assets/ materials	Quantity	Name & address	Cash Memo/Bank No	Cash of asset /material		
1	2	3	4	5	6	7	8	9

(b) Stock register from Donors

Sl No.	Date of donation	Name of donor	Particulars of materials donated	Quantity	Signature of Member Secretary
1	2	3	4	5	6

(c) Stock issue register

Sl. No.	Particulars of assets/ materials	Date of receipts/issued	Quantity received (Purchased + Donation) (Col.4 of A+Col.5 of B)	Date of issue of materials	Item issued	Balance quantity left	Signature of Member Secretary
1	2	3	4	5	6		7

(d) Cash Transaction Voucher :

In this register, all the information pertaining to voucher number, debit and credit of cash shall be recorded.

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Sl. No.	Date of Voucher	Detail transaction with Voucher No/Payment Voucher	Name of Borrower	Amount	Purpose	Remarks

Name of the Borrower

Payment is made for ....

Amount `..................... (in words) only.

Signature of lender
Signature of Borrower

Signature of approval member/members

(e) Bank transaction register:

In this register, all the money withdrawn and deposited in the bank shall be recorded.

Date	Amount Received	Amount Deposited	Cheque No with Date	Amount not deposited	Rest of amount in Cash	Remarks

CHAPTER-11

WATER AUDIT & LEAKAGE CONTROL

Water Audit of a water supply scheme can be defined as the assessment of the capacity of total water produced by the Water Supply Agency/VWSC and the actual quantity of water distributed throughout the area of service by the Agency/VWSC, thus leading to an estimation of the losses otherwise known as non-revenue/ un-accounted-for water (NRW/UFW) and it is the expression used for the difference between the quantity of water produced and the quantity of water billed or accounted for.

11.1 Definition of Water Audit :

Water audit in a water supply system is broadly, similar in nature to energy audit and determines the amount of water lost from source of water to a distribution system including losses at users' taps due to leakages and other reasons such as theft, unauthorized or illegal withdrawals from the systems and thus, these loss costs the utility. Complete water audit plan gives a detailed profile of a water supply system including its distribution system and water users, thereby facilitating easier and effective management of the resources with improved reliability. It helps in correct diagnosis of the problems faced and suggests optimum solutions. It is also an effective tool for realistic understanding and assessment of the system's performance level, efficiency of the service and the adaptability of the system for future expansion & rectification of faults during modernization. Elements of water audit include a record of the amount of water produced, total water supplied, water delivered to metered users, water delivered to unmetered users, water losses and suggested measures to address water loss (through pinpointing & minimising leakages and other unaccounted for water losses). Generally, the following are the steps of water audit exercise:

(a) To conduct a water audit of the water distribution system and water accounting practices etc. and validation

(b) Preparation of worksheets and sample calculations for each step of the water audit

(c) To identify, measure and verify all water consumption and loss

(d) To identify and control apparent losses in metering and billing operations, and recover missed revenues

(e) To implement a leakage and pressure management program to control real losses, conserve water and contain costs

(f) Develop plans to assemble the proper resources, information and equipment to launch a sustained accountability and loss-control program

(g) Prepare game-plan for setting short, medium and long-term goals and estimate return on investment.

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Leak detection program, a tool, help in minimizing leakages and tackling small problems before they scale-up to major ones. These programs lead to (a) reduced water losses, (b) improved reliability of supply system, (c) enhanced knowledge of the distribution system, (d) efficient use of existing supplies, (e) better safeguard to public health and property, (f) improved public relations, (g) reduced legal liability (h) reduced disruption, thereby improving level of service to customers, and (i) improved financial performance.

11.2 Application of Water Audit :

Application of water audit process in domestic/ municipal sector may consist of various steps viz. water audit, interventions for water conservation/leakages/ losses control, regulatory framework & community involvement and evaluation of effectiveness of interventions undertaken.

11.2.1 Water Audit Methodology :

A reliable water audit methodology was developed jointly by the American Water Works Association (AWWA) and International Water Association (IWA) in year 2000. The water balance of this methodology is given below and shows schematically the various components in which water volumes (typically one year) are tracked.

System Input Volume (corrected for known errors)	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption (including water exported)	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW)
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Customer Metering Inaccuracies	
			Data Handling Errors	
		Real Losses	Leakage on Transmission and Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to point of Customer metering	

The water balance tracks – from left to right – how a water agency supplies water volumes from source to customer and provides the format for the agency to quantify amounts of billed and lost water. Fundamental to the AWWA/IWA Water Audit Methodology is the distinction that treated drinking water goes to two places: authorized consumption by consumers (its intended use) and a portion to losses (through inefficiencies). Within the component of losses, two broad types exist:

Apparent Losses are the "paper" losses that occur in utility operations due to customer meter inaccuracies, billing system data errors and unauthorized consumption. In other words, this is the water that is consumed but is not properly measured, accounted or paid for. These losses cost utilities revenue and distort data on customer consumption patterns.

Real Losses are the physical losses of water from the distribution system, including leakage and storage overflows. These losses inflate the water utility's production costs and stress water resources since they represent water that is extracted and treated, yet never reaches beneficial use.

11.2.2 Installation of Bulk Meters :

The major activity during the overall water audit will be bulk meter installation at those points on the distribution network where water enters the system. It is expected that bulk meters will be required at the following locations:

(a) All major system points (e.g. raw water inlet, clear water outlet, main distribution branch, SRs etc.).

(b) All tube wells/ sources which supply the system directly.

(c) Major transfer mains which are expressly required for audit.

(d) At distribution centres, the most appropriate meter position is on the outlet pipe from the service reservoir. Installation of a meter at this point will allow measurement of flows into the system not only if supplies are coming from the service reservoir but also if they are being pumped directly from the clear water reservoir (CWR)

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The size of the meter can be determined by flow of water, size of pipe line and Meter manufacturer's specifications having consideration of the following :

* Number of properties served.
* Per capita consumption (liters/person/day).
* Population density.
* Meter manufacturer's specifications

It is expected that bulk meters installed in locations where supply is rationed will tend to over read. This is because when supplies are turned on, the air present in the pipes can cause the meter to spin. This problem may be overcome through the use of combined pressure and flow loggers. Flow through the meter will be recorded in the normal way. However, analysis of the pressure and flow plots together will enable the identification of that period of time when a flow is recorded at zero pressure. This time should correspond to the period when the meter is spinning, and the true flow through the meter over a period of time can therefore be calculated.

11.2.3 Monitoring of the Production System :

The assessment of the leakage rates through the various features of the water supply system should be undertaken. These will include raw water transmission system, reservoirs, treatment plant, clear-water transmission system, inter-zone transmission system, tube wells/ sources of water supply.

11.2.4 Transmission System :

The methodology adopted to make an assessment of the level of losses in the transmission system is to install insertion probes/bulk meter at both ends of each section of main being monitored, thus monitoring both the inflow and outflow of the section. This monitoring should be done for a minimum period of 7 days. The difference of inflow and outflow will indicate the losses in the transmission main. The advantage of this method is that the trunk main need not be taken out of service. Another way to measure leakage is to close two valves on the main. 25mm tapping are made on either side of the upstream valve and a small semi-positive displacement flow meter is connected between the two tapings. Flow through this meter will indicate the leakage in the main between the two closed valves. It must be ensured that the downstream valve is leak proof. The approximate position of any leakage measured can be determined by the successive closing of sluice valves along the main in the manner of a step test.

