Technical Manual

February, 2015

Department of Water Supply & Sanitation
Govt. of Punjab
## Chapter 1: Introduction

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CHAPTER – 1

INTRODUCTION

Water is called the life stream of a community. The supply of safe water to the community in adequate quantity and quality is one of the important responsibilities of a civic body.

1.1 Objective:
The overall project development objective is to assist Government of Punjab in improving the quality of rural water supply and sanitation service delivery to achieve sustainability of investments. Specifically the objectives would be to institutionalize on a significant scale, decentralization of Rural Water Supply and Sanitation (RWSS) service delivery to Gram Panchayats and user group and build the State’s capacity to scale up the new decentralized services delivery model statewide.

The Punjab Rural Water Supply and Sanitation Sector Improvement Programme, aims at improving the quality of life in rural area by RWSS service standards. The project will adopt a demand response approach and use of participatory process and change the role of Government at all levels from direct service provider to that of a facilitator.

In the Punjab Rural Water Supply and Sanitation (RWSS) sector, present key issues are:

1) Poor operational performance of existing RWSS facilities due to lack of funds coupled with declining ground water sources and deteriorating/poor water quality.

2) Poor sanitation coverage and poor management of existing facilities.

Some of the above issue can be traced to inadequate planning and designing of the existing Rural Water Supply and Sanitation facilities.

1.2 Objectives of the technical manual:
The main objective of this technical manual is to develop guidelines to plan, design, construction, operation and maintenance of water supply and sanitation facilities to be developed/strengthened under the project. The technical manual is produced in a user friendly manner with simple text, sketches / drawings, type designs, rate analysis, estimates etc.

1.3 Scope of the Technical Manual:
The technical manual contains: The significance of water quality, population forecast, design criteria for all technology options for Rural Water Supply and Sanitation schemes, requirements, procedures and guidelines for selection of sources for water supply, methods of field survey and investigations along with guidelines for planning ground water recharge facilities.

Requirements, contents and formats for preparation of Preliminary Scheme Report (PSR), Detailed Scheme Report (DSR), Standard designs, drawings, cost estimates and specifications for typical work & installations proposed under the project such as water supply, sanitation (latrines), lane improvements, drains and other works.

1.4 Methodology to be adopted for preparation of estimates:
Common schedules of rates used by the Water Supply department along with latest ceiling premium shall be used to obtain rates of items covered in the common schedule of rates. However market rates items/goods not covered in CSR shall be obtained by committee of officers from the current price list issued
by reputed manufacturers will be basis for preparation of cost estimates. For the sake of uniformity for plain, kandi, water logged areas analysis of the rates should be prepared and circulated either at zone level or jointly for all zones for estimating purpose only. Water Supply and Sewerage project shall be carried by single responsibility contract system.” However, wherever field conditions warrant more than one package, approval of the concerned Chief Engineer should be accorded citing reasons for the same and a copy of the same should be sent to the Programme Director for record by the concerned Chief Engineer. No centralized purchase of machinery pipes etc shall be carried out. No rate contract shall be carried out with manufacturers or suppliers of materials to be used in the water supply and sanitation project. Inspection /Testing to be done by the engineers to ensure the goods and works are in conformity with the specification. Engineer-in-charge wherever feels necessary for testing of the construction material and untreated / treated effluent the same shall be got tested from nearest NABL approved laboratory which can be traced from the internet. Quality of water sources, shall be got tested from the DWSS laboratory.

1.4.1 Who can use the Manual?

This manual is meant for the following categories of users:

- Gram Panchayat functionaries and GPWSC members involved in planning and implementing the project.
- Govt. agencies and consultants involved in planning and implementing the project.
- Agencies / persons involved in technical administration approval of the project.
- Non-government Organization and Support Agencies involved in planning and implementing the project.

Besides this, manual can also be used as a guide for conducting training programs for the above functionaries.

1.5 Limitations for Manual:

The use of the manual is limited to the World Bank Assisted Punjab Rural Water Supply and Sanitation Sector Improvement Programme with the project philosophy, design criteria and site-specific conditions of the project villages. This manual is an attempt to start the project activities and learning from the project implementation, the guidelines contained in this manual will be modified, if necessary, as the project implementation proceeds.
CHAPTER 2
WATER SUPPLY

This chapter contains the basic design criteria for rural water supply systems, significance of water quality, quality standards, scientific selection of sources and assessment of yield of water from sources.

2.1 Basic Design Criteria

The basic minimum design criteria to be followed in this project are discussed below.
(See Annexure -B)

2.1.1 Per Capita Supply:

The design per capita supply shall be of \( @70 \text{ Lpcd (with addition of 15\% as water losses)} \) for all types of villages. However if any habitation / village wants to design water supply scheme at higher per capita water supply rate they shall be allowed to do so with the condition that it bear all the incremental cost required in addition to basic 10\% share. Water demand shall be calculated for the projected population for the design period of the project which is 30 years for rising main and distribution lines and 15 years for water works structures and machinery.

In a community water supply system, the O & M cost is to be borne by the users. To make the scheme self sustainable, the community shall be encouraged to have house connections so that maximum revenue is realized from the users.

In fluoride affected areas or in water scarcity areas, the minimum per capita supply can be modified after discussion with the community. In some areas, if fluoride free water is to be transmitted over long distances, it may be expensive to operate and maintain and the community may not be able to afford the high user charges. In such cases, the feasibility of dual policy with reduced per capita supply of fluoride free water for cooking and drinking only (about 10 Lpcd) and supply of fluoride water for all other uses as mentioned above with appropriate per capita supply can also be considered.

2.1.2 Source of Supply

The sources for water supply are Deep tube wells or irrigation canal water where potable water is not available from deep tube wells. In Kandi area of Punjab, springs / infiltration galleries may also be used as source of drinking water. In Punjab a rural water supply schemes have traditionally been designed based on Tube wells. However, where the quantity of ground water is insufficient or quality of ground water is not of required standards, surface sources are chosen depending upon the availability. The rural water supply schemes with bore wells and open wells are economically viable and easy to operate and maintain whereas schemes designed with ground water as source are not economically viable and often difficult to operate and maintain by the Rural Communities. Hence, in order to make the surface source schemes viable, which required skilled operation and maintenance, it is preferable to design schemes with surface sources for a group of 3 to 4 villages. In cases wherein the surface water is to be transmitted from a long distance and wherever limited quantity of ground water is available dual supplies for such villages shall also be examined thereby satisfying both quality and quantity requirements.
2.1.2.1 Water Quality:

The drinking water required to the community shall conform to the relevant clauses so as to minimize health hazards to the community. The quality of water supplied shall satisfy the criteria contained in the CPHEEO manual, which are reproduced in this chapter at Annexure- J.

2.1.3 Storage:

Capacity of OHSR shall be calculated by Mass curve (Refer annexure- O) method keeping in view the realistic availability of Electricity and water supply hours. Two number typical mass curves are enclosed as sample for different types of conditions of availability of electricity. As electricity is available for longer hours hence it is being proposed to pump water for at least 8 to 12 hr. Pumping hours will vary as per availability of electricity. Hence before fixing the capacity of OHSR mass curve should be plotted for all the three shifts pumping of water and supply hours. OHSR capacity should be worked out for worst case scenario. The tank shall be located such that the minimum residual pressure at the remotest point in the village is at least 12 mts. If elevated lands are available at a reasonable distance, ground level reservoirs can be proposed for storage of water. If such location is not available, an elevated service reservoir can be proposed with staging such that it gives a minimum residual pressure of 12 mts after counting for loss of head during peak hours due to simultaneous opening of the all the taps on the distribution system.

2.1.4 Treatment:

Ground waters, which are free from odour and colour and turbidity problems, can be supplied after plain disinfection by chlorinating. Surface waters may require conventional treatment consisting of sedimentation, filtration and disinfection. The treatment proposed for water shall be such that it is easy to maintain and operate by the village community. Presence of fluorides requires treatment to remove fluorides, which is not easy for the community to operate and maintain the treatment scheme. Nitrate and TDS cannot be removed in conventional Treatment System. Iron presence, though amenable, its removal becomes difficult and the plant is uneconomical to the community to maintain.

Disinfection of water supply shall be carried out with Bleaching powder/ Sodium Hypochlorite using diaphragm based dosing pumps etc. ‘Dosatron’ which uses Chlorine dioxide and is non-electricity system can also be used to carry out disinfection of water supply.

2.1.5 Distribution system

The project proposes to have piped water supply schemes in all the villages covered in the project. It is expected that there will be substantial demand for individual house connection. Hence, pipe network in the form of dead/loop system (which is mostly suitable for rural areas) shall be planned. For the benefits of community not opting for house connection stand post shall be provided at appropriate places @ one per 150 persons in the villages. However, as explained above use of stand posts shall be discouraged as it results in avoidable wastage. As electricity is available for longer hours, it is proposed to pump water for at least 8 to 12 hr. The storage capacity of service reservoir shall be taken on the basis of mass curve plotted or 30% of the daily requirement.
2.1.5.1 Water Supply Duration and Peak Factor:

Usually water supply is made twice/thrice a day to the village community at the rate of 3 hrs each time which is equal to 6 hrs. Considering improvement in availability of electricity, water supply schemes will be designed for 8 to 12 hr. pumping. It may be further kept in mind that demand of water is more in the morning which may be 1.25 –2 times of the average daily demand. CPHEO manual recommends following peak factors for various population figures:

For population less than 50,000 : 3.0
For population range of 50,000 to 2,00,000 : 2.5
For population above 2,00,000 : 2.0
For smaller water supply schemes : 3.0
(Where water supply is effected through standposts for only 6 hours)

For rural water supply distribution scheme, CPHEEO manual recommend the design peak factor for 4 times of average demand (duration of supply is 6 hours).

Hence irrespective of the population of the village, supplying hours, the peak factor for designing of scheme shall be taken as 3.0.

2.1.5.2 Selection of size of Distribution Pipe:

The size of distribution pipe shall be calculated on the basis of discharge to be carried by the pipe line, pressure requirement and number of connections to be drawn form the pipe by using following formula:

Number of Connections = \( \frac{D^2}{d^2} \)

Where ‘D’ is diameter of main pipe and ‘d’ is the diameter of branch pipe

E.g. if diameter of main pipe is 150 mm and branch pipe is 90 mm then number of branch pipe connections = 2.78 say 3

Size of branch pipe shall also be checked for number household private connections and stand posts to be proposed on the branch line using the following formula:

Number of Connections = \( \frac{D^2}{d^2} \)

Where D is diameter of main pipe and d is the diameter of service pipe

E.g. if diameter of main pipe is 90 mm and branch pipe is 15 mm then number of branch pipe connections = 36
In case of Rural Water Supply Schemes for multi-villages the transmission main from the water works running along Phirni (village ring road) shall not be used as distribution main. The delivery main and distribution system in village should be so proposed that supply to Ist village and any intermediary village/villages is given from only one point on the delivery main and that the delivery main should not be made a part of the distribution system of the Ist or intermediary village/villages. This will ensure equitable water supply to all the villages as supply to individual village can be regulated at one point using the sluice valve. No private connection or stand post should be allowed on the transmission main. (Refer CE Rural Water Supply circular no 34028-34PH/W dated 6.7.78)

2.1.5.3 Design Velocity:
The design velocity in the distribution system shall be not less than 0.6 m per second to prevent silting in the pipes.

2.1.5.4 Material of Pipes:
PVC pipes shall be used for distribution system with appropriate pressure class of 6 to 10 Kg/sq.cm

2.1.6 Depth and Width of Trench required to lay the pipe:
The pipes shall be laid with a minimum earth cushion of 1.0 m. However, in narrow streets 1mt-1.5 mt wide where no vehicular traffic is expected and digging deep may cause danger to the stability of adjoining structures cushion may be reduced to 60 cm. The width of trench required to lay PVC pipes shall be outer diameter+30 cm and wider trench shall only be excavated near the coupler joint. Practice of measuring the uniform width of trench shall be discouraged as for laying PVC pipe a wider trench is only required at joints. It will reduce the damage to the brick paving laid in the village and reduce the cost of excavation and repairing.

For high level and low level areas if difference in elevation is more than 4 meters separate feeders shall be provided. Pressure reducing valves shall also be provided to stop excessive water supply to low lying areas where separate feeders have not been provided.

2.1.7 Pumps:
Submersible pumps shall be provided for all borewells and centrifugal pumps/submersible pumps for canal based water supply schemes. While calculating the capacity of pump, the resulting suction head, delivery head and frictional losses shall be considered appropriately. Only commercially available pump capacities shall be adopted in the project.

Normally Standby pumps are not proposed in rural water supply systems based on borewells and for other sources. Standby pumps shall be provided only in exceptional circumstances. In such cases if the number of pumps installed are more than one, then one standby pump is suggested. For economical selection of the pump, the actual pump capacity required shall be worked out using the family curves furnished by pump manufacturer. However, in arriving at economic size of rising main only overall efficiency of pumps can be taken as 60 % for submersible pumps and 65 % for centrifugal pumps.

Note:
All the above referred design parameters are mentioned in Annexure – B Titled as Design Standards both for Tube well based schemes and canal based schemes
2.1.8. **Ground Water Recharge Measures**:

Due to continuous and over extraction of water from ground, there will be a possibility of drying up of source well in the summer months. Hence, proposals are to be included in the water supply scheme for recharging of ground water through artificial recharge measures depending upon the geological conditions of the area. Possibilities of using Rain water harvesting as a source and roof water harvesting shall also be explored in the project areas. Rain water harvesting shall be used to recharge shallow aquifers as deep aquifers cannot be recharged as deep aquifers are artesian aquifers. By recharging shall aquifers static water table level shall be increased which will cause saving in electricity as head required to pump water shall decrease which will reduce electricity consumption. Various ground water recharge measures based has been explained in chapter :16 of this manual.

2.1.9 **Water quality standards and significance-Norms for Acceptance**

The quality of drinking water affects health of the consumers because certain diseases and toxic chemical compounds may be transmitted by water. Experience has shown that community health and supplied water qualities are directly related to each other and that an improvement of water qualities of drinking water supply is followed by an improvement in the community’s health. Hence, the water supply systems shall provide water that is safe and available in adequate quantity. A water supply engineer is expected to know what diseases are waterborne, what are toxic chemicals and how they get in to water supplies.

2.2. **Attributes of Drinking Water**:

The community’s drinking water shall be –

- Free from disease producing organisms
- Colourless and clear
- Palatable, i.e. free from odours,
- Preferably cool
- Reasonably soft (not hard)
- Not causing scales or corrosion.
- Free from objectionable substances such as hydrogen sulphide, iron, and Manganese;
- Unpolluted by substances in quantities that are toxic or have adverse physiological effects and available in adequate quantities.

2.2.1 **Definitions**:

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

i) **Water Pollution**: It is the introduction into water, substances in sufficient quantity that affects the original acceptable quality of water, making it objectionable to sight, taste and smell and hence making it less useful.
ii) **Water Contamination**: It is the introduction of toxic materials, bacteria, or other deleterious agents into water that make the water hazardous and therefore making it unfit for human use.

iii) **Safe water**: It is the water that can be consumed without menace to the health of the consumer. Sometimes the word pure water is used which is incorrect, in the sense that there exists no pure water.

iv) **Potable water and wholesome water**: Potable water is the water that is satisfactory for drinking purposes from the standpoint of its chemical, physical and biological characteristics and is also known as ‘wholesome’.

v) **Palatable water**: It is the water that is appealing to the senses of taste, sight and smell. Palatable water need not always be potable.

vi) **Water-Natural State**: Water in nature is never hundred percent Hydrogen and Oxygen, it always contains mineral matter in solution or suspension or dissolved gasses.

vii) **Parts per million (ppm) or milligrams per litre (mg/L)**: These terms are used to express the concentrations of dissolved and suspended matter in water. The Parts per million (ppm) is a weight to weight relationship. Except in highly mineralized water this quantity would be same as mg/Lt. This is preferable since it indicates how it is determined in the laboratory.

viii) **pH of water**: It is an indication of the hydrogen ion concentration the water. Alkaline water will have pH of above 7; while acidic water will have pH of below 7; whereas water with pH 7 is neutral.

ix) **Toxic**: It is a harmful, destructive, or deadly poisonous chemical.

x) **Physiological Effects**: These are the effects which change the normal functions of the body.

xi) **Pathogens**: These are the disease-producing bacteria present in water.

xii) **Bacteria**: These are groups of universally distributed, essentially Unicellular microorganisms, lacking chlorophyll.

xiii) **Coliform bacteria**: These are groups of bacteria predominantly inhabiting the intestines of human beings and animals but also occasionally found elsewhere. Their presence indicates pollution of water by sewage.

xiv) **Enteric**: Having its normal habitat in the intestinal tract of human beings or animals.

xv) **Virus**: The smallest form of bacteria capable of producing disease in human beings.

xvi) **Chlorine residual**: Chlorine remaining in the water at the end of a specified period.

xvii) **Chlorine demand**: The differences between the amount of chlorine added to water and amount of residual chlorine remaining in the water at the end of a specified period i.e. after total disinfection.

2.2.2 **Water and health of community**

Community’s health is affected by drinking water quality because –
(i) Certain disease causing bacteria are enteric and survive long enough in water to infect the water users.

(ii) The excreta of human beings and warm-blooded animals contain bacteria harmful to human beings, and these bacteria can find their way into drinking water sources.

(iii) Chemical substances affecting the health of people can also enter drinking water sources.

2.2.3 Natural water:

Water free from both bacteria and dissolved chemicals is seldom found in nature. Water falling as rain, snow or hail washes impurities out of atmosphere; some of these may be present as solids or some may be dissolved. The first water that falls tends to be higher in material removed from atmosphere than that falling later. Even prolonged rainfall may not completely clear the air. Rain water and snow may have dissolved solids as high as 150 mg/Lt and total hardness up to 40mg/Lt. In industrial areas due to air pollution carbon dioxide dissolves into rain water. This phenomenon is known as Acid rain. Normally, the pH value of rainwater is 6.7 to 6.9. Rainwater is also saturated with dissolved oxygen from the atmosphere.

2.2.4.1 Environmental significance of water quality:

Water that is clear and colorless gives an impression that is safe for human consumption. This may not be correct, since both disease causing bacteria and objectionable matter may be present but invisible to naked eye. Water quality parameters are classified as physical, chemical and biological nature. The environmental significance of some common parameters of water quality is given below:

2.2.4.1 Physical Parameters:

Turbidity:

Any turbidity in water is associated with pollution and associated with health hazards arising out of it. Increased turbidity makes treatment difficult and costly due to increase in chemical coagulation costs and increased frequency of cleaning the filters. In turbid waters the pathogenic organisms may be trapped in the turbid particles and hence protected from the disinfectant. Ground water is less likely to contain turbidity. Turbidity of surface water may settle down by plain sedimentation.

Colour:

Natural colour may be acquired by water from decay in swamps and forests; but the colour may not be harmful. The fact is that if the potable water is having colour and hence aesthetically not acceptable, the consumers tend to seek water from other sources which may not be safe. Ground water is less likely to contain colour and surface water may contain colour due to industrial activity. However colour is not removed in conventional treatment adopted in Rural Water Supply Schemes.
Taste and Odour:

Both should not be noticeable to consumers. Taste is not measurable but should not be objectionable. For odour, Threshold Odour Numbers (TON) are given to indicate the dilutions required for the odour to disappear. It should be preferably one and not greater than three. However, odour is not removed in conventional treatment adopted in Rural Water Supply Schemes.

2.2.4.2 Chemical Parameters

Carbon dioxide And Mineral Acidity:

Water that contains mineral acidity is unpalatable. Acidity causes corrosion and affects the consumption of chemicals in water softening.

Alkalinity:

Measures the content of bicarbonates, carbonates and causticity of waters. Waters that contain high alkalinity are unpalatable. Chemically treated water sometimes may have high alkalinity. Alkalinity is important in coagulation and corrosion control. However alkalinity is not removed in conventional treatment adopted in Rural Water Supply Schemes.

Hardness:

Calcium and Magnesium compounds cause hardness-soap consuming property. Hardness is derived by water largely from contact with soil and rock formations. In general hard waters originate in areas where top soil is thick and limestone formations are present. Soft waters originate where topsoil is thin and limestone formations are absent. However Hardness is not removed in conventional treatment adopted in Rural Water Supply Schemes.

Total Dissolved Solids (TDS):

Waters with TDS of less than 500 mg/Lt are suitable for domestic use. Waters with higher TDS have a laxative effect upon people who are not accustomed to it. Conventional treatment methods don’t address the removal of TDS. This can be removed only through distillation and reverse osmosis membrane filtration. However TDS is not removed in conventional treatment adopted in Rural Water Supply Schemes as this is not economically viable and cannot be maintained by the rural communities.

Chlorides:

Chlorides impart salty taste if present beyond 250 –mg/Lt. Unusual presence of Chlorides in water indicates contamination of ground water with wastewater. However Chlorides are not normally removed in conventional treatment adopted in Rural Water Supply Schemes.

Nitrogen salts:

They may be reported in the form of free ammonia and Nitrates (nitrates in terms of Nitrogen). When present beyond trace amounts, indicate pollution by human wastes. Water containing
organic and ammonia nitrogen indicate recent pollution; water-containing nitrogen in the form of nitrates indicate pollution; water-containing nitrogen in the form of nitrates indicate pollution that has occurred a long time back. Waters with appreciable amounts of nitrites are of questionable character. The amount of ammonia nitrogen determines the efficacy of chlorinating. Nitrates in water may be due to ‘agricultural run off ‘water source, due to fertilizer use, leaches from septic tanks, sewerage and erosion of natural deposits. Excessive amounts of nitrates in drinking water causes ‘blue baby syndrome disease’ (methaemoglobineamia) in infants under six months which is a threat to life if immediate medial attention is not available. The infant looks blue and has shortness of breath. However Nitrates are not removed in conventional treatment adopted in Rural Water Supply Schemes.

**Dissolved Oxygen:**

Dissolved Oxygen (DO) is of significance in corrosion of iron and steel particularly in distribution systems. However DO is not removed in conventional treatment adopted in Rural Water Supply Schemes.

**Fluorides:**

Minimum of 1 mg/lt may be required to prevent dental carries; but beyond 1.5 mg/lt may cause staining of teeth/dental fluorosis and also skeletal fluorosis. Treatment units set up in India for removal of excessive fluorides in Rural water supply schemes are so far not functioning satisfactorily.

**Iron:**

Iron may be present in water as a dissolved impurity from the earth’s crust or enter the water supplies from corroded pumps and pipes. Excess iron may cause staining of clothes during washing, stains on plumbing fixtures and encrustation and deposits on the interior surfaces of the pipe. Treatment units set up in India for removal of excessive Iron in Rural water supply schemes are so far not satisfactory.

**Manganese:**

Manganese at lower concentrations causes troublesome deposits in mains. However Manganese is not removed in conventional treatment adopted in Rural Water Supply Schemes.

2.2.4.3 **Trace elements**

**Barium:** Even at 1 mg/l it causes muscular and cardiovascular disorders and Kidney damage.

**Cadmium:** At low levels and exposure for prolonged periods it causes high blood pressure, sterility among males, kidney damage and flu like disorders.

**Chromium:** Beyond 0.05 mg/lt it is carcinogenic.

**Copper:** Beyond 0.05 mg/lt it is found to be toxic to fish.
**Lead:** Beyond 0.05 mg/1 it causes brain and kidney damage. In youngsters it may cause mental retardation.

**Mercury:** At very low concentration it forms methylated mercury compounds which are toxic to human beings and fish.

**Silver:** Has no adverse effect but silver salts are good disinfectants.

**Arsenic, Selenium & Cyanide:** They are toxic and carcinogenic, however none of the trace elements are removed in conventional treatment adopted in Rural Water Supply Schemes.

### 2.2.4.4 Biological Contaminants:

**Bacteria:** Diseases caused by waterborne bacteria are always intestinal and include typhoid, dysentery, cholera and gastro-enteritis.

**Viral:** Infectious hepatitis may be waterborne.

Slow sand filtration may remove bacteria and viral contaminants. Disinfection with bleaching powder, chlorine dioxide or any other disinfectant alone makes the water wholesome. However, due to labour problem for regular sand washing of slow sand filters, continuous sand filtration should be preferred.

### 2.2.5 Sanitary Survey:

Water safety and quality are maintained through water treatment, disinfection and prevention of pollution and contamination. Rural water supplies are normally disinfected using bleaching powder, which makes the water wholesome. However, it will be necessary to search for sources of contamination and prevent such contamination of drinking water supplies.

**Identifying sources of contamination:**

Surface run off comes into contact with wastes containing pathogenic bacteria or the storage reservoirs may get inflows of domestic sewage and or industrial effluents. Contamination from domestic waste can enter the raw water sources such as borewells or open wells. Casing pipes for sufficient depth can prevent such entry of wastes into borewells. Watertight seining has to be proposed for sufficient depth to prevent entry of such wastes into the open wells. Harmful wastes can also enter the water distribution systems through cross connections or back-siphonage conditions. A systematic sanitary survey can be undertaken to identify the sources of contamination and preventive measures taken where necessary.

### 2.2.6 Water Quality Reports:

The following are the observations to be incorporated in the tabular form while preparing the reports –

1) Review of existing Water Quality status in project villages.
2) Details of all existing water supply schemes / sources (Number of BW/OW/Traditional Tanks, etc., working/defunct) with clear markings (painted with blue colour for potable
sources and red colour for non potable sources) of the sources in the village (using geographical/global positioning systems).

3) Latest water supply analysis (physical, chemical and biological tests)/water quantity yield results of all working sources should be incorporated in the report enclosed as Annexure I.

4) Compare the latest water quality results with old available data (secondary data from Water Supply and sanitation department ) and find out the difference.

5) Justify the proposed source details from the quality angle. Also mention the distance of this source from the existing potable/non-potable sources.