11.2.5 Reservoirs :

To reduce or avoid any leakage or consequent contamination in reservoirs, the reservoirs should be periodically tested for water tightness, drained, cleaned, washed down and visually inspected. The losses in water storage structures can be monitored for a particular period noticing the change in the level gauges when the structure is out of use i.e. there is no inflow and outflow of water during this monitoring period.

The most reliable method for measurement of leakage from a service reservoir is to fill it to full level and isolate it from supply and to measure change in level over suitable time period. Suitable equipment to measure reservoir levels could be chosen like:

(a) Sight gauges

(b) Water level sensors (as per manufacturer's instruction)

(c) Float gauges

(d) Submersible pressure & level transducers (as per manufacturer's instruction).

11.2.7 Treatment Plant :

The losses in treatment plant can be monitored by measuring the inflow into the plant and out flow from the plant with the help of mechanical electronic flow recorders. The difference of inflow and outflow for the monitoring period will indicate the water losses in the plant. In case the loss is more than the design limit, further investigation should be carried out for remedial measures.

11.2.8 Tube Wells :

In conjunction with the programme of bulk meter installation is the operation to monitor the approximate yield from the tube wells. This exercise can be carried out by the installation of semi-permanent meters to the tube wells on a bypass arrangement similar to that for the bulk meters. This can be affected utilizing the smaller diameter bulk meters.

Insertion probes or the portable ultrasonic flow meters will be used for measurement of flows on the common feeder mains.

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11.2.9 Monitoring of Distribution System :

Distribution system comprises of service reservoirs, distribution mains & distribution lines. Metered, unmetered (flat rate), public stand posts, hydrants, illegal connections.

Water audit of the distribution system consists of:

(a) Monitoring of flow of water from the distribution point into the distribution system.

(b) Consumer meter sampling i.e. water monitoring Area (WMA) and estimating metered use by consumers, if any.

(c) Estimating losses in the appurtenances and distribution pipe line network including consumer service lines.

11.2.10 Monitoring Flow into the Distribution System :

A bulk meter of the appropriate type and size is installed at the outlet pipe of the service reservoir or at the point where the feeding line to the area branches off from the trunk main. If water from the WMA (water monitoring Area) flows out into another zone a valve or meter is to be installed at this outlet point.

11.2.10.1 Customer Meter Sampling :

Water audit is a continuous process. However, consumers' meter sampling can be done on yearly basis by Review of all existing bulk and major consumers for revenue. A co-relation between the production/power consumed in the factory viz-a-viz water consumption can be evaluated by :

(a) Sampling of 10% of all bulk and major consumers.

(b) Sampling of 10% of small or domestic consumers.

(c) Series meter testing of large meters suitably according to standard, calibrated meter

(d) Testing of 1% large and 1% domestic meters.

(e) Estimating consumption at a representative 5% sample of Public Stand Posts (PSP) and unmetered connections by carrying out site measurements.

All non-functioning and broken meters in the sample areas will be replaced and all meters may be read over a week. This information will be brought together with information derived from the workshop and series testing in order to estimate the average water delivered and correction factors for consumer meters. These factors can then be extrapolated to the rest of the customer meter database.

11.2.10.2 Losses in Customer Service Lines and Appurtenances :

Losses can be calculated by deducting the following from the total quantity by the following:

(a) Metered consumption.

(b) Illegal connection consumption (assuming metered use).

(c) PSP use.

(d) Free supply, use in public toilets, parks etc.

11.2.11 Analysis :

The information of the results of monitoring the distribution system together with the results of the bulk metering exercise will be consolidated and brought together to produce the water balance report and the overall water audit report. These results may be interpreted in financial terms. Further exercise will be done to classify the water consumed/wasted/lost in financial terms with relation to the current and future level of water charges. This exercise will be carried out as a result of the field tests and the review of existing records forming part of the overall water audit. This water audit will provide sufficiently, accurate area wise losses to priorities the area into 3 categories viz.

(a) Areas that need immediate leak detection and repair.

(b) Areas that need levels of losses (UFW) to be closely monitored.

(c) Areas that appear to need no further work at the current time.

It is recommended that cursory investigation should be carried out in the areas that appear to have the least levels of losses (UFW), locating any major leaks, followed by the leak repairs would reduce the losses (UFW) levels further. After water audit of few cities/ villages, it has been reported that the components of UFW may generally be as follows:

(a) Leakage (physical losses) 35 to 50%

(b) Meter under-registration 10 to 15%

(c) Illegal/unmetered connections 3.5 to 6%

(d) Public use 1.5 to 3.5%

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11.3 Leakage Control :

The overall objective of leakage control is to diagnose how water loss is caused and to formulate and implement action to reduce it to technically and economically acceptable minimum. Specifically the objectives are:

(a) To reduce losses to an acceptable minimum.

(b) To meet additional demands with water made available from reduced losses there by saving in cost of additional production and distribution.

(c) To give consumer satisfaction.

(d) To augment revenue from the sale of water saved.

(a) WATER LOSSES

The water losses can be termed into two categories.

(a) Physical losses (Technical losses)

(b) Non-physical losses (Non-technical losses/Commercial losses)

(i) PHYSICAL LOSSES (TECHNICAL LOSSES)

This is mainly due to leakage of water in the network and comprises of physical losses from pipes, joints & fittings, reservoirs & overflows of reservoirs & sumps.

(ii) NON-PHYSICAL LOSSES (NON-TECHNICAL LOSSES)

Theft of water through illegal, already disconnected connections, under-billing either deliberately or through defective meters, water wasted by consumer through open or leaky taps, errors in estimating flat rate consumption, public stand posts and hydrants.

(b) LEAKAGE DETECTION AND MONITORING

The major activities in the leak detection work in the distribution system :

(a) Preliminary data collection and planning.

(b) Pipe location and survey.

(c) Assessment of pressure and flows.

(d) Locating the leaks.

(e) Assessment of leakage.

11.4 Benefits of Water Audit and Leak Detection :

Water audits and leak detection programmes can achieve substantial benefits, including the following :

(a) Reduced Water Losses

Water audit and leak detection are the necessary first steps in a leak repair programme. Repairing the leak will save money for the utility, including reduced power costs to deliver water and reduced chemical costs to treat water.

(b) Financial Improvement

A water audit and leak detection programme can increase revenues from customers who have been undercharged, lower the total cost of whole sale supplies and reduce treatment and pumping costs.

(c) Increased Knowledge of the Distribution System

During a water audit, distribution personnel become familiar with the distribution system, including the location of main and valves. This familiarity helps the utility to respond to emergencies such as main breaks.

(d) More Efficient Use of Existing Supplies

Reducing water losses helps in stretching existing supplies to meet increased needs. This could help defer the construction of new water facilities, such as new source, reservoir or treatment plants.

(e) Safeguarding Public Health and Property

Improved maintenance of a water distribution system helps to reduce the likelihood of property damage and safeguards public health and safety.

(f) Improved Public Relation

The public appreciates maintenance of the water supply system. Field teams doing the water audit and leak detection or repair and maintenance work provide visual assurance that the system is being maintained.

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CHAPTER-12

ENERGY AUDIT

12.1 Introduction :

Energy is very scarce and short supply commodity particularly in most of the states in the country and its cost is spirally increasing day-by-day. Generally pumping installations consume huge amount of energy wherein proportion of energy cost can be as high as 40 to 70% and even more of overall cost of operation and maintenance of water works. Need for conservation of energy, therefore cannot be ignored. All possible steps need to be identified and adopted to conserve energy and reduce energy consumption, and cost so that water tariff
can be kept as low as possible and gap between high cost of production of water and price affordable by consumers can be reduce.
Some adverse scenarios in energy aspects as follows are quite common in pumping installations:

(a) Energy consumption is higher than optimum value due to reduction in efficiency of pumps.
(b) Operating point of the pump is away from best efficiency point (b.e.p.).
(c) Energy is wasted due to increase in head loss in pumping system e.g. clogging of strainer, encrustation in column pipes, and encrustation in pumping main.
(d) Selection of uneconomical diameter of sluice valve, butterfly valve, reflux valve, column pipe, drop pipe etc. in pumping installations.
(e) Energy wastage due to operation of electrical equipment's at low voltage and/or low power factor.

Such inefficient operation and wastage of energy need to be avoided to cut down energy cost. It is therefore, necessary to identify all such shortcomings and causes which can be Strategy as follows, therefore need to be adopted in management of energy

(a) Conduct thorough and in-depth energy audit covering analysis and evaluation of all equipment, operations and system components which have bearings on energy consumption, and identifying scope for reduction in energy cost.

(b) Implement measures for conservation of energy.

(c) Energy audit as implied is auditing of billed energy consumption and how the energy is consumed by various units, and sub-units in the installation and whether there is any wastage due to poor efficiency, higher hydraulic or power losses etc. and identification of actions for remedy and correction.

(d) In respect of the sources like, infiltration wells, open wells, collector wells, the working head can be decided based upon the suction head, delivery head, frictional loss with reference to the pipe material used and other losses.

(e) In respect of bore well sources, while submersible pump sets are used, the pump suction depth may be fixed with reference to the final spring achieved during drilling.

(f) Working of head of pumps shall be made in conservative way.

(g) If head of pump is excess of actual requirement then pump impeller shall be trimmed as per affinity law.

(h) In large pumping station pumps with variable frequency shall be used.

(i) With low power factor loads, the current flowing through electrical system components is higher than necessary to do the required work. In order to achieve power factor greater than 0.9 power capacitors of required capacity shell be installed on all the installation of Pumping machinery.

(j) Electric motors usually run at a constant speed, but a variable frequency (speed) Drive(VFD) allows the motor's energy output to match the required load. This achieves energy savings depending on how the motor is used. When we use a control valve or regulator, we lose energy because the pumps are always operated at high speed.

12.2. Scope of Energy Audit :

Energy audit includes following actions, steps and processes:

(1) Conducting in depth energy audit by systematic process of accounting and reconciliation between the following:

   (a) Actual energy consumption.

   (b) Calculated energy consumption taking into account rated efficiency and power losses in all energy utilizing equipment and power transmission system i.e.

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(2) Conducting performance test of pumps and electrical equipment if the difference between actual energy consumption and calculated energy consumption is significant and taking follow up action on conclusions drawn from the tests.

(3) Taking up discharge test at rated head if test at Sr. No. (ii) is not being taken.

(4) Identifying the equipment, operational aspects and characteristic of power supply causing inefficient functioning, wastage of energy, increase in hydraulic or power losses etc. and evaluating increase in energy cost or wastage of energy

(5) Identifying solutions and actions necessary to correct the shortcomings and lacunas in (IV) and evaluating cost of the solutions.

(6) Carrying out economic analysis of costs involved in (iv) and (v) above and drawing conclusions whether rectification is economical or otherwise.

(7) Checking whether operating point is near best efficiency point and whether any improvement is possible.

(8) Verification of penalties if any, levied by power supply authorities e.g. penalty for poor power factor, penalty for exceeding contract demand. Broad review of following points for future guidance or long term measure :

(a) C-value or f-value of transmission main.

(b) Diameter of transmission main provided.

(c) Specified duty point for pump and operating range.

(d) Suitability of pump for the duty conditions and situation in general and specifically from efficiency aspects.

(e) Suitability of ratings and sizes of motor, cable, transformer and other electrical appliances for the load.

12.2.1 Study and Verification of Energy Consumption :

(a) All Pumps Similar (Identical):

(i) Examine few electric bills in immediate past and calculate total number of days, total kWh consumed and average daily kWh (e.g. in an installation with 3 numbers working and 2 numbers standby if bill period is 61 days, total consumption 5,49,000 kWh, then average daily consumption shall be 9000 kWh).

(ii) Examine log books of pumping operation for the subject period, calculate total pump - hours of individual pump sets, total pump hours over the period and average daily pump hours (Thus in the above example, pump hours of individual pump sets are: 1(839), 2(800), 3(700), 4(350) and 5(300) then as total hours are2989 pump-hours, daily pump hours shall be 2989 ÷ 61 = 49 pump hours. Average daily operations are: 2 numbers of pumps working for 11 hours and 3 numbers of pumps working for 9 hours).

iii) From (i) and (ii) above, calculate mean system kW drawn per pump set (In the example, mean system power drawn per pump set = 9000 / 49 i.e. 183.67 kW).

(iv) From (i), (ii) and (iii) above, calculate cumulative system kW for minimum and maximum number of pumps simultaneously operated. (In the example, cumulative system kW drawn for 2 numbers of pumps and 3 numbers of pumps operating shall be 183.67 x 2 = 367.34 kW and 183.67 x 3 = 551.01 kW respectively).

(v) Depending on efficiency of transformer at load factors corresponding to different cumulative kW, calculate output of transformer for loads of different combinations of pumps. (In the example, if transformer efficiencies are 0.97 and 0.975 for load factor corresponding to 367.34 kW and 551.01 kW respectively, then outputs of transformer for the loads shall be 367.34 x 0.97 i.e. 356.32 kW and 551.01 x 0.975 i.e. 537.23 kW respectively).

(vi) The outputs of transformer, for all practical purpose can be considered as cumulative inputs to motors for the combinations of different number of pumps working simultaneously. Cable losses, being negligible, can be ignored.

(vii) Cumulative input to motors divided by number of pump sets operating in the combination shall give average input to motor (In the example, average input to motor shall be 356.32 ÷ 2 i.e. 178.16 kW each for 2 pumps working and 537.23÷ 3 i.e. 179.09 kW each for 3 pumps working simultaneously.

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(viii) Depending on efficiency of motor at the load factor, calculate average input to pump. (In the example, if motor efficiency is 0.86, average input to pump shall be 178.16 x 0.86 i.e. 153.22 kW and 179.07 x 0.86 i.e. 154.0 kW).

(ix) Simulate hydraulic conditions for combination of two numbers of pumps and three numbers of pumps operating simultaneously and take separate observations of suction head and delivery head by means of calibrated vacuum and pressure gauges and/or water level in sump/well by operating normal number of pumps i.e. 2 number and 3 numbers of pumps in this case and calculate total head on the pumps for each operating condition. The WL in the sump or well shall be maintained at normal mean water level calculated from observations recorded in log book during the chosen bill period.

(x) Next operate each pump at the total head for each operating condition by throttling delivery valve and generating required head. Calculate average input to the pump for each operating condition by taking appropriate pump efficiency as per characteristic curves.