2.2.7 Review of source water quality:

After the water quality report is received the parameters may be compared with the standards and if the water satisfies the standards the same source can be accepted with disinfection only. If fluorides and TDS are present in excess of permissible limits, dilution if possible can be one of the options. Conveying potable water from distant source either surface or ground water can also be other option. If nitrates and iron are higher, it is necessary to search for the source of contamination and take remedial measures. However, treatment of such water for removal of iron and nitrates is not a viable option in villages. If the contamination is not traceable and if the presence of iron and nitrates is due to natural acquisition, then another source is to be selected. Use of PVC casing pipe avoids corrosion, also extending the casing pipe up to 12 m will enable prevention of ingress of nitrates. Treatment for removal of fluorides and Iron shall be the last option since the rural community cannot operate and maintain such treatment plants.

2.2.8 Scientific selection

Scientific selection of water sources is more important for the project area since the ground water table has been depleting very fast. Hence, the locations selected for water sources shall be amenable for encouraging ground water into the aquifers. The presence of underground fractures in the geological formations will encourage the seepage of the water into the aquifers. The deeper the fractures, better will be yield. Hence, while doing the geophysical survey for selection of source, particular attention is required to this aspect. The technology has progressed and now there are more reliable methods for conducting geological and geophysical investigations with instruments working on very low frequency (VLF).

The exploration methods that can be adopted to locate the ground water are:

1) Geological methods: Demarcating the boundary between lithologic units, faults, fractures, fissures, formation characteristics, lineaments, and dykes, intrusive and shear zones.

2) Remote sensing techniques: Interpretation of satellite images to locate lineaments and other structural discontinuities, mapping of various hydrogeomorphic unit, vegetation, soil, and land use and land cover categories.

3) Geophysical methods: Surface geophysical surveys using electrical resistivity, electromagnetic, seismic and magnetic methods to delineate the weak and water-saturated zone.

2.2.9 Geophysical exploration:

Geo Physical methods comprise measurement and interpretation of signals from natural or induced physical phenomenon generated as a result of a subterranean formation. These signals
measured repetitively at several points of space and time are approximately interpreted, considering the available geological information, in terms of such sub-surface structures/features as may themselves have good ground water potential or are indicative of good aquifers. Knowledge of the geology of ground water areas is essential to establish the water bearing formulations. Surface geology, exposed due to quarrying, mixing etc. provide useful information. Well logs of existing wells (records that give the nature and depth of various strata that were encountered during sinking of the wells) also contribute as a supplementary information in assessing the nature of the sources being explored.

2.3 Geomagnetic:
Measurements of variations of gravity and of the earth’s magnetic field are made with the aid of the torsion balance and the magnetometer. These instruments do not determine the presence of water itself. They suggest the location of geological structures that may be favourable water carriers.

2.3.1 Acoustic and Seismic:
Acoustic and Seismic methods measure the speed of travel and sound and shock waves through the underground formations. Dependence of wave velocity upon the density of the materials through which it passes makes it possible for a geophysical analysis of the test area. This also indicates the presence of water in the test area being explored for water. Measurements are made as wave reflection for deep strata exploration and on wave retraction when water bearing formation is near the surface of the earth.

2.3.2 Electrical Resistivity:
The resistance of the ground is determined by impressing a current on electrodes inserted in the ground. A drop in resistance shows the presence of water within the water bearing stratum, the depth of penetration of the current being approximately equal to the electrode spacing.

It is essential to take the assistance of the departments/agencies experienced and engaged in such investigation to assess the water potential for selection of a suitable ground water source for the community water supply.

Resistivity data for rock formations in Punjab

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Resistivity Ohm-m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly weathered and saturated Gneiss/Granite</td>
<td>≤40</td>
</tr>
<tr>
<td>Weathered and saturated Gneiss/Granite</td>
<td>40-80</td>
</tr>
<tr>
<td>Weathered but less saturated</td>
<td>80-170</td>
</tr>
<tr>
<td>Un-weathered Granite/Gneiss with water filled joints</td>
<td>170-400</td>
</tr>
<tr>
<td>Massive rock</td>
<td>&gt;400</td>
</tr>
<tr>
<td>Vesicular basalts saturated with water</td>
<td>100-150</td>
</tr>
<tr>
<td>Highly weathered basalt saturated with water</td>
<td>5-10</td>
</tr>
<tr>
<td>Gravelly sands with fresh water</td>
<td>100</td>
</tr>
<tr>
<td>Shale and clay</td>
<td>1</td>
</tr>
</tbody>
</table>

2.4 Assessment of yield:
An accurate assessment of the yield of the source is essential to decide which source can be dependable.
The yield of borewells is to be assessed preferably in the lowest seasonal water level conditions. In Punjab, the preferable season for conducting yield test is from April to June, when the summer is at its peak and rainfall has not yet set in. Yield test units are available which can be used to pump out the water from the borewell for a maximum period of six hours at a time. Care should be taken that the water pumped out is led away from the source and does not re-enter the source. The draw down and discharge are measured and the results tabulated from which the safe yield is calculated. The assessed yield is multiplied by a coefficient to arrive at the safe yield from the source to account for the seasonal variations and also to prevent over exploitation from the borewell, which may lead to collapsing of the borewell. In case the yield test is conducted during non-summer months, a suitable coefficient for assessing the safe yield has to be used. While drilling the bore wells, it is essential that a correct record of the strata of the borewell and the depths of water column are noted in a dated long book and this record must be made available at the GP. Maximum permissible size of pump to be installed in the Tube Well should be clearly mentioned at the wall of the Pump chamber to prevent over pumping from the Tube well.

For assessing the yield from infiltration wells sunk in the riverbeds the same methods as described above is used for determining the safe yield from the source. In the case of canals, the levels at which water can be made available and the quantum of water and the period for which the canal is flowing are used to assess the sizes of various components of the water supply scheme.

2.5 Water Quality Monitoring

Supply of safe drinking water in adequate quantity to the public is a prime responsibility of a civic body. This task could be achieved if and only if the water supply agency is adequately equipped with necessary infrastructure for routine water quality monitoring and control. Presently, there is no agency with a well defined mandate for routine water quality monitoring and control of rural water supply in the State. The EE in-charge checks the potability of any newly established tube wells/surface source by conducting all the tests on the water samples collected. If the quality parameters are within the prescribed limits, the source is developed and allowed to be used by the community. If the water does not satisfy the required quality parameters, new bore wells are drilled after conducting detailed geophysical surveys. In areas where ground water is not potable canal based schemes are designed. Raw water is collected from canals and after treatment supplied to the community. It is very important that a suitable mechanism should be adopted to have regular quality surveillance. During rainy season water quality surveillance should be more stringent.

2.5.1 Water Quality Surveillance:

2.5.1 A Disinfection:

Each water supply scheme shall be equipped with adequate equipment like Dosing Pumps/Silver ionization plant to disinfect water supply at source. If water supply is to be chlorinated then Bleaching Powder/Sodium Hypochlorite shall be used for chlorination. Normally dosage of chlorine at source is @ 0.5 to 1.0 mg/lt. Dosage of chlorine should be kept at a level so as to ensure that residual chlorine at tail end is 0.1-0.2 mg/lt. Quantity of Bleaching powder/Sodium hypochlorite/Chlorine Dioxide shall be calculated as per annexure – A. Tube Well Operator/Water Works attendant shall regularly maintain record of disinfection at water works site and he shall check residual chlorine available at various points in the distribution.
points. He shall visit peoples houses at regular intervals and check the residual chlorine available in their house. He shall maintain record of checking as per below sample performa.

<table>
<thead>
<tr>
<th>Date</th>
<th>Name and designation of sampling officer/official</th>
<th>Location of Sampling Point</th>
<th>Residual Chlorine present in the sample</th>
<th>Residual chlorine present in the sample drawn at water works</th>
<th>Name and address of the person who was resent at the time of sampling and his signatures</th>
</tr>
</thead>
</table>

2.5.1.1 Water Quality Surveillance Programme

a. **Objective:**
   i. To ascertain the quality of water in various rural water supply schemes (Tubewells or canal based) as well as in the distribution network.
   ii. To examine physico-chemical and bacteriological quality to establish whether the drinking water is fit for human consumption and meets the standards as laid down in IS - 10500 : 2012 (Second Revision).

b. **Location for sampling:**
   Selection of location for sampling should indicate true representative samples.
   i. Public Stand Posts
   ii. Selected consumer locations at random
   iii. In addition to above, raw water source and treated water should also be analyzed in case of canal based water supply schemes.

c. **Type of sampling:**
   Generally, for drinking water quality monitoring, grab samples should be preferred.

d. **Frequency of sampling:**
   Mainly depends on population served, size, source and type of the scheme. Frequency of sampling shall be done as per Uniform Drinking Water Quality Monitoring Protocol of Ministry of Water and Sanitation, GoI.

<table>
<thead>
<tr>
<th>Source</th>
<th>Minimum frequency of sampling and analysis</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bacteriological</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical/Chemical</td>
<td></td>
</tr>
<tr>
<td>Tubewell based</td>
<td>Once initially, thereafter as situation demands.</td>
<td>Situation requiring testing : change in environmental conditions, outbreak of water borne disease or increase in incidence of waterborne diseases.</td>
</tr>
<tr>
<td></td>
<td>Once initially, then 2 times yearly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Once initially then 2 times yearly.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Residual chlorine test daily</td>
<td></td>
</tr>
<tr>
<td>Canal based</td>
<td>Once monthly</td>
<td>Increase frequency of bacteriological test if situation demands.</td>
</tr>
<tr>
<td></td>
<td>- Once initially then 2 times yearly.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Residual chlorine test daily</td>
<td></td>
</tr>
</tbody>
</table>

e. **Precautions to be taken during collection, preservation and storage of samples**

i. Properly labeled sampling bottles to avoid any error.
II. No significant change in samples between time of collection and conducting water analysis and samples should be dispatched to lab under iced conditions as soon as practicable.

III. Samples should be examined maximum within 24 hours after collection.

IV. De-chlorination is prerequisite for sampling for bacteriological examination.

V. No contamination should take place while collecting the sample prior to examination especially for bacteriological tests. For taking sample of water from a tap on distribution system, allow the water to run for 4 to 5 minutes to allow cleaning of service pipe.

VI. The water sample shall be collected and its data sheet as per Annexure I should be filled up along with sample for onward submission to Water quality testing lab.

g. **Quantity of sample**
   1. For physical and chemical examination, two liters of samples in colourless or pale green bottles.
   2. For bacteriological examination 250 ml sterilized glass bottles provided with ground glass stopper.

**g. Quality of drinking water desired**
Quality of drinking water should meet with the standards as prescribed in IS-10500: 2012 second revision. Refer table placed at Annexure –J

2.5.1.2 Present status of rural water quality surveillance and lab infrastructure proposed

Adequately equipped analytical laboratory with competent analysis is an important and an integral part of any water quality monitoring and surveillance programme. The analytical determinations of different physical, chemical, biological and bacteriological parameters must be carried out most efficiently and accurately. However, the laboratory infrastructure needed shall necessarily depend upon the level of analysis desired, location and other support facilities available.

Realizing the need to institutionalize water quality monitoring and surveillance system, Government of India in Uniform Drinking Water Quality Monitoring Protocol has formulated a implementation plan based on three tier structure or catchment area approach where existing resources available with grass root level education and technical institutions would be utilized. In case of need be, these institutions would further be strengthened by providing additional financial sources. DWSS is also planning to set-up three tier structure of lab facilities, so as to make the system foolproof and also to ensure the public participation.

- **Village level**: To make the WQS programme more effective, DWSS is distributing water testing kits to community based organization i.e. Gram Panchayat Water & Sanitation Committee (GPWSC), which would mainly the representative of various segment of community living in the village itself. Further, these GPWSCs would act as an extension of district/village administration. Under WQS programme, field kits for both chemical and bacteriological analysis would be provided to 10+2 schools having science stream or in the primary rural Health Centres. These field kits would mainly indicate the presence of turbidity, pH, hardness, chloride, fluoride, iron, residual chlorine and bacteriological quality. The field kit will be basically meant for qualitative assessment of water and would help to identify unsafe drinking water supply system immediately. In case, water is unfit for drinking, samples would be sent for detailed investigations to the district labs.
District level: In addition to 8 sub. Divisional level lab, 22 district level labs are already functional. Small portable kit capable of measuring temperature, conductivity, pH and dissolved oxygen is being provided so to as to carry on the spot tests, besides district labs also have lab equipments, chemicals and glassware.

State level: One State level water quality testing laboratory is functioning in Public Health Department Head Office Patiala since 1962. Whereas, DWSS has approved Punjab Pollution Control Board lab at the State level for any arbitration or reconfirmation of the results.

Further for facilitating effective water surveillance programme, 3 mobile water testing laboratory is also in operation which independently helps in identification of source of contamination.
CHAPTER-3
POPULATION FORECAST

In this chapter, various methods of population forecast and assessment of the demand for designing water supply scheme are discussed.