(xi) If difference between average inputs to pumps as per (viii) and (x) for different working combinations are within 5% - 7%, the performance can be concluded as satisfactory and energy efficient.

(xii) If the difference is beyond limit, detailed investigation for reduction in efficiency of the pump is necessary.

(xiii) Full performance test for each pump shall be conducted as per procedure.

(xiv) If for some reason, the performance test is not undertaken, discharge test of each single pump at rated head generated by throttling delivery valve need to be carried out.

(xv) If actual discharge is within 4% - 6% of rated discharge, the results are deemed as satisfactory.

(b) Dissimilar Pumps

Procedures for energy audit for dissimilar pumps can be similar to that specified for identical pumps except for adjustment for different discharge as follows:

(a) Maximum discharge pump may be considered as 1(one) pump-unit.

(b) Pump with lesser discharge can be considered as fraction pump-unit as ratio of its discharge to maximum discharge pump. [In the above example, if discharges of 3 pumps are 150, 150 and 100 litters per second respectively, then number of pump-units shall be respectively 1, 1 and 0.667. Accordingly the number of pumps and pump-hours in various steps shall be considered as discussed for the case of all similar pumps.

12.3 Measures for Conservation of Energy :

Measures for conservation of energy in water pumping installation can be broadly classified as follows :

(a) Routine Measures

The measures can be routinely adopted in day to day operation and maintenance.

(b) Periodical Measures

Due to wear and encrustation during prolonged operation, volumetric efficiency and hydraulic efficiency of pumps reduce. By adopting these measures, efficiency can be nearly restored. These measures can be taken up during overhaul of pump or planned special repairs.

(c) Selection Aspects

If during selection phase, the equipment i.e. pumps, piping, valves etc. are selected for optimum efficiency and diameter, considerable reduction in energy cost can be achieved.

(d) Measures for System Improvement

By improving system so as to reduce hydraulic losses or utilized available head hydraulic potentials, energy conservation can be achieved. Use of water harvesting through storages as supplementary to the main water supply system, saves lot of energy.

12.3.1 Routine Measures :

(a) Improving Power Factor

Generally as per guidelines of power supply authority, average power factor (PF) of more than 0.9 is to be maintained in electrical installations. The power factor can be improved to level of 0.97 or 0.98 without adverse effect on motors. Further discussion shows that considerable saving in power cost can be achieved if PF is improved. The low power factor may attract penalty by respective power supply authorities.

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(b) Operation of Working and Standby

Transformers As regards operation of working and standby transformers, either of two practices as below is followed:

(i) One transformer on full load and second transformer on no-load but, charged.

(ii) Both transformers on part load.

(c) Voltage Improvement by Voltage Stabilizer or at Transformer by OLTC

If motor is operated at low voltage, the current drawn increases, resulting in increased copper losses and consequent energy losses.

(d) Reducing Static Head (Suction Side)

A study shows that energy can be saved if operating head on any pump is reduced. This can be achieved by reducing static head on pumps at suction end or discharging end or both. One methodology to reduce static head on pumps installed on sump (not on well on river/ canal/lake source) is by maintaining WL at or marginally below FSL, say, between FSL to (FSL - 0.5 m) by operational control as discussed below.

(1) Installation where inflow is directly by conduit from dam

(2) In such installations, the WL in sump can be easily maintained at FSL or slightly below, say, FSL to (FSL - 0.5m) by regulating valve on inlet to sump.

(3) Other installations

(e) Keeping Strainer or Foot Valve Clean and Silt Free

Floating matters, debris, vegetation, plastics, gunny bags etc. in raw water clog the strainer or foot valve creating high head loss due to which the pump operates at much higher head and consequently discharge of the pump reduces. Such operation results in:

(a) Operation at lower efficiency as operating point is changed. Thus, operation is energy wise inefficient.

(b) Discharge of the pump reduces. If the strainer/foot valve is considerably clogged, discharge can reduce to the extent of 50% or so.

(c) Due to very high head loss in strainer/foot valve which is on suction side of the pump,

(f) Preventing Throttling of Pump

(g) Replacement of existing Mercury Vapour Lamps & Sodium Vapour Lamps by LED or solar lamps

12.3.2 Periodical Measures :

(a) Restoring Wearing Ring Clearance

Due to wear of wearing rings, the clearance between wearing ring increases causing considerable reduction in discharge and efficiency. Reduction in discharge up to 15- 20% are observed in some cases. If wearing rings are replaced, the discharge improves to almost original value. Initial leakage through wearing rings is of the order of 1 to 2% of discharge of the pump. Due to operation, wearing rings wear out causing increase in clearance which increases leakage loss and results in consequent reduction in effective discharge of the pump. A study shows that even though discharge is reduced, power reduction is very marginal and as such the pump operates at lower efficiency. Reduction in discharge up to 15% to 20% is not uncommon. Thus the pumps have to be operated for more number of hours causing increase in energy cost.

(b) Reducing Disk Friction Losses Disk friction losses in pump accounts for about 5% of power consumed by the pump. The A study shows that if surfaces of the impeller and casing are rough, the disk friction losses increase. If casing is painted and impeller is polished, disk friction losses can be reduced by 20% to 40% of normal loss. Thus as disk friction loss is about 5% of power required by the pump, overall saving in power consumption will be 1% to 2%. For large pump the saving can be very high.

(c) Scrapping down Encrustation inside Column Pipes

Due to operation over prolonged period, encrustation or scaling inside the column pipe develops causing reduction in inside diameter and making surface rough. Both phenomenon cause increase in friction losses. If scrapping of encrustation is carried out whenever column pipes are dismantled energy losses can be avoided.

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12.3.3 Selection Aspects :

(a) Selection of star rating motor pump

Now a days, three star/five star rating pump sets are available in the market, which can save 10-15 & of power, can be used in place of normal pumping machinery.

(b) Optimum Pump Efficiency

Optimum efficiency of pump can be ensured by appropriate selection such that specific speed is optimum. Specific speed

(c) Optimisation of Pipe appurtenance-

Sluice Valve/Butterfly Valve and Non-Return Valve on Pump Delivery 'K' values of sluice valve and non-return valve are 0.35 and 2.50 respectively which amount to combined 'K' valve of 2.85. Due to very high 'K' value, head loss through these valves is significant and therefore, it is necessary to have optimum size of valves.

(d) Delivery Pipe for Submersible Pump

As delivery pipe for submersible pump is comparatively long and therefore, head loss in delivery pipe is considerable, it is of importance to select proper diameter. Optimum design velocity is around 1.1 - 1.5 m/s. However, pipe diameter should not be less than 50 mm.

CHAPTER-13

INSTITUTIONAL ROLE AND RESPONSIBILITIE

13.1 Institutional roles and responsibilities :

It is very important to provide clear-cut roles and responsibilities for O & M activities for water supply system amongst different stakeholders. PHE & WS department is nodal agency in Arunachal Pradesh for facilitating infrastructure and service of water supply. However, for ensuring system sustainability and to empower the community with ownership and decision making power, VWSC should take over the responsibility of O & M of the in-village drinking water assets. Accordingly, roles and responsibilities of the institution on O & M are outlined here.

13.1.1 Role of PHE & WS Department :

1. Creation of water supply system from source to tap connection in both single and multi-village schemes.
2. Ownership of assets from intake point to WTP and sub mains upto distribution tanks except solar panels and accessories, pump and accessories, IoT and Electro chlorinators.
3. Maintenance of Intake point to WTP except scrapping of fine sand layer in SSF and cleaning of solar panels from time to time from dusts and leaves etc.
4. Replacement of sand and absorbent media (Katalox –for removal of iron and turbidity, balancing ph & Purolite - for removal of iron & solid particles, manganese, chlorine, balancing ph) and activated carbon (for odour and colour) on need base in pressure filters.
5. Fixation of major problems if any in solar power system, electro chlorinator, pumps and motors and accessories thereof.
6. Imparting skill training to VWSC members for plumbing, masonry and electric/pumping works.
7. Facilitating IEC and training activities with the help of ISAs/NGOs/SHGs on water conservation, handling water, water quality monitoring etc.
8. The PHED Field Engineers shall prepare Annual Maintenance estimate and obtain necessary sanction.
9. Fixation of major problems including calibration of pressure valves, air valves, flow meters etc.
10. Providing technical input on source strengthening and catchment area protection.
11. Preparation of Annual Action Plan and estimate for maintenance, source strengthening, catchment protection etc.

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12. In cases of villages where the sudden migration or shifting of people result into increased in large no of households, on the request of the VWSCs, the department can help in providing new connections subject to provisioning of materials by the VWSCs or by the state govt. through an extension scheme. However, the Government sanction for extension shall not be an option for minimal increase of households say one or two households and where the VWSC decides to extend connection to commercial settlements within the village jurisdiction. In all such cases, the resources generated through new connections or water tariff collection should be utilised.
13. The electricity charge for the drinking water supply system shall be exempted or will be borne by the State Government.

13.1.2 Role of VWSCs :

1. Ownership of assets pertaining to in-village system from distribution reservoir/tank to distribution network, tap points and water recycle works if any. In case of a scheme powered with solar/electric energy, the ownership of solar panels & accessories, pumps & accessories, DG sets would remain with VWSC. If added features of electro chlorinators and IoT are there, the same would also be owned by the VWSC.
2. O & M of intra-village water supply system. Skilling of plumbing, masonry and electrician have either been provided or are being provided through JJM in every VWSCs.
3. Giving new water connections within the village jurisdiction.
4. Monitoring of scheme from intake to supply point. Clearance of debris/leaves/blockages at different points on regular basis.
5. Scrapping, washing & refilling of top layer of fine sand in SSF system as and when filtration rate is seen diminishing.
6. Backwashing of pressure filter on need base. During rainy season it could be once daily for 30 minutes for smaller capacities to 90 minutes for larger capacities till clear water comes out. Likewise, if iron contamination is present it is advised to backwash daily at least for 15 minutes.
7. Cleaning of solar panels in solar powered water supply system monthly to ensure proper power harnessing.
8. Regular testing of household level supplied water through FTK.
9. Sanitary Survey of PWS sources at least once every year.
10. To raise water tariff amongst consumers as decided in the gram sabhas. Funds also to be mobilized from relevant Govt. programmes and individuals as donations.
11. Ensuring equitable distribution of water for all section of village population. Timely operation of valves.
12. Water audit and energy audit.
13. Cases of theft or tampering/ causing damage to water supply installation or illegal tapping of water should be dealt with strictly by the VWSC.
14. Protection and preservation of drinking water catchment areas for source and quality sustainability.

13.1.3 Joint responsibilities :

In the event of natural calamity or emergency, joint responsibility should be shouldered by both PHE&WSD and VWSCs to overcome the situation. PHE & WS shall look for re-infrastructural aspects and permanent restoration of system. Whereas, VWSCs shall support the department in activities like

(a) Restoration of intake works with makeshift headwork.
(b) Cleaning of sediments and debris.
(c) Washing of media, tanks and reservoir.
(d) Carrying, relaying and refixing of pipes.
(e) Construction of temporary wooden/bamboo bridges for crossing or laying of pipes.
(f) Facilitation of local construction materials.

13.2 **Source of funding :**

1. (i) The source of funding for PHE & WS Department may be State's allocation, CSS and any other fund received by the State Government. The schemes to be considered for O&M should be mapped under Gati Shakti portal.

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(ii) State's allocation shall include BE of state plans or any other sources from state's internal or external resources.

2. The source of funding for VWSCs are tariff collection and voluntary donation, FC grants, MGNREGA, other relevant grants from GoI and State-owned Resources (SoR).

13.3. O & M cost of JJM Infrastructure :

1. The average annual O & M cost for intake to WTP inclusive of natural calamity damages will be arrived at on case-to-case basis.

2. O & M cost analysis of in village water supply system

(a) Total Villages = 5509 Nos.

(b) Total households = 230090 Nos.

(c) Average household per village = Total Household/Total Villages ~ 42 Nos.

(d) Approximate O & M cost of in- village components may range from ` 0.50 Lakh in small gravity based schemes to ` 1.15 Lakh in large villages. Whereas, in case of lift water supply schemes, the approximate requirement could be ` 1.90 Lakh. Accordingly, considering less than 20 households as small villages, the monthly O&M cost per HH would come to Rs. 208. For other villages with more than 20 HHs, the monthly O&M cost per HH would come to ` 228.00, whereas, in case of lift based system, the monthly O&M cost per HH would come to ` 369.

(e) O & M cost of in-village water supply system shall be covered by water tariff collection (25%) and remaining (75%) through FC fund or any other State Government allocation.

(f) Minimum tariff shall be decided by the Gram Sabha to be convened by VWSC.

13.4 Role of State /UT Government in maintenance of multi village water supply schemes (MVWSS) and single village water supply schemes (SVWSS) :

1. To make policy decision on fixing of responsibilities of O&M, undertaking new & augmentation projects &repairs etc.

2. Review of operation and maintenance of MVWSS and SVWSS.

3. Review of aspects related to sustainability of water supply systems.

4. To create synergic ally coordinated team of various departments of State Government like Rural Development Deptt, Electricity Deptt, Health Deptt. etc.

13.5 Urban Water Supply Role & Responsibility :

As state has a full-fledged department of public health engineers and as the works related to urban water supply systems are enormous and more technical, therefore, PHE&WSD shall be responsible for O & M of urban water supply systems. However, the district administrations and urban local bodies where ever in place would be responsible for facilitating land for WTP, pipe laying etc. besides in source identification and sustainability matters. 'The Arunachal Pradesh Water Supply Act, 2015' and subsequent additions/modifications would be basis of functioning on matters included therein.

CHAPTER-14

EMERGENCY WATER SUPPLY

14.1 Introduction :

The health of survivors of a natural disaster is exposed to high risk, even if the actual disaster was of short duration. In most disasters and other emergencies, the main health problems are caused by poor hygiene due to insufficient water supply and the consumption of contaminated water. Water and sanitation are critical determinants for survival immediately after and during the initial stages of a disaster. Therefore, the availability of sufficient clean water in the immediate aftermath of a disaster is crucial in order to take care of the sick, provide for human consumption and maintain basic hygiene, support search and rescue efforts, and ensure that productive and commercial activities get back to normal. In addition, the lack of water and water facilities often adversely affects the dignity of those caught up in emergencies.

14.2 Emergency Water Supply and Purification: What and How? :

The general objectives of emergency water supply and purification are:

(a) To protect water sources in order to minimise the risk of contamination and transmission of water borne diseases (immediate objective);

(b) To provide water of a reasonable quantity (immediate objective);

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(c) To improve the physical and biological quality of the water (medium-term objective);

(d) To improve access to supplies through improved water distribution networks and storage facilities (medium-term objective).