3.1 Population Forecast

Present population will be available from figure of census for 2011. Forecast of population shall be calculated based on arithmetic progression, geometric progression, incremental increase and national average. However, village specific assessment of growth potential shall be taken into consideration while arriving at the final population forecast. Population forecast shall be done considering the following factors:

- Trend of population growth in the previous decade (from 2001-2011 Census Figure)
- Possibilities of village growth due to factors such as industrial projects and other projects which influence the growth of population.
- Any special factors causing sudden influx or migration of population like proximity to a city/town.

The population growth in any region can be assessed either through graphical methods or arithmetical methods as discussed below :

(Sample calculations for Population forecast are enclosed at Annexure K)

3.1.1 Demographic Method :
Population change can occur only in three ways – (1) by births (population gain), (2) by deaths (population loss) or (3) by migration (population loss or gain due to ‘movement out’ or ‘movement in’ occurs in excess)

Population forecasts are made by assessing separately the births, the deaths and migration and then summing them up to get the net effect for the considered projection period.

Diseases, Epidemics, Catastrophic natural calamities and other technological changes are the possible causes of error in forecasting the population correctly in this method.

3.1.2 Arithmetical Progression
This method is based on the assumption that population increase at constant rate. A Constant increment growth is added periodically, based on the past records. This method generally gives a low rate of population growth and can be used for villages where the growths are not conspicuous and practically controlled.

3.1.3 Geometrical Progression Method
In this method, percentage increase or percentage growth rate per decade is assumed to be constant, and the increase in compounded over the existing population every decade. This
method normally gives larger values of population and is used for areas with unlimited scope for expansion and where a constant growth rate is expected.

3.1.4. **Logistic Method**

When the various factors affecting the population growth do not change abnormal, the groups of population follow a ‘S’ curve, called a logistic curve.

This method is suitable for areas where the rate of increase or decrease of population with time is likely to reach a saturation limit ultimately because of specially local factors. The growth rate of which follows a logistic curve will plot as a straight line on the arithmetic paper, with time intervals plotted against population in percentage of saturation.

3.1.5. **Incremental Increase Method**

In this method, the average in incremental increase is calculated from the available data. To the present population, the average incremental increase per decade is added and the population of next decade is obtained. Like this, the process is repeated till the population in the desired decade is determined.

3.1.6. **Graphical Comparison Method**

This method involves the extension of the population- time curve into the future based on a comparison of a similar curve for comparable areas and modified to the extent depending on the factors governing such predictions. The method has a logical background, and if statistics of similar villages are available, quite precise and reliable forecast can be made. However, it is very difficult to get identical villages with respect to population growth.

3.1.7 **Population forecast for Peri-Urban Areas**:

It has been observed that growth of population in rural areas near main cities grows at rate higher than the rate of growth for other villages. These areas falls under the Peri Urban area category. It is proposed that in all Rural areas falling under a radial distance of 5 Km from Class A and B cities population growth rate shall be calculated by Graphical comparison method. In case no such comparison is available then Population growth rate of such areas shall be determined by using Geometrical progression method.

3.2 **Final Prediction**

The design of rural water supply and sanitation schemes shall be based on actual existing population with realistic projection for the project using the methods described above. However, the per year growth rate must be taken @ 0.798 % per annum based on census 2011.

Software packages are available for estimation (using the methods described earlier) of population growth and the same shall be used in the project.
CHAPTER – 4

TYPES OF SOURCES FOR WATER SUPPLY

This chapter provides information on various types of sources that can be used for providing water supply to rural communities.

4.1 Hydrological Cycle:

Hydrological Cycle is a process by which nature circulates water from the oceans and other water bodies through the atmosphere and returns it back to land. This water finds its way into underground and to the sea through various paths. Radiation from the sun also evaporates the water from the surface sources (including oceans) into the atmosphere. The water vapors rise into the atmosphere and form clouds. Under certain conditions the clouds condense and water falls back to the earth as rain. Some of the rainfall runs over the surface to the streams and some portion of the water percolates into the ground by infiltration. The rate of infiltration depends upon the terrain, soil and geological characteristics, climate etc in the area. Usually, if intensity and duration of rainfall rate is much higher than the infiltration rate, water starts flowing on the surface and will collect in depressions forming lakes, ponds etc. and further excess water flows into streams and rivers and reaches the sea. This is known as surface run off.

Hence the source for water supply shall be either from ground water or surface source.

4.2 Ground Waters:

Ground water has been traditionally the main sources of drinking water in Punjab. With the advent of drilling rigs and consequent indiscriminate extraction of ground water from deeper Aquifers, mainly for agricultural purposes, the yield from the Tubewell sources is depleting at a fast rate. Apart from depleting ground water table, there had been an increase in concentration of Total Dissolved solids that seriously affect the quality of drinking water. Hence, there is a need to select the Tubewell sites on a scientific basis, which will have sustenance as sources of water and amenable for recharge. The sustainability of the tube wells as drinking water sources can therefore be ensured by applying the provisions of legislation strictly and appropriate ground water recharge measures.

4.2.1 Tubewells

Tubewells collect the ground water infiltrated to deeper layers in the soil strata compared to dug wells and hence the quality of water will be good and can be supplied after disinfections (using bleaching powder.) Tubewells have been successfully used in rural water supply in Punjab. This is an acceptable technology option for rural communities since the irrigation tubewells are being operated and maintained by the communities. The market facilities are available in the project districts to supply the pumps/spares and also to provide skilled personnel for repairs and servicing. With the advent of modern drilling rigs it is possible to drill as much as 300 m below ground level even penetrating hard rock formations. Submersible pumps fitted to a small diameter pipe are installed in these Tubewells. Depending upon the entry of water into the well, the tube wells are classified into cavity tube wells and screen type tubewells.
4.2.2 Driven Wells (Hand Pumps):

Hand Pumps are installed by drilling small diameters pipes up to about 100 M depth as per India Mark-II/III design. The driving end is fitted with a pointed ‘drive point strainer’. The pipe is connected to a pump or hand pump. These are suited in soft soils, if ground water is available at shallow depths. All the following standards including amendments of India Mark II Hand Pump, Deepwell /India Mark III hand pumps (VLOM) and extra Deepwell Hand pumps have been amalgamated in IS 15500 (Parts 1 to 8) : 2004:

- IS 9301:1990 Deepwell handpumps – Specification (third revision)
- IS 13056:1991 Deepwell handpumps (VLOM) – Specification
- IS 14107:1999 Special tools for Deepwell handpumps – Specification

In Fig.-1 (Drawing) typical details of Deepwell Hand Pump as per Indian Standard are illustrated.

4.2.3 Springs:

The springs are also a technology option for rural water supply but are found in hilly areas of Gurdaspur district only. Springs occur due to the emergence of base flow as ground water to the surface. Springs may be either perennial or intermittent. The discharge of a spring depends on the nature and size of catchment, recharge and leakage through the sub surface. Their usefulness as source of water supply depends on the discharge and its variability during the year. To select the spring as source of water supply, it is necessary to ensure its dependability by measurement of flow, local enquiry and study of catchment area, rainfall in the area. Suitable intake and collection structures are to be planned to meet the requirement of the scheme. Normally, the springs occur at elevated locations and hence the supply to the community can be by gravity avoiding pumps.

4.2.4 Percolation Wells:

It is large diameter dug up well adopted generally in Kandi Area nearer rivers of Perinial source. Where static water level is not so deep i.e in the range 10 to 15 meter and there are no chances of contamination. It is dug up manually and its diameter is in the range of 5-8 meter depending upon the requirement water.

4.3 Methods of Drilling

There are numerous methods of drilling wells and each method has advantages related to ease of construction, cost factors, character of formations to be penetrated; well diameter and depth, sanitary protection and intended use of the well itself. The basic principles of some of the methods are described here.

4.3.1 Percussion Drilling

The percussion method, often referred to as cable tool method, is one of the oldest, most versatile and simplest drilling methods. A string of tools suspended on a cable is given up and down spudding motion either manually or by power. The string of tools, in ascending order, consists of a bit, a drill stem, drilling jars and a swivel socket which is attached to the cable. The bit strikes the bottom of the hole, crushing, breaking and mixing the cuttings. Above the water table or in
otherwise dry formations, water is added to dissolve the cuttings which are lifted out by means of a bailer. This method is most suitable for drilling in stratum where large boulders are encountered in abundance at different depths.

4.3.2 Direct Circulation Drilling:

The rotary rig drills by mechanical rotation of a drill bit at the bottom of a string of drill pipe. The typical string consists of a bit which scrapes, grinds, fractures or otherwise breaks the formation drilled; a drill collar of heavy walled pipe to maintain a straight hole; and a drill pipe which extends to the surface and imparts rotation to the bit. As the bit is turned drilling fluid (usually bentonite mixed with other suitable material) is circulated under pressure which lubricates and cools the bit, carries the cuttings in suspension to the surface, and plaster the wall of the hole to prevent caving in.

4.3.3 Reverse circulation drilling:

The reverse circulation rotary rig operates essentially in the same way as a direct rotary rig except that water is pumped up through the drill pipe rather than down through it. A string of drill pipes with a drill bit at the bottom is rotated by mechanical means. Plain water or a drilling fluid, depending on the strata conditions, is allowed to flow into the borehole; the drill cuttings along with water are sucked through the drill pipes by a centrifugal pump and thrown into a settling pit.

4.3.4 Down-the-Hole (DTH) Hammer Drilling:

It is accomplished by a tool called the down-the-hole hammer which is essentially a pneumatic hammer operated at the lower end of the drill pipe and combining the percussion and the rotary actions. The method utilizes compressed air for the rapid impacting action given by the hammer to the bit, thus crushing the formation into small chips which are flushed out through the annular space between the bore and the drill pipes by the up coming compressed air.

4.3.5 Hand Boring:

This method is employed in soft stratum. In this method or power driven auger is used for the emaciation purpose. By means of rope the bailer is manually lifted and then allowed to drop, the soil is filled in the hollow portion of the auger, which is removed from time to time. In this method of boring the correct position of aquifer is also noted. The depth and length of water bearing stratum and hard stratum etc are correctly recorded in a chart showing various layers met in.

4.3.6 Selection of Drilling Rigs:

The recommendations for selection of drilling rigs include the suitability aspects of different types of drilling rigs for their proper selection for drilling water wells and bore holes in different geological formations.

4.3.7 Classification:

Based on diameter of hole, depth of hole and the size of drill rod used, the drilling rigs shall be classified into light medium and heavy duty as specified in Table 4.1.

The tool weight at the surface for percussion (cable tool) type of drilling rig of light, medium and heavy classes shall be 1135 kg, 1735 kg and 2315 kg respectively.

4.3.8 Selection:

Based on the formation to be encountered during drilling, the diameter and depth of the borehole well, the recommended class of drilling equipment and the size of drill rod to be selected for drilling is given in SP (QAWSM) 56 1994
<table>
<thead>
<tr>
<th>Type of Drilling</th>
<th>Classification</th>
<th>Dia of bore Hole</th>
<th>Depth of Bore Hole</th>
<th>Size of Drill Rods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mm</td>
<td>m</td>
<td>mm</td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
<tr>
<td><strong>Percussion</strong></td>
<td>Light</td>
<td>200</td>
<td>up to 50</td>
<td></td>
</tr>
<tr>
<td>(Cable Tool)</td>
<td>Medium</td>
<td>200</td>
<td>up to 170</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heavy</td>
<td>200</td>
<td>above 170</td>
<td></td>
</tr>
<tr>
<td><strong>Rotary-Direct</strong></td>
<td>Light</td>
<td>200</td>
<td>up to 250</td>
<td>73</td>
</tr>
<tr>
<td><strong>Circulation</strong></td>
<td>Medium</td>
<td>200</td>
<td>up to 450</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>Heavy</td>
<td>200</td>
<td>above 450</td>
<td>89, 101, 114</td>
</tr>
<tr>
<td><strong>Rotary-Reverse</strong></td>
<td>Medium</td>
<td>500</td>
<td>up to 170</td>
<td>150</td>
</tr>
<tr>
<td><strong>Circulation</strong></td>
<td>Heavy</td>
<td>675</td>
<td>above 170</td>
<td>150</td>
</tr>
<tr>
<td><strong>Down-the-Hole</strong></td>
<td>Light</td>
<td>114</td>
<td>up to 50</td>
<td>76</td>
</tr>
<tr>
<td>(DTH) Hammer</td>
<td>Medium</td>
<td>150</td>
<td>up to 170</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Heavy</td>
<td>150</td>
<td>above 170</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Heavy</td>
<td>200</td>
<td>above 170</td>
<td>114</td>
</tr>
<tr>
<td><strong>Combination</strong></td>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Rotary cum-Percussion)</td>
<td>Rotary</td>
<td>200</td>
<td>up to 450</td>
<td>89</td>
</tr>
<tr>
<td><strong>Percussion</strong></td>
<td>Percussion</td>
<td>300</td>
<td>up to 170</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Heavy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rotary</td>
<td>200</td>
<td>above 450</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>Percussion</td>
<td>300</td>
<td>above 170</td>
<td>-</td>
</tr>
<tr>
<td><strong>DTH cum-Rotary</strong></td>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DTH</td>
<td>150</td>
<td>up to 170</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Rotary</td>
<td>250</td>
<td>up to 50</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Heavy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DTH</td>
<td>150</td>
<td>above 170</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Rotary</td>
<td>250</td>
<td>up to 100</td>
<td>114</td>
</tr>
</tbody>
</table>
i) Consolidated Formations
   - Like hard sandstone, lime-stone, Trap, Basalt, Quartzite, Granite, etc.
     - Up to 50 DTH: Light 76
     - Up to 170 DTH: Medium 114
     - Above 170 DTH: Heavy 114

ii) Semi-consolidated formations:
   a) Sandstone, Clay, Shale
      - Up to 250: Rotary - Direct Circulation Light 73
      - Up to 450: Rotary - Direct Circulation Medium 89
      - Above 450: Rotary - Direct Circulation Heavy 89, 101, 114
   b) Bouldery
      - Up to 170: Percussion (Cable tool) Medium
      - Above 170: Percussion (Cable tool) Heavy 89

iii) Semi-consolidated And Bouldery Formation
     - Up to 300: Rotary - cum - Percussion Heavy 89

iv) Unconsolidated formation
    - Up to 250: Rotary - Direct Circulation Light 73
    - Up to 450: Rotary Direct Circulation Medium 89
    - Above 450: Rotary - Direct Circulation Heavy 89

iv) Soft alluvial, clay, gravel small (upto 125 mm size) cobbles formation
    - Up to 170: Rotary - Reverse - Circulation Light 150
    - Above 170: Rotary - Reverse - Circulation Medium 150

4.4 Well Casing

Well casing is a pipe and is used to prevent caving in of surrounding soil into the well or bore-hole. The upper portion of the casing, used for housing the pumping equipment, is called housing pipe. The casing may be temporary and removed on completion of the well (drive pipe) or it may be a permanent part of the structure. The length and diameter of the casing pipe is selected on the basis of static water level, drawdown, discharge expected from the pump and the size of pump to be installed.