After a first assessment of water needs and water sources as well as existing water distribution networks, the optimal of immediate response is chosen depending on the local conditions and implemented. However, upgrading of the systems for long-term water supply and reconstruction has to be considered already at the beginning.

14.2.1 Immediate Assessment of Water Supply :

The first step to provide water in emergencies is an immediate assessment. Questions to be asked are:

(i) How many people need water ?

(ii) What are the problems related to water availability and quality now and how will the situation evolve in some time ?

(iii) Which surface or groundwater sources in the area are affected ?

(iv) How is the water quality of these sources, what is their capacity and how far are they away?

(v) How can this water be brought to the people in need and what are the possibilities for treatment if required?

The concrete measures to be taken after a disaster depend on the answers to these questions, the geographical and climatic context (cold or warm weather; draught or flooding); the reason for people being without water and type of target groups (refugees, internally displaced persons, returnees who may temporarily be accommodated in camps or temporary housing, or populations whose lives have been modified by the emergency, but have not been displaced).

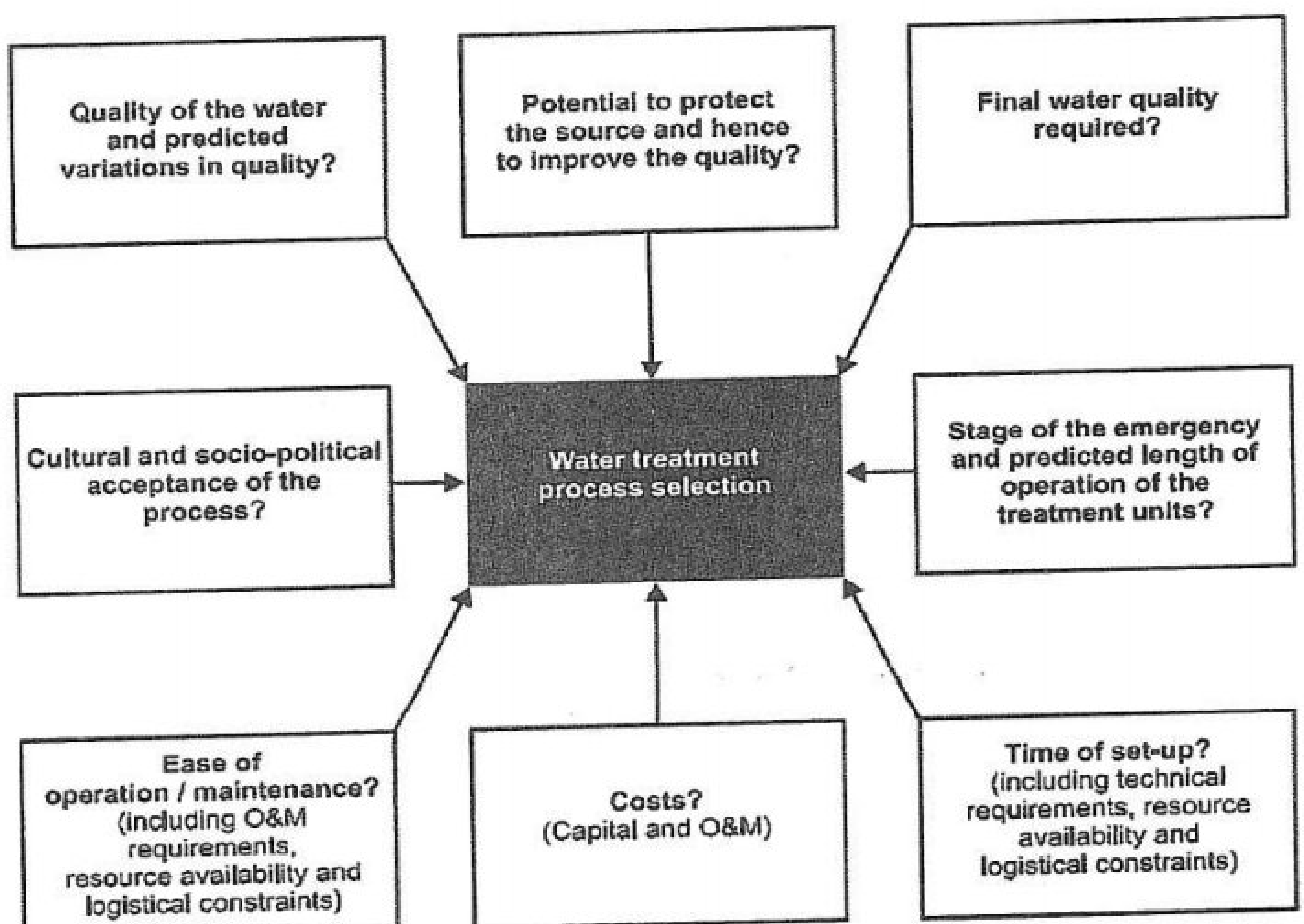

Fig 14.1 : Key factors to be considered when selecting the most suitable water treatment process in case of emergencies.

The on-going assessment of water needs is divided into four typical emergency phases:

(a) Immediate emergency phase, the 1-2 weeks following the event;

(b) Stabilisation phase, typically starting 2 or 3 weeks from and up to 2 months after the event;

(c) Recovery phase, taking several months;

(d) Settlement phase, lasting perhaps years.

14.3 Minimum Standards :

The standard needs of 7.5 to 15 litres per day as the basic water needs per person per day should be considered in emergencies. In some situations, only water used for drinking and preparing food needs to be treated, which still amounts to 5.5 to 9 litres. In refugee situations, 20 litres per person per day for domestic needs and personal hygiene may be considered. The absolute minimum amount of water required for survival is 7 litres.

Survival needs: water intake (drinking and food)	2.5 – 3 litres per day	Depends on the climate and individual physiology
Basic hygiene practices	2 – 6 litres per day	Depends on social and cultural norms
Basic cooking needs	3 – 6 litres per day	Depends on food type and social and cultural norms
Total basic water needs	7.5 - 15 litres per day	

Table 14.2 : The basic survival water needs according to the humanitarian standards

14.4 Water Supply and Purification in Emergencies :

Depending of the availability of water sources and the needs, different options are going to be chosen and for each type of source and type or predicted use (e.g. cooking, washing, medical care, etc.) the right treatment is considered.

The water may be brought to people in need by existing water distribution networks, which may need to be repaired. Either the water is then distributed at water points with or without treatment depending on the use (e.g. drinking, cooking, washing, etc.). In some cases, organisations also choose to promote point of use treatment that users can apply themselves after they have recovered the water manually from the water points or a water tanker. If distribution via a network is not possible, motorised distribution is a very common method in the first phase of emergencies. However, if possible tinkering water should be avoided, as it is expensive and difficult to organise. Water tinkering should be seen as no more than an interim measure to allow for the development of new water sources or the improvement of existing supplies. If there is no viable solution to the water problem, then people should be relocated.