Steel tubes most suitable for varied type of water well drilling operations - either casing or drive - are those made to IS 4270 : 2001. The tubes are seamless, automatic fusion welded or electric resistance welded or high frequency induction welded. They are designated Fe 410 or Fe 450 grades based on the minimum tensile strength. The dimensions and masses of various types of tubes are as given in Tables mentioned below. Unless otherwise agreed to between the supplier and the purchaser, the pipes shall be supplied in random lengths of 4 to 7 metres.

**Tolerances**

a) **Outside diameter** - Permissible tolerance on outside diameter of pipe and socket shall be ±1% percent but not greater than 3 mm in the case of socket.

b) **Thickness** - The permissible tolerances on tubes thickness shall be as follows:
Seamless tube + 20 percent
Welded tube - 12.5 percent
Up to and including + 15 percent
406.4 mm outside - 12.5 percent
diameter
Over 406.4 outside + 15 percent
Diameter - 10 percent
c) Mass - No single tube shall deviate from the mass specified in table 4.2 mentioned below with a tolerance of +10.5 percent.

Table 4.2: Dimensions and Masses of Screwed and Socketed casing pipes

<table>
<thead>
<tr>
<th>Nominal Dia or Pipe (mm)</th>
<th>Outside Diameter or Pipe (mm)</th>
<th>Thickness or Pipe (mm)</th>
<th>Mass of Plain Tube kg/m (kg/m)</th>
<th>Socket Outside Diameter (mm)</th>
<th>Overall Length Of Socket, Min (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>114.3</td>
<td>5.4</td>
<td>14.5</td>
<td>130.0</td>
<td>114.3</td>
</tr>
<tr>
<td>125</td>
<td>141.3</td>
<td>5.4</td>
<td>18.1</td>
<td>157.0</td>
<td>120.6</td>
</tr>
<tr>
<td>150</td>
<td>168.3</td>
<td>7.1</td>
<td>21.6</td>
<td>184.0</td>
<td>127.0</td>
</tr>
<tr>
<td>175</td>
<td>193.7</td>
<td>6.4</td>
<td>29.6</td>
<td>211.6</td>
<td>152.4</td>
</tr>
<tr>
<td>200</td>
<td>219.1</td>
<td>8.0</td>
<td>33.6</td>
<td>237.0</td>
<td>152.4</td>
</tr>
<tr>
<td>225</td>
<td>244.5</td>
<td>7.1</td>
<td>41.6</td>
<td>262.5</td>
<td>165.1</td>
</tr>
<tr>
<td>250</td>
<td>273.1</td>
<td>8.0</td>
<td>52.3</td>
<td>291.0</td>
<td>177.8</td>
</tr>
<tr>
<td>300</td>
<td>323.9</td>
<td>8.0</td>
<td>62.3</td>
<td>346.0</td>
<td>177.8</td>
</tr>
</tbody>
</table>

4.4.1 Coating of Tubes:
Unless otherwise specified by the purchaser, the tubes shall be externally coated with bituminous solution or any other protective anticorrosion coating. The bituminous solution shall be of a quality such as to produce a coating which, when dry, shall be smooth, tough and tenacious and sufficiently hard not to flow on exposure to a temperature of 63°C and shall not be brittle at 0°C. It shall not be such as will impart a taste to the water.

Well screens serve as intake section of a well that allows water to flow freely into the well, prevents sand from entering with water and acts as a structural retainer to support the borehole in unconsolidated material. To accomplish fully its intended purposes, the well screen must be of efficient design i.e. it should let ample quantity of sand-free water to flow into the well with minimum loss of head. The screens may range from pipes perforated in place to carefully fabricated cage-type wire wound screens with accurately sized slot openings.

4.4.2 Types
The following are the various types of well screens and slotted pipes:
- Plain Slotted Pipes - These are pipes with slots cut by milling.
- Bridge Slotted Pipes - The slots here are not cut but pressed out.
• **Mesh Wrapped Screens** - These are made by wrapping copper mesh over perforated steel pipe using spacers about 3 mm thick in between the copper mesh and the perforated pipe.

• **Cage Type Wire-wound Screens** - These are special type of screens wherein a continuous trapezoidal or circular wire is spirally wound around a fabricated cage. The screen consists of wedge profile wire of various dimensions, resistance welded to a cylindrical body made of various members and cross sections of longitudinally arranged metal rods, which are in turn welded into cylindrical ring couplings at either end.

### 4.4.3 Material:
The well screens and slotted pipes shall be made of either corrosion resistant material or steel pipes having sufficient thickness to guard against the effect of corrosion and to ensure reasonable life of tubewell. The following are the recommended materials for various type of well screens and slotted pipes:

- Low carbon steel or mild steel;
- Stainless steel

Normally Stainless steel strainer is to be used and Low carbon strainer is to be adopted in case steel strainer is not commercially available. However for rural areas the required diameter of strainer is in the range of 150 mm to 250 mm and for these sizes stainless steel strainer is easily available in the market.

### 4.5 Design Features:
#### 4.5.1 Length of Screen:
The length of screen shall be governed by the thickness of aquifer and shall be sufficient to obtain the specified yield from tubewell. However, the minimum total length shall be such that the entrance velocity is less than the permissible entrance velocity of 0.03 m/s to ensure longer life of the well. The lengths of individual pipes shall be such as to afford easy handling for transport and to account for possibility of inaccuracy in logging, screen shall not be placed in at least 0.3 metre on both sides of the stratum.

#### 4.5.2 Diameter of the Screen:
The screen diameter shall be so selected that the percentage of slot area to screen surface area is generally between 20 to 25 percent. For gravel packed Tube wells and 8-10% for natural packed Tubewells.

Screen diameters for various discharges to be pumped from the well, are given in Table 4.3 for general guidance.

**Table 4.3 Screen Diameter**

<table>
<thead>
<tr>
<th>Discharge LPM</th>
<th>Screen Dia (mm)</th>
<th>Minimum</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 475</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>475</td>
<td>1125</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>1300</td>
<td>3000</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>3000</td>
<td>5250</td>
<td>250</td>
<td>300</td>
</tr>
<tr>
<td>5200</td>
<td>9500</td>
<td>300</td>
<td>350</td>
</tr>
<tr>
<td>9500</td>
<td>13300</td>
<td>350</td>
<td>400</td>
</tr>
<tr>
<td>13300</td>
<td>19000</td>
<td>400</td>
<td>450</td>
</tr>
<tr>
<td>19000</td>
<td>26500</td>
<td>450</td>
<td>500</td>
</tr>
<tr>
<td>26500</td>
<td>34000</td>
<td>500</td>
<td>550</td>
</tr>
</tbody>
</table>
4.5.3 Slot Size:

The shape and size of the slots shall be such that the gravel or aquifer material is not allowed to block the open spaces. Based on the sieve analysis of the aquifer material, the size of the slot openings shall be determined in such a way that finer fractions remain outside the slots. The slots shall not be too wide to cause entry of the gravel and resulting in plugging. Sharp edges on the periphery of the pipe may offer resistance to flow and hence it is preferable to have smooth rounded edges.

The slot size for gravel pack shall be so selected as to retain at least 90 percent of the pack material. However, in case the well is not provided with gravel pack, slot size shall be such that it allows 40 to 60 percent of the aquifer material to pass through. The normal slot sizes shall be 1.0, 1.6 and 3.2 mm.

**Percentage Openings**
The percentage slot openings shall be such that the screen length provides sufficient inlet area to limit the entrance velocity to 0.03 m/s.

**SPECIFIC DESIGN FEATURES of STRAINERS:**

Plain Slotted Pipes

*Low Carbon or Mild Steel Slotted Pipes*

The slots shall be cut by milling or by slitting saw. The recommended thicknesses for different diameters for various depths of tube well under normal conditions are given in below mentioned Table 4.4:

Table 4.4: Thickness of Pipes to be used as slotted pipes:

<table>
<thead>
<tr>
<th>Depth of Well (m)</th>
<th>Thickness for Pipe Size (OD) in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>166.6 to 168.3</td>
</tr>
<tr>
<td>50</td>
<td>4.85</td>
</tr>
<tr>
<td>100</td>
<td>5.4</td>
</tr>
<tr>
<td>125</td>
<td>5.4</td>
</tr>
<tr>
<td>150</td>
<td>5.4</td>
</tr>
<tr>
<td>175</td>
<td>5.4</td>
</tr>
<tr>
<td>200</td>
<td>5.4</td>
</tr>
<tr>
<td>250</td>
<td>7.11</td>
</tr>
<tr>
<td>275</td>
<td>7.11</td>
</tr>
<tr>
<td>300</td>
<td>7.11</td>
</tr>
</tbody>
</table>

**Cage Type Wire-wound Screens**
The wrapping wire having a wedge profile with flat surface on the outside and producing expanding slots on the inside should be used. This shape facilitates setting and back washing operation and also avoids the screens being clogged by fine particles.
For obtaining a minimum of 15 percent open area, the screen aperture shall not be less than 0.375 mm. The number and cross-section of the vertical support rods and the profile of the wrapping wire shall be such as to give sufficient axial and collapse-strength (see Fig. 4).
4.6 Guidelines For Selection Of Slot Size

4.6.1 Determination of Slot Size:

The size of slot openings suitable for different formations shall be based on sieve analysis of the aquifer material. Following procedure- and design criterion is laid down for general guidance:

A weighed quantity of the thoroughly mixed sample is passed through a set of Indian Standard sieves from No. 75 onwards. The sieves are arranged such that the coarsest sieve is placed at the top and the finest at the bottom. After proper shaking, the sieve set is opened and material retained on each sieve is correctly weighed. The cumulative weight passing through each sieve is plotted on semilogarithmic graph paper having percentage weight as ordinate on arithmetic scale and size of the sieve opening as abscissa on logarithmic scale. A smooth graph is then drawn through the points based on which selection of slot size shall be done.

4.7 GRAVEL PACKING

4.7.1 Need For Gravel Packing:

a. The four common reasons for gravel packing are:
b. to increase the specific capacity of the well,
c. to minimize sand flow through the screen in fine formations,
d. to aid in the construction of well, and
e. to minimize the rate of incrustation by using a larger screen slot opening where the formation is relatively thin but very permeable and the chemical characteristics of the groundwater indicate potential for significant incrustation.

4.7.2 Criterion for Gravel Packing

The desirability of gravel packing decreases as the water bearing formation becomes coarser. Generally, formation with an effective grain size, $D_{10}$ that is that size, than which only 10 percent of the formation is finer, or more than 0.30 mm and a uniformity co-efficient of 5 or more can be safely developed without gravel packing.

4.7.2.1 Choice of Strainer:

It is recommended that for natural packed/ Gravel Tube wells Stainless steel Strainer shall be adopted.

Gravel Sizes

The gravel sizes shall be as given in Table. 4.5.

Table 4.5 Gravel Sizes

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Grade</th>
<th>Pack</th>
<th>Practical Size Range (mm)</th>
<th>IS Sieves (see IS 460 (part 2) : 1985)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>A</td>
<td>Fine gravel</td>
<td>Over 2.0 to 3.35</td>
<td>2.0, 3.35</td>
</tr>
<tr>
<td>2.</td>
<td>B</td>
<td>Fine gravel</td>
<td>Over 3.35 to 4.75</td>
<td>3.35, 4.75</td>
</tr>
<tr>
<td>3.</td>
<td>C</td>
<td>Medium gravel</td>
<td>Over 4.75 to 6.3</td>
<td>4.75, 6.3</td>
</tr>
<tr>
<td>4.</td>
<td>D</td>
<td>Medium gravel</td>
<td>Over 6.3 to 8.0</td>
<td>6.3, 8.0</td>
</tr>
<tr>
<td>5.</td>
<td>E</td>
<td>Coarse gravel</td>
<td>Over 8.0 to 12.5</td>
<td>8.0, 12.5</td>
</tr>
</tbody>
</table>
To avoid trouble in placing and inspective of gradation, packs should not contain particles greater than 13 mm.

4.7.2 Particle Size Distribution:
The particle size distribution of gravel shall be determined by screening through standard sieves in accordance with IS 460 (Part 2): 1985. The percentage distribution of the sizes shall be determined from a graph in which the percentage of material passing through each sieve is plotted against the standard aperture of that sieve. Any size, say D20 will thus indicate that the cumulative weight of all the grains smaller than this size is 20 percent of the total weight of the test sample.

The uniformity coefficient of the gravel, that is, the ratio of its D60 to D10 sizes shall not exceed 2. A material with uniformity coefficient less than ‘2 shall be classified as uniform and if greater than 2 it shall be taken as non-uniform.

4.7.3 Pack Aquifer Ratio:
The pack aquifer ratio (PIA ratio) is defined as the ratio of 50 percent size $D_{50}$ of the gravel pack to the 50 percent size of the aquifer. The size of gravel when used as pack in tubewells shall be decided in accordance with the size of the aquifer material proposed to be tapped. The gravel size, based on minimum head loss through gravel pack and minimum sand movement, shall be limited as below:

a. Uniform aquifer with uniform gravel pack:

b. Pack aquifer ratio shall be 9 to 12.5

c. Non-uniform aquifer with uniform gravel pack:

d. Pack aquifer ratio shall be 11 to 15.5

4.7.4 Thickness:
The thickness of gravel pack shall be limited to 13 to 18 cm. The size of the screen slot opening is governed, among other factors, by the size of the gravel or aquifer material which it has to retain. The slot size for gravel packed wells should be such that it retains about 90 percent of the gravel.

The development of a well is its treatment for the purpose of establishing the maximum rate of usable water by cleaning the produced water of turbidity, sand, sediment or other impurities introduced during drilling.

4.8 Methods of Development

There are numerous methods of development, and an important factor in all these is that the development work be started slowly and gently and increased in vigour as the well is developed. The development should be started as far as possible from the bottom of the screen because with this compaction takes place as the work progresses upward and the overlying material can move downwards. The known methods of development are described below:

4.8.1 Over pumping:

Over pumping means pumping the well at a higher rate than it will be pumped when it is put in service. It may be simpler to over pump in small wells or poor aquifers by employing the pumping equipment intended for regular use in the well.

4.8.2 Compressed Air:

Another popular way of development is by using compressed air but it requires considerable equipment and skill on the part of the operator. The capacity of compressor should be at least 9.35 cum per minute (330 cfm) at 250 PSI pressure for depth up to 200 meter. In case depth of bore
well is more than 200 mt a proportionately higher capacity compressor shall be used

4.8.3 Calculation of Discharge: Discharge of Tube well shall be determined by using V-notch. Tables indicating discharge for various V-notch readings has been placed at Annexure –N. After completion of the testing of tubewell information should be supplied as in Form B.

4.9 Verticity and Alignment

If a turbine well pump is to be installed in a well, the well should be true to line from its top to a point just below the maximum depth at which it is proposed to set the pump. A tubewell out of alignment and containing kinks and bends or cork-screws should be rejected because such deviations cause severe wear on the pump shaft bearings and discharge casing and in a severe case, might make it impossible to get a pump in or out. If an air-lift or a suction pump is used for pumping. Alignment is not so important and the same is applicable to the submersible type of pump.

4.9.1 The conditions that cause wells to be out of plumb are:
   a) the character of the sub-surface material penetrated during drilling,
   b) the trueness of the pipe used as well casing, and
   c) The pull-down force on the drill pipe during rotary drilling.

   While drilling, gravity tends to make the drilling bit cut a vertical drill hole. Varying hardness of the materials being penetrated, however, deflects the bit from a truly vertical course;
   d) Improper leveling of the Rig before the drilling is started.

4.9.2 The measurements made are of the plumbness and straightness of the cased bore. Thus, an oversized hole may be out of plumb but the casing may fall within specified limits. The casing should not be permitted to excessively encroached the annulus and hinder placement of grout or gravel pack.

4.9.3 In case of gravel-shrouded tubewells, if the pipe assembly is found inclined in a slant position before completing the gravel pack, the assembly should be pulled in a desired direction by suitable methods with a view to rectify slantness and bringing the pipe assembly within the 'permissible limits of verticality. The gravel pack should be completed immediately after the verticality has been tested and rectified.

4.9.4 The verticality of the tubewell shall be tested by using plumb or plunger E (see Fig. Clause 4.9.4) 6 mm smaller in diameter within the inside diameter of the well casing. The plumb may be made from a piece of sheet steel or a short piece of pipe. Which-ever is used, it shall be heavy enough to keep the plumb line taut. The hub of the ring shall not be solid, as the water shall pass through it as it is lowered in the well. The bore F from which the plumb line A passes shall be in the exact centre of the ring. Knots or marks shall be made every 3 m on the plumb line to indicate the depth to which the ring has been lowered in the well. The plumb shall be suspended from the guide pulley where it shall be at least 3 m above the top of the well. The guide pulley is fixed on a tripod or frame B as shown in the figure. The vertical centre of the pulley shall be so located that the plumb line A comes off its outer edge exactly over the centre D of the well casing. The results shall be recorded in Form A.

4.9.5 For tubewells encased with pipes up to 350 mm diameter, the verticality of the tubewell shall be measured in terms of clear cylindrical space available within the housing pipe after the construction of the tubewell.

4.9.5.1 Verticality of the tubewell may have a deviation so as to provide clear cylindrical space not less than the clear cylindrical space available in a hypothetical tubewell of the same size but having deviation of 10 cm per 30 m in one direction and in one plane only.

4.9.5.2 The verticality of tube well is to be tested as given in 4.9.4 After the necessary computation is made, cross sections of housing pipes at different depths are drawn on a graph and
clear cylindrical space is, determined. The cylindrical space of the actual- constructed tubewell shall be referred to as 'G' in the following paragraphs.

Fig. Clause 4.9.4 METHOD OF PLUMBING A WELL

Cross sections of hypothetical tubewell identical in dimensions to the actual tubewell but having deviation of 10 cm per 30 m in one direction and in one plane are drawn on the graph sheet and the minimum allowable cylindrical space 'H' is determined.

4.9.5.3 If cylindrical space ‘G’ of the actually constructed tubewell is equal or more than the cylindrical space 'H' of the hypothetical tubewell (having deviation 10 cm in 30 m in one direction and one plane), the tubewell actually constructed shall be considered within the permissible limits of verticality.

4.9.5.4 As an example, cross sections of two tubewells G1 and G2 having 300 mm diameter of housing pipe have been drawn after computation of verticality results in Fig. G1 and Fig. G2 while Fig. G3 shows the cylindrical space H of hypothetical
### A Normal Test

<table>
<thead>
<tr>
<th>SL No.</th>
<th>Rated Discharge (m/s)</th>
<th>Depression Discharge at Rated Yield (m)</th>
<th>Specific Yield Run (h)</th>
<th>Total Hours Of Test</th>
<th>Sand in ppm at End of Test (m)</th>
<th>Static Water Level (m)</th>
<th>Pumping Water Level (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
</tr>
</tbody>
</table>

### B. Discharge at 1.2 times normal Yield or 1.5 times normal depression

<table>
<thead>
<tr>
<th>Specific Yield Run (h)</th>
<th>Total Hours</th>
<th>Sand in ppm at End of Test (m)</th>
<th>Static water Level (m)</th>
<th>Pumping Water Level (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
</tbody>
</table>
4.10 Maintenance of Tube Wells:

Wells, like all other engineering structures, need regular, routine maintenance in the interest of a continuous high level of performance and a maximum useful life. The maintenance of wells and pumps is often neglected, since the greater portion of both the well and the pump are located beneath the ground surface. The nature of deterioration which occurs in a well may not be readily discernible during operation and may not be recognized until the well fails. The deterioration
usually develops slowly to a critical point and then accelerates rapidly to failure. Therefore, any neglect of well maintenance often results in the complete loss of the well.

4.10.1 Factors Affecting Well Performance

Several factors initiate well losses in inefficient wells. Care should be taken to differentiate between those factors associated with the normal wearing of pump parts and those directly associated with changing conditions in and around well. A well may show a reduced yield because of reduction in the capacity of the pump due to excessively worn parts. On the other hand, the excessive wearing of pump parts may be due to the pumping of sand entering the well through a corroded screen. It is also possible for corrosion to affect only the pump, reducing its capacity but to have little or no effect on a properly designed well.

The common reasons of decrease in yield of a well include: (a) losses caused by reduction in permeability from mud invasion or by compaction and shearing of the formation face during drilling, and (b) losses from the turbulent flow of water adjacent to the well through the screen or well face and inside the casing to the pump intake.

4.11 Preventive Design Features

High well losses are unnecessary since they can be minimized by a good well design and construction. Therefore water well maintenance procedures begin with the techniques implemented during the drilling of the original well and continue with the type of materials used and with the extent of care, or the lack of it, that the well is given over the months and years of operation.

Critical well design feature is the entrance velocity through the screen. An ideal entrance velocity is 1.5 to 3.8 cm/s depending upon the average permeability. Maintaining low entrance velocity results in high efficiency, minimizing sand pumping and reducing the rate of corrosion and incrustation in well. The distribution and shape of slot openings is as important as the entrance velocity in influencing well efficiency.

3.3 A comprehensive design of the well system includes certain features in the discharge and distribution facilities to permit proper monitoring and maintenance of the well and pump. The more important of these features are:

a) provision of an outlet in the discharge system to permit diversion from the system during future test pumping and water sample collection,
b) a permanent throttling valve on the discharge,
c) a permanent airline with valve and gauge for water level reading,
d) access into the pump chamber casing which can also be used to measure water levels to permit back up water level reading by tape or electric probe, and
e) ready access to the well to pull the pump and maintain the well.

4.12 Maintenance Planning

The planning of well maintenance procedures should be based on a system of good record keeping. The problems that result in reduced well yield occur at and around the well screen and are very much out of sight. The analysis of good records must, therefore, be relied upon for detection of problems in the well.

Among the records kept should be pumping rates, draw-down, total hours of operation, power consumption and water quality analysis. Pumping rates and drawdown are particularly useful in determining the specific yield which is the best indicator of existing problems in a well. The specific yields of wells should be checked periodically and compared with previous values to determine if any significant reduction has taken place. Such a reduction is often due to clogging of
well screen and formation around it by incrustation.

Power consumption records also provide valuable evidence of existence of problems in wells. An increase in power consumption, not accompanied by a corresponding increase in the quantity of water pumped, indicates problem in either the pump or the well. If an investigation shows no problems in the pump nor appreciable increase in the dynamic head against which the pump is operating, then it is most likely that a problem exists in the well and the problem is causing an increased draw down. A check on draw down should then be undertaken and the well checked for incrustation.

Regular chemical analyses of water will indicate the type of incrustation that might occur and the expected rate of deposition in the well and its vicinity. The quality of water in some wells changes slowly with time and only a regular analysis would detect such changes.

In wells, the waters of which have a high incrustation potential, the frequency of observations of all types should be as high as possible and consistent with the use to which water is being put. Observations should be much more frequent in wells serving a community.

4.12.1 Interpretation of observed or Measured Changes in Well Performance or Conditions:

A decrease in specific yield without a proportional decline in the static water level may indicate blockage of the screen by accumulated sediment in the bottom of the well, blockage of the screen or gravel pack by incrustation, or collapse of casing or screen. Should the specific yield during a test for yield and draw-down show a decline of 10 percent or more from the original test at a given discharge, the well should be surveyed to determine the location and extent of possible contributing conditions. If collapse appears to be the problem, the well should be surveyed to determine the location and nature of the collapse. If collapse is not the problem, the inside of the well should be scraped and the pertinent that was subsequently bailed from the bottom should be examined to determine the chemical composition, nature and extent of the encrusting material as a basis for a plan of rehabilitation.

An increase in the sand content of the discharge, particularly if it is associated with a measurable accumulation of sand in the bottom of the well, may indicate enlargement of slot sizes by corrosion; settlement of gravel pack beneath a bridge leaving an unpacked zone opposite a screened section; a break in the casing or screen, usually at a joint; or failure of a packer seal. Mechanical and mineralogical examination of a sample bailed from the bottom of the hole and comparison with the original description of the aquifer and gravel pack materials made during construction of the well may give some indication of the nature of the difficulty. If the material is noticeably smaller in grain size than the grain size of any aquifer screened in the well, or if the material contains the full range of sizes of the gravel pack, there is probably a break in the casing or screen. If all the material is smaller than the screen slot sizes, it is probably a bridge. If the above interpretations of grain size and distribution are not applicable, the problem may be due to enlargement of a slot size by corrosion. If the problem is apparently due to bridging, it can frequently be corrected by redevelopment while pouring water down the gravel refill terrynes and the addition of gravel pack material. The other problems usually require a photographic survey to be made of the well to more clearly assess the problem. Decisions can then be made concerning the practicability of rehabilitation and the procedures to be followed.