	Camp Water Supply and I Purification (mobile treatment units)		Point-of-use Water Supply and Purification	
Principles	After and during an emergency, a mobile water treatment unit (either pre-assembled or assembled in the field) is brought close to the water source and the people in need and installed and operated by trained staff.		End-users (households and communities) are trained to apply simple multi-barrier methods based on the HWTS approach.	
Typical technologies used	Different units available on the market.		**<u>Sedimentation</u>**, chemical disinfection and flocculation, boiling, SODIS.	
Advantages and Disadvantages	Fast to set up Effective treatment processes	Expensive Requires knowhow to operate and maintain	Low-cost Easy-to-use after short introduction briefing	Requires awareness raising and hygiene promotion High responsibility of user

Table 14.3 : Comparison of semi-centralised (camp water supply) and small-scale supply in emergencies (first response).

It is important to note that in emergencies, the securing of appropriate water quantity is prior to securing that water quality is at safe drinking water level. Quantity is more related to water sources selection (availability, proximity and sustainability of sufficient water quantity), while quality affects hygiene promotion and all aspects of water safety plans.

Simply providing sufficient water will not, on its own, ensure its optimal use or impact on public health. In order to achieve the maximum benefit it is imperative that disaster-affected people have the necessary information, knowledge and understanding to prevent water- and sanitation-related diseases and to mobilise their involvement in the design and maintenance of those facilities.

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Annexure I

Bureau of Indian Standards

Drinking Water – Specifications for some of the important parameters

IS 10500 – 2012 (Second revision)

S. No.	Characteristic	Unit	Requirement (Acceptable Limit)	Permissible Limit in the absence of alternate source
1	Total Dissolved Solids (TDS)	Milligram/litre	500	2000
2	Colour	Hazen unit	5	15
3	Turbidity	NTU	1	5
4	Total Hardness	Milligram/litre	200	600
5	Ammonia	Milligram/litre	0.5	0.5
6	Free Residual Chlorine	Milligram/litre	0.2	1.0
7	pH	--	6.5-8.5	6.5-8.5
8	Chloride	Milligram/litre	250	1000
9	Fluoride	Milligram/litre	1.0	1.5
10	Arsenic	Milligram/litre	0.01	0.05
11	Iron	Milligram/litre	0.3	0.3
12	Nitrate	Milligram/litre	45	45
13	Sulphate	Milligram/litre	200	400
14	Selenium	Milligram/litre	0.01	0.01
15	Zinc	Milligram/litre	5.0	15.0
16	Mercury	Milligram/litre	0.001	0.001
17	Lead	Milligram/litre	0.01	0.01
18	Cyanide	Milligram/litre	0.05	0.05
19	Copper	Milligram/litre	0.05	1.5
20	Chromium	Milligram/litre	0.05	0.05
21	Nickel	Milligram/litre	0.02	0.02
22	Cadmium	Milligram/litre	0.003	0.003
23	E-Coli or Thermotolerant coliforms	Number/ 100 ml	NIL	NIL

Note : Please refer to BIS Standard IS-10500- 2012 (second revision) for other parameters

Annexure II

1. Sanitary Inspection Form for Piped Water

I. Type of Facility PIPED WATER

1. General Information: Zone: Area:
2. Code Number
3. Date of Visit
4. Water samples taken? .... Sample Nos. ....

II. Specific Diagnostic Information for Assessment

(Please indicate at which sample sites the risk was identified) Risk Sample No

1. Do any tap stands leak? Y/N ....
2. Does surface water collect around any tapstand? Y/N ....
3. Is the area uphill of any tapstand eroded? Y/N ....
4. Are pipes exposed close to any tapstand? Y/N ....
5. Is human excreta on the ground within 10m of any tapstand? Y/N ....
6. Is there a sewer within 30m of any tapstand? Y/N............
7. Has there been discontinuity in the last 10 days at any tapstand?Y/N ....
8. Are there signs of leaks in the mains pipes in the Parish? Y/N............
9. Do the community report any pipe breaks in the last week?Y/N ....
10. Is the main pipe exposed anywhere in the Parish? Y/N ....

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Total Score of Risks ..../10

Risk score: 9-10 = Very high; 6-8 = High; 3-5 = Medium; 0-3 = Low

III. Results and Recommendations:

The following important points of risk were noted :(list nos. 1-10)

Signature of surveyor :

Comments:...

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2. Sanitary Inspection Form for Piped Water with Service Reservoir

I. Type of Facility PIPED WATER WITH SERVICE RESERVOIR

1. General Information: Zone: Area:
2. Code Number:
3. Date of Visit:
4. Water samples taken? .... Sample Nos. ....

II. Specific Diagnostic Information for Assessment

(Please indicate at which sample sites the risk was identified) Risk Sample No

1. Do any standpipes leak at sample sites? Y/N ....
2. Does water collect around any sample site? Y/N ....
3. Is area uphill eroded at any sample site? Y/N ....
4. Are pipes exposed close to any sample site? Y/N ....
5. Is human excreta on ground within 10m of standpipe? Y/N ....
6. Sewer or latrine within 30m of sample site? Y/N ....
7. Has there been discontinuity within last 10 days at sample site? Y/N ....
8. Are there signs of leaks in sampling area? Y/N ....
9. Do users report pipe breaks in last week? Y/N ....
10. Is the supply main exposed in sampling area? Y/N............
11. Is the service reservoir cracked or leaking? Y/N ....
12. Are the air vents or inspection cover insanitary? Y/N ....

Total Score of Risks ..../12

Risk score: 10-12 = Very high; 8-10 = High; 5-7 = Medium; 2-4 = Low; 0-1 = Very Low

III. Results and Recommendations:

The following important points of risk were noted:
(list nos. 1-12)

Signature of surveyor :

Comments :

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3. Sanitary Inspection Form for Gravity-fed Piped Water

I. Type of Facility GRAVITY-FED PIPED WATER

1. General Information: System name:
2. Code Number
3. Date of Visit
4. Water samples taken? .... Sample Nos. ....

II. Specific Diagnostic Information for Assessment

(please indicate at which sample sites the risk was identified) Risk Sample No

1. Does the pipe leak between the source and storage tank? Y/N............
2. Is the storage tank cracked, damaged or leak? Y/N............
3. Are the vents and covers on the tank damaged or open? Y/N............
4. Do any tap stands leak? Y/N ....
5. Does surface water collect around any tap stand? Y/N ....
6. Is the area uphill of any tapstand eroded? Y/N ....
7. Are pipes exposed close to any tapstand? Y/N ....
8. Is human excreta on the ground within 10m of any tapstand?Y/N ....
9. Has there been discontinuity in the last 10 days at any tapstand?Y/N ....
10. Are there signs of leaks in the main supply pipe in the system?Y/N ....
11. Do the community report any pipe breaks in the last week?Y/N ....
12. Is the main supply pipe exposed anywhere in the system?Y/N ....

Total Score of Risks ..../12

Risk score: 10-12 = Very high; 8-10 = High; 5-7 = Medium; 2-4 = Low;0-1 = Very Low

III. Results and Recommendations:

The following important points of risk were noted:

(list nos. 1-12)

Signature of surveyor:

Comments :

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4. Sanitary Inspection Form for Deep borehole with Mechanized Pumping

I. Type of Facility DEEP BOREHOLE WITH MECHANISED PUMPING

1. General Information: Supply zone: Location:
2. Code Number:
3. Date of Visit:
4. Water sample taken? .... Sample No. .... FC/100ml ....