Settlement of the land surface around a well, the development on the ground surface of small drainage channels towards the well, and cracking and settlement of pump pads and foundations are all indicative of settlement of the well structure. In some areas, the problem may be associated with land subsidence due to excessive pumping of the aquifers. Usually, however, the problem is related to poor well design, construction, or development, and results from
excessive pumping of sand. In many instances, the sand pumping is complicated by collapse of casing or screen, bridging of gravel packs, and similar deterioration. When such conditions are encountered, the well should be taken out of service, sounded for depth, and surveyed photographically to determine whether any structural damage has occurred. If the well cannot be shut down because of the need for water, the casing should be temporarily supported by welding heavy I-beams to it.

Decline in pump discharge and head may be due to deterioration of pump or simultaneous deterioration of both the well and the pump. A common occurrence is a decrease in shut-in head and significant decrease in discharge without a corresponding decline in static water level and specific yield. Such an occurrence is usually due to one of the following conditions: (1) improper adjustment of the impeller due to wear or other causes, (2) a hole in the column pipe, or (3) erosion of the impeller or bowls.

A condition which is usually associated with considerable vibration when the pump is running. If the condition cannot be corrected by adjusting the impellers, the pump should be pulled and repaired or replaced. The cause of the problem should be thoroughly investigated and made a part of the permanent well and pump record.

Excessive vibration of the pump may result from imbalance of the impeller or from the pump being installed in a crooked well. A pump which makes a crackling noise similar to gravel being thrown on a tin roof is probably experiencing cavitations at the impellers. This is particularly true if the discharge is surging and irregular and contains considerable air. The condition usually results from a decline in the static water level or reduced well capacity because of incrustation or accumulation of sand on the screen. Either of these conditions results in excessive drawdown for pump and a decline below that required in the available net positive suction head. If the condition is due to a decline in the static water level, it can usually be corrected by lowering the bowl assembly. In severe cases, it may be necessary to add additional stages and a larger motor in addition to lowering the bowls. The well should also be checked for possible incrustation of the screen or other causes of reduced efficiency.

Excessive heating of the motor is occasionally encountered and is usually associated with an overload condition and the consumption of excessive electrical energy. Such heating may be caused by a poorly adjusted impeller which is dragging on the bowls, too tight a packing gland, improper or unbalanced voltage, poor electrical connections, or improper sizing of motor. Occasionally, an inadequate discharge will be associated with trash that has lodged in the bowls or blockage of the impellers or bowl channels by products of corrosion and incrustation. Correction entails pulling the pump for repair. These conditions may also be reflected in overheating of the motor. Where overheating is encountered, the installation should be first checked by an electrician to determine whether the trouble is in the power system or in the pump, rather than in the well.

Occasionally, a noticeable increase in oil consumption is encountered in oil-lubricated pumps. The excessive consumption may be due to a hole in the wall of the oil tubing or excessive wear on a packing gland in the tubing. These conditions can result in a decrease in differential pressure in the oil tubing and loss of oil into the well. The first condition can result in inflow of water into the tubing and formation of an emulsion of water and oil. The emulsion lacks adequate qualities and can result in excessive wear or burning out of the bearings. The escape of oil into the well can result in the accumulation of oil floating on the water surface in the casing. With adequate pump submergence, this latter condition may not cause serious trouble but if draw-down increases due to a decline in water table or deterioration of the well, oil may be drawn into the pump, causing impairment of water quality. In addition, the presence of oil may contaminate the
groundwater and preclude accurate measurement of static water and pumping water levels.

Small capacity wells usually have discharges of less than 500 Lt/min. casing and screen used for such wells commonly are 15 cm in diameter or smaller, and materials used in their construction are relatively light in weight. While the observations and measurements outlined above are equally applicable for large capacity pumps and wells they are usually difficult to justify economically.

**Maximum Safe yield and specific yield**

Maximum safe yield of the well is the quantity that can be drawn without continuous lowering of the water table and without “sand blowing” indicated by soil particles appearing in pumped water. The specific capacity of a well is the discharge per meter of draw down at the well. Design yield of Tube Well shall be taken after incorporating the decline in the yield of the well during its design life of 15 years. It is observed that over a period of time yield of Tube well decreases. Safe yield of Tube Well should be 130% more than the required design discharge to cover the decreases in yield over a period of time for Natural Packed Tube wells and 50% more for Gravel packed Tube Wells. Sample calculation to determine yield of Tube well are placed at annexure –M

4.13 **Well Rehabilitation and Abandonment**

Well Rehabilitation

The rehabilitation of well means repair of wells which have failed because of collapse, broken casing and screen or other similar damage, and the treatment of wells which have begun to pump sand, have experienced a change of water quality or have shown a marked decrease in discharge and efficiency because of incrustation, or other factors which tend to reduce the intake area of the screen and permeability of the adjacent aquifer. It shall be undertaken when the specific yield falls to about 80 percent of the initial value.

- The cause and extent of well sickness must be diagnosed before the rehabilitation programme is undertaken.
- If the decrease in yield is due to the lowering of water table in the aquifer as a result of over pumping or interference from other wells, then nothing can be done.
- However the failures due to incrustation, corrosion, improper design, gravel placement and faulty construction may be remedied by a suitable rehabilitation programme.
- The major problem in rehabilitation is estimating the exact nature of the deterioration since the screen and other components most likely to deteriorate are not open to usual inspection or testing. This may be overcome to an extent by adequate investigation and planning prior to undertaking the work as given below.

**Information to be given by user**

The following information shall be made available by the owner:

a) Initial and present well yield, depression, and water level as observed periodically during the well's service life;

b) Sand content in ppm, if any;

c) Grain size distribution of the strata tapped as a result of sieve analysis;

d) Location of screen, its opening size, percentage of screen surface area to the total open area, screen material, length and diameter of screen and well pipes, etc, and data of acceptance of the well;

e) Size and quantity of pea-gravel used initially and during its service life;

f) Method used and details of development with results;

g) Method of drilling adopted, name of drilling agency, original pump and well test results
and results of subsequent tests, if available;
h) Results of the initial and present chemical analysis of the well water;
i) Details of any chemical treatment, if ever given to the well and results achieved therefrom;
j) Sounding of the well observed every year
k) Details of repairs to the pumping equipment carried out every year; and
l) Number of electricity units consumed per kilowatt ratings every year during service life of the well.

Investigations to be carried out by the contractor

The following data shall be determined for reference when starting rehabilitation of any well:

a) Date of acceptance of well;
b) Name of contractor;
c) Method of drilling;
d) Method of formation sampling;
e) Formation log;
f) Mechanical analyses of aquifer samples;
g) Mechanical analyses of pack material;
h) Screen materials, slot sizes, diameter and depth of setting;
i) Present open area of screen, design inflow velocity;
j) Depth, diameter and material of pump chamber;
k) Method and completeness of development;
l) Original pump and well test results and result of subsequent tests with dates;
   1) Static water level
   2) Measured depth of bottom of hole
   3) Discharge
   4) Draw down
   5) Specific yield
   6) Step tests
   7) Production tests
m) Ground water hydro graphs of the area;
n) Quality of water analyses of well with dates; and
o) Resume of maintenance, rehabilitation and performance.

The following investigations shall be carried out and data determined before starting rehabilitation on any well:
a) Chemical and bacteriological analysis of the well water shall be carried out and compared with the original one, with regard to its original and the present apparent incrustation potential. If it is high or has increased with time, treatment may be required;
b) If the well is yielding sand, the discharged sand sample shall be collected and compared with the original formation log so as to locate precisely the position of the possible rupture or loose connection, etc;
c) If equipment is available, an underwater photographic survey shall be carried out and location of any evidence of incrustation, organic growth or accumulation on the casing and screen recorded. Also, any filamentous algae, iron bacteria or. Similar organisms floating in the water shall be noted. Any evidence of mechanical damage to the casing and screen shall be carefully inspected with the camera and recorded with regard to 'its description and depth;
d) The present specific yield at design discharge rate and draw down, low enough to permit
continuous pumping for 4 hours, without breaking suction, shall be determined. This will give a qualitative measure of the degree of deterioration and by comparison with the later tests, the success of rehabilitation programme.

e) The pump shall be pulled out and various parts examined immediately as they are removed from the well. The column pipe, drive shaft, bearing spiders and bowl shall be inspected for evidence of excessive accumulations or deposits of ferric or ferrous hydroxides. If the deposits are present, sufficient samples shall be collected to fully fill a bottle capable of being sealed airtight. This shall be done as rapidly as possible and the samples sent to the laboratory immediately, so as to avoid generation of heat in the sample. The samples shall be sent to the chemical and biological laboratories for identification of chemical compounds present and identification, if possible, of organism involved.

f) The pump parts shall be examined for evidence of pitting, tuberculizations, graphitization, cavitation and wear. Pump bowls and impellers shall be inspected for evidence for graphitization in areas where sulphate-bacteria are known or suspected to be present; and

g) The static water level and depth of the bottom of the well assembly shall be checked when the pump is taken out of the well.

Acid treatment using hydrochloric (muriatic) or sulfamic (H2NS02H) acid is commonly employed for rehabilitation. It efficiently eliminates incrustation due to calcium, magnesium and iron carbonates, or iron hydroxides which can be detected by examining the scrapings from the inside of the screen for chemical composition.

The strongest grade of muriatic acid, designated the '27.92 percent hydrochloric acid, is used in full strength for acidizing. The amount of acid added for a single treatment is 1.5 to 2 times the volume of water in the casing, screen and gravel pack between the bottom of the well and 3 m above the topmost screen slot. It is poured through a black iron or plastic pipe 38 to 50 mm in diameter and long enough to reach the bottom of the well. Acid to fill 1.5 to 3 m of screen is poured first; the conductor pipe raised about 1.5 to 3 m to pour more acid and the process is continued till all the acid has been added to the well. The acid, being heavier than water, displaces it as it is poured.

Iron and manganese hydroxides and oxides, although soluble in hydrochloric' acid, precipitate out if pH is above 3. To keep iron in solution, regardless of pH so that it can be pumped from the well with spent acid, a chelating agent like Rochelle salt, citric acid, tartaric acid, phosphoric acid or glycolic acid may be added to the acid. About 900 g of chelating agent may be used for 45 liters of hydrochloric acid.

To curb the tendency of the acid to attack metallic casing and screen, either inhibited acid or an inhibitor such as knox gelatine should be used. 2.3 to 2.7 kg gelatine dissolved in warm water and added to 450 liters of acid serves the purpose. The acid is left in the well for about 4 to 6 hours. At the end of about 3 min, sufficient water is added to displace the acid from 3 m above the topmost slot to the bottom of the well. While the acid is in the well, it is surged by air or with surge block for 15-20 minutes each hour. The acid is bailed out at the end of about 6 hours. Hydrochloric acid is dangerous to use unless handled by experienced personnel and suitable equipment. It gives off poisonous fumes and its reaction with carbonates is some times violent spraying around the well. The transport of liquid hydrochloric acid to the field is also not easy.

Hydrochloric acid of adequate strength is readily available at a relatively low price. It has been used observing safety precautions and no injuries or casualties have resulted. Under the circumstances, if appears that hydrochloric acid, despite the danger and difficulties associated with its use, will continue to be used. However, if trained and experienced crew are not available to carry on the acidizing work, consideration shall be given to employing the less dangerous
sulfamic acid.

It is for these reasons that sulfamic acid is increasingly used for well rehabilitation. It is more expensive than hydrochloric acid but less aggressive and safer to use and easily shipped and stored as dry crystal or powder. Its corrosive effect on well screens and pumping equipment is markedly less. It, however, requires about twice as long to treat a well as does hydrochloric acid. When using sulfamic acid in a well, the same estimates are made regarding the column of water in the well to be displaced and 1.5 to 2 times that volume is poured into the well through a black iron or plastic pipe as described earlier. It is, available in granular form and may be poured into the well from the top.

Because sulfamic acid is a milder and less aggressive acid, it is mixed in a black iron or wooden tank at the surface. A tank about 1.2 x 15 x 3 m is usually adequate and holds about 5360 lt. The tank shall have a bottom valve through which the acid solution is drawn into the well. 41 kg sulfamic acid, 450 g of phuonic F68 and 2.7 kg chelating agent such as Rochelle salt, citric acid, tartaric acid, etc, are added and dissolved in each 450 l of water to be poured into the well. If well is screened with metal, an inhibitor such as knox gelatine shall be used at the rate of 1.8 to 2.3 kg per 450 litre of solution. The acid shall remain in the well for at least 12 hours during which it shall be surged by air or surge block about 15 to 20 minutes every hour. Then it is bailed or pumped to waste.

The spent acid is bailed or pumped out of the well using a corrosion-resistant pump for the purpose. In many wells, pumping with a centrifugal pump is possible. Close observation of the bailing or pumping discharge and the drawdowns during removal of the acid shall give an indication of the success of the treatment.

During acid treatment of a well the crew shall wear protective clothing and respirators. One or two 250 lt drums of concentrated sodium bicarbonate shall be available for quick neutralization of acid with which crew members may come in contact during the operation. During treatment, incrustation is dissolved and the fines incorporated in the agent remain in the pack and base material. On completion of acidizing the well shall be redeveloped using polyphosphate, sufficient chlorine for a shock treatment and one of the methods of surging or jetting.

**Glossy Phosphate Treatment**

Glossy phosphates (polyphosphates) act by dispersing clays and salts and loosening their adhesion to sand and gravel so that they may be readily pumped out of the well. Treatment with one of the polyphosphates, coupled with vigorous agitation, effectively breaks up the incrusting material and cleans the well. An important advantage is that polyphosphates are safe to handle.

The polyphosphates are usually used in conjunction with a wetting agent, sodium carbonate and chlorine compound. The wetting agent facilitates the penetration of the polyphosphate solution into the fine-grained material and hastens the operation. Sodium carbonate has a cleaning action on rust on iron screens and pipes and also serves to neutralize the effects of oil and other organic compounds that might interfere with the action of chlorine. Chlorine acts as a catalyst and apparently improves the action of the polyphosphates besides sterilizing the well and the adjacent formations.

**NOTE** - Under the fabric. Therefore, until more is known of the fabric and composition some circumstances, the wetting agents cause too rapid a breakdown of the aquifer, it is recommended that wetting agents be omitted from the solutions.

In wells screened with fiberglass-reinforced epoxy, sodium carbonate may be left out of the
solution without any loss of efficiency.

The following procedure may be adopted for rehabilitation:

Estimate the volume of water in the pack and screen between the water table and the bottom of the hole to the nearest 450 lt. On the basis of the following amount of reagents per 450 lt of water in the well, estimate the amount of various chemicals required:

a) For fibre glass-reinforced epoxy screens - Sodium hexametaphosphate 3.6 kg;
b) For metal screens - In addition to the above 900 g sodium carbonate; and
c) Should experience show use of a wetting agent is helpful, 450 g pluronic F 68 or equivalent.

Most wells contain between 10,900 to 15,900 lt of water. A wooden or black iron tank 1.2 x 1.5 x 3 m is a convenient size for transportation, etc, and holds in excess of 5 360 lt of water. Therefore, two or three batches of solution mixed in the tank shall be required for each well. A convenient but not necessary arrangement that speeds up the operation is to use two tanks in order that the next batch of solution may be mixed while the previous one is being placed in the well.

The solution is poured or pumped into the well through a 38 or 50 mm plastic or black iron pipe that initially is installed from the surface to about 1.5 m above the bottom of the well. Sufficient solution is put in the well to displace an estimated 1.5 or 3 m of the water in the casing and pack. The pipe is then raised 1.5 or 3 m and the procedure repeated until all water in the well and pack are displaced by the solution. The solution has higher specific gravity than the water and displaces it upward and outward from the well. When all the solution is installed in the well, a volume of water equal to about one-half that contained in the casing and screen is poured" is at the top to displace the solution from the screen and force it out into the formation (see Table 4.6). A 200mm casing contains about 11 lt and 200 mm screen about 18 lt of water per metre of length. A surge block bail or similar tool is then run from the bottom of the well to above the water table two or three times of the inductor pipe for air surging may be replaced to near the bottom of the well and air bubbled up through the well to thoroughly mix the solution remaining in the casing screen.

**Chlorine Treatment**

Chlorine has been found effective in loosening clogging of the intake section of the well and water-bearing formation caused by deposition of iron oxide. Chlorine, when added to water, forms hypochlorous and hypochloric acids, which kill the bacteria and produce an effect of "burning up" the organic slime.

Sufficient amount of calcium or sodium hypochlorite to give a concentration of 100 to 200 ppm of free chlorine is added to the well either directly or in water solutions. Alternatively, chlorine gas may be used but it is dangerous and requires experienced personnel and equipment which may not always be available. It must be put into the well in a water solution as it is both corrosive and toxic when inhaled. Hypochlorite solutions are cheaper, more convenient and safer to use than gas but generally less effective.
The chlorine solution is introduced in the well through a small diameter plastic pipe. A quantity 11 to 18 kg added slowly over a period of 12 hours shall suffice for a large well. The pipe carrying chlorine must be positioned so that the solution does not impinge directly upon any part of the pump, well casing, or well screen. After introduction, the chlorine solution is forced into the water bearing formation by adding about 50 to 100 times the volume of water standing in the well.

The well shall be surged or the solution agitated vigorously as in acid treatment. Repeated chlorine treatment will have more chance of flushing the clogged formation around the well. Alternate acid and chlorine treatments are found to be even more effective.

**Dry Ice Treatment**

The use of dry ice, that is, solid carbon dioxide is still in the experimental stage. Dry ice changes from solid to gaseous state rapidly with considerable pressure, when put into well water. The rapidly expanding gas is confined within the well casing and is forced through the screen openings to loosen the clogged material. On account of high pressure developed, provision shall be made for the control and relief of pressure to guard against any damage. As dry ice may cause severe burns, if handled with bare hands, heavy gloves or tongs shall be used in handling the ice.

**Explosives**

These are sometimes employed to develop and enlarge crevices and fissures in tubewells drilled in hard rocks. Charges of 30 to 500 kg are used according to the hardness of the rock and the depth at which the charge is to be detonated.

**Criteria for Acceptance**

An increase in yield of the well by 20 percent of the pre-rehabilitated yield of the well or attainment of 75 percent of the initial yield, whichever is more, shall be the basis of acceptance. Alternatively; it may be agreed to between the contractor and the owner.

Information to be supplied by the contractor to Owner for future use

The Contractor shall supply the following in formation to the owner for future use:

a) Results of the investigations carried out before taking up rehabilitation;

b) Result of chemical tests carried. out before and after rehabilitation work;
c) Methods used along with name and quantity of chemicals used and number of treatments given;
d) Results of rehabilitation; that is, discharge, depression and sand content in ppm at start and after 20 minutes;
e) Sounding of the well after treatment;
f) Condition of the pumping unit before rehabilitation and details of repairs carried out to it;
g) Suggestions, based on investigations, for future upkeep and maintenance of the well including recommended limit to continuous discharge and depression, that is, rate of pumping in order to avoid harmful over pumping and thereby limiting the entrance velocities; and
h) Any other relevant information desired by the owner.

WELL ABANDONMENT

Proper plugging of abandoned wells is a fundamental practice in the preservation of high groundwater quality. Permanent sealing of abandoned wells is important because serious groundwater pollution can occur from either contaminated surface water or interaquifer transfer of groundwater from a contaminated aquifer.

The basic concept in the proper sealing of an abandoned well is the restoration as far as possible of the geologic conditions that existed before the well was drilled. The local geologic conditions must be assessed in detail to determine the most effective method of well sealing. Sealing is usually achieved by, grouting; when grouting below the water table, the cementing material should be placed from the bottom up, by methods that would avoid segregation or excessive dilution of the material. The upper portion of the casing should be removed to ensure intimate contact of the grout with the wall of the hole to form a water-tight plug in the upper 5 to 7 m.

2.3 To seal an abandoned well properly, the type of groundwater occurrence must be considered. Under water table conditions, the objective is to prevent percolation of the surface water through the well or along the periphery of the casing to the water table. Under artesian conditions, the sealing operations must confine the water to the aquifer in which it occurs.

4.14 Surface Waters

Artificial impounding reservoirs (Storage and Sedimentation Tanks):

Rural water supply systems are planned with large impounding reservoirs as sources. If an existing impounding reservoir is available nearby, it can be used as source for rural water supply also, since construction of impounding reservoirs exclusively for rural water supply schemes will be expensive. Where water is drawn from canal or from a non-perennial river, it may be necessary to create a storage reservoir with capacity equal to the closure period of canal or equal to the dry flow period in the river, it may be necessary to create a storage reservoir with capacity equal to the closure period of canal or equal to the dry flow period in the river or streams. Usually, the canal closure period will be about 2 weeks and the river or streams may be dry for 3-4 months. The raw water from stream/river/canal may have to be pumped over long distances and larger heads for storage in the impounding reservoirs resulting in higher power charges. The capacity of impounding reasons to be constructed shall be equal to the canal closure period/ dry season of stream or river plus the evaporation and seepage losses. The pumping plant for pumping the raw water from the canal / river/ stream shall be designed such that the pumps, in addition to pumping the daily requirement will also have capacity to fill the impounding reservoir before commencement of the closure period of the canal or before stream/river goes dry.
The preferred technology option for treatment of surface water for rural communities is plain sedimentation followed by balancing tank, slow sand filtration and disinfections (with bleaching powder), pure water sump or filter water sump. Usually a jackwell is constructed in the canal/stream or river and water is pumped to the elevated storage reservoirs for distribution to the villages thus resulting in higher power charges. In view of the treatment cost and higher power charges and larger skilled manpower involved, user charger for supplying treated water from streams and lakes are likely to be higher. Hence, the community is to be informed for the high user charges and their willingness should be obtained for such surface schemes before selecting as technology option.

Surface Schemes shall be designed only where the following conditions prevail:

1. Where ground water is insufficient or having quality problems such as high fluorides and/or high TDS.
2. For the surface schemes to become viable the number of villages must be minimum 3. However lack of cooperation among the villages may create problems in operation and hence affect supply to the villages beyond the source. Hence this aspect is also to be considered before a surface scheme is proposed.
3. Since the cluster of villages requiring surface water has to be large to make the scheme viable, some en-route villages (Which do not have quality problem) can also be clubbed with the surface scheme. However, with increasing number of villages, communication problems may affect operation and maintenance.
CHAPTER 5
PRELIMINARY SCHEME REPORT

This chapter describes the preparation of Preliminary Scheme Report (PSR) for a rural water supply scheme, which is essential to arrive at an economical technology option in consultation with the rural community.

Usually a PSR will consist of the following:
1. An executive summary in a single sheet describing the concept of the proposed rural water supply scheme including rehabilitation of existing water supply scheme
2. Salient features of the existing and proposed scheme.
3. Simple design calculations for the sizes of the components, line estimates of capital cost for all the components including cost of rehabilitation of the existing water supply scheme and proposed water supply scheme.
4. Cost of storage tanks shall be worked out by calculating per litre rate and cost of pumping machinery shall be worked out on per BHP /KW basis
5. Environment Data sheet
6. Below mentioned is sample rough cost estimate using single line rate method.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Item</th>
<th>Quantity</th>
<th>Rate</th>
<th>amount</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lump sum cost of Pump Chamber 3.7x4.3 mt size complete with all fittings plinth area =15.62 sqmt</td>
<td>15.62 sqmt</td>
<td>6000 per sq mt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Water works development of area = 2000 sqmt including cost of fencing gate pillars etc</td>
<td>2000 sqmt</td>
<td>100 per sq mt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>RCC OHSR 20 KL capacity FSL 20 mt</td>
<td>20 kl</td>
<td>12000 per KL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Submersible pumpset of 7.5 BHP capacity including cost of electric control panel piping etc</td>
<td>7.5 BHP</td>
<td>5000 per BHP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Distribution system</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PVC pipe 150 mm</td>
<td>2000 mt</td>
<td>300 per mt</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PVC pipe 110 mm</td>
<td>5000 mt</td>
<td>200 per mt</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PVC pipe 90 mm</td>
<td>10000 mt</td>
<td>150 per mt</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PVC pipe 50 mm</td>
<td>5000 mt</td>
<td>100 per mt</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost of misc fittings and contigent expenses like cost of surveying supervision</td>
<td>LS</td>
<td>100000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environment provision</td>
<td>2% of Estd. Cost of scheme or actual</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Alternatively rough cost estimates can also be prepared by using per capita cost method. However line estimates will be more realistic.

7. O&M cost for the present population for water supply (including existing and proposed), and small bore sewer (wherever proposed)
8. Schematic diagram of existing and proposed water supply schemes showing the source, OHSR, transmission and distribution along with lengths and levels.
9. A village map showing the layout of the roads along with existing and proposed water supply scheme showing the source OHSR, transmission and distribution and roads and drains preferably using Total Station method.

5.1 Reconnaissance
A support Agency consisting of social scientist, consulting engineer & geologist and the community shall go round the village for collecting the data required for preparation of the PSR. During the reconnaissance, the functioning of the existing water supply scheme is studied and the rehabilitation needs are noted. For the proposed scheme, the location of the source and the location of OHSR have to be identified with the consent of the community. The ground water availability and quality of water may be ascertained by studying the water table in the existing sources and discussion with the community. The highest ground level and the lowest ground level and lengths of various components of pipeline have to be assessed. During the reconnaissance the nature of terrain and soil condition are noted and alignment for the out fall drain leading to the disposal point is also identified and noted on the map. At the end of the reconnaissance, the extent