II. Specific Diagnostic Information for Assessment Risk

1. Is there a latrine or sewer within 100m of pump house? Y/N........
2. Is the nearest latrine unsewered? Y/N..........
3. Is there any source of other pollution within 50m? Y/N.........
4. Is there an uncapped well within 100m? Y/N.........
5. Is the drainage around pump house faulty? Y/N........
6. Is the fencing damaged allowing animal entry? Y/N..........
7. Is the floor of the pump house permeable to water? Y/N........
8. Does water forms pools in the pump house? Y/N......
9. Is the well seal insanitary? Y/N........

Total Score of Risks ..../9

Risk score: 7-9 = High; 3-6 = Medium; 0-2 = Low

III. Results and Recommendations:

The following important points of risk were noted:

(list nos. 1-9)

Signature of surveyor:

Comments :

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5. Sanitary Inspection Form for Protected Spring

I. Type of Facility PROTECTED SPRING

1. General Information: Zone: Location :
2. Code Number :
3. Date of Visit :
4. Water sample taken? .... Sample No. .... FC/100ml ....

II. Specific Diagnostic Information for Assessment Risk

1. Is the spring unprotected? Y/N........
2. Is the masonry protecting the spring faulty? Y/N........
3. Is the backfill area behind the retaining wall eroded? Y/N........
4. Does spilt water flood the collection area? Y/N...........
5. Is the fence absent or faulty? Y/N........
6. Can animals have access within 10m of the spring? Y/N.........
7. Is there a latrine uphill and/or within 30m of the spring? Y/N.........
8. Does surface water collect uphill of the spring? Y/N........
9. Is the diversion ditch above the spring absent or non-functional? Y/N.......
10. Are there any other sources of pollution uphill of the spring? Y/N........ (e.g. solid waste)

Total Score of Risks ..../10

Risk score: 9-10 = Very high; 6-8 = High; 3-5 = Medium; 0-3 = Low

III. Results and Recommendations :

The following important points of risk were noted :

(list nos. 1-10)

Signature of surveyor :

Comments :

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6. Sanitary Inspection Form for Rainwater collection and Storage

I. Type of Facility RAINWATER COLLECTION AND STORAGE

1. General Information: Zone: Location:
2. Code Number :
3. Date of Visit :
4. Water sample taken? .... Sample No. .... FC/100ml ....

II. Specific Diagnostic Information for Assessment Risk

1. Is rainwater collected in an open container? Y/N.........
2. Are there visible signs of contamination on the roof catchment? Y/N........
   (e.g. plants, excreta, dust)
3. Is guttering that collects water dirty or blocked? Y/N.......
4. Are the top or walls of the tank cracked or damaged? Y/N......
5. Is water collected directly from the tank (no tap on the tank)? Y/N......
6. Is there a bucket in use and is this left where it can become contaminated/N.........
7. Is the tap leaking or damaged? Y/N........
8. Is the concrete floor under the tap defective or dirty? Y/N.........
9. Is there any source of pollution around the tank or water collection area?Y/N.........
10. Is the tank cleans inside? Y/N........

Total Score of Risks ..../10

Risk score: 9-10 = Very high; 6-8 = High; 3-5 = Medium; 0-3 = Low

III. Results and Recommendations:

The following important points of risk were noted:

(list nos. 1-10)

Signature of surveyor :

Comments :

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7. Sanitary Inspection Form for Piped Water Supply with service reservoir and mechanized pumping :

I. Type of Facility Piped Water Supply with service reservoir and mechanized pumping

1. General Information: Zone: Location :
2. Code Number:
3. Date of Visit:
4. Water sample taken? .... Sample No. .... FC/100ml ....

II.

1. Does the pipe leak between the source and storage tank? Y/N.............
2. Does surface water collect around any tap stand? Y/N ....
3. Can animals have access within 10m of the reservoir ? Y/N------
4. Does open defecation is prevalent or cattle-dung is observed within 50 m of the reservoir? Y/N........
5. Is there a sewer within 30m of any tap stand or reservoir ? Y/N--------
6. Are the pipes corroded ? Y/N--------
7. Are there signs of leaks in the mains pipes in the Parish? Y/N.............
8. Are the reservoirs used for human and cattle bathing ? Y/N--------
9. Are the buried pipes ever checked for leakage ? Y/N--------
10. Are storage tanks are cleaned at specified intervals ? Y/N--------

Total Score of Risks ..../10

Risk score: 9-10 = Very high; 6-8 = High; 3-5 = Medium; 0-3 = Low

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8. Sanitary Inspection Form for the source of Dugwell (Ringwell) :

I. Type of Facility : Dugwell/Ringwell

1. General Information: Zone: Location :
2. Code Number :
3. Date of Visit :
4. Water sample taken? …….. Sample No. ……… FC/100ml ……….

II. Specific Diagnostic Information for Assessment Risk :

1. Is there a latrine or sewer within 30m of the dugwell? Y/N………
2. Is the wall of the well lined properly and the well covered adequately ? Y/N……..
3. Does open defecation is prevalent or cattle-dung is found within 50 m of the ringwell? Y/N……..
4. Does the well have raised concrete/cemented platform around its fence?

   Y/N----
5. Is there any water drainage facility available around platform of the well and does the drainage facility leads to water stagnation within 30 m of the wall ? Y/N……..
6. Does the well have fixed stainless steel/aluminium buckets with chain pulley around its fence for drawing water? Y/N…….
7. Is the well deep ? Y/N……………….
8. Does the water of the well appears visibly clean ? Y/N………..
9. Is there any other source of pollution within 10 m of the well? (e.g. animal breeding, cultivation, roads, industry etc) Y/N……..
10. Was the well chlorinated during last 7 days Y/N……..

Total Score of Risks …./10

Risk score: 9-10 = Very high; 6-8 = High; 3-5 = Medium; 0-3 = Low

III. Results and Recommendations :

The following important points of risk were noted:

(list nos. 1-10)

Signature of surveyor:

Comments :

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Annexure III

Activity : Coagulation-Flocculation Process and Trouble shooting

Problems	Operator Actions	Possible process changes
Source water Quality changes Turbidity	1.Perform necessary analyses to determine extent of change 2.Evaluate overall process performance 3. Perform jar tests. 4. Make appropriate process changes (see right hand column possible process changes) 5.Increase frequency of process monitoring	1. Adjust coagulant dosage. 2. Adjust flash mixer/flocculator mixing intensity. 3. Add coagulant aid or filter aid. 4. Adjust alkalinity or pH. 5.Change coagulant(s)
Coagulation process Effluent quality changes		
Turbidity Alkalinity pH	1.Evaluate source water quality 2. Perform jar tests. 3.Verify process performance: (a)Coagulant feed rate(s) (b)Flash mixer operation. 4.Make appropriate process changes	1. Adjust coagulant dosage. 2.Adjust flash mixer intensity (if possible) 3.Adjust alkalinity or pH 4.Change coagulant(s)
Flocculation Basic Floc Quality Changes		
Floc formation	1.Observe floc condition in basin: a. Dispersion. B.Size and c.Floc strength (break up) 2. Evaluate overall process performance. 3. Perform jar tests. a. Evaluate floc size setting rate and strength. B .Evaluate quality of supernatant: Clarity (turbidity) ph. And colour 4. Make appropriate process changes.	1. Adjust coagulant dosage 2.Adjust flash mixer/flocculator mixing intensity. 3. Add coagulant aid. 4.Adjsut alkalinity or ph. 5.Change Coagulant(s)

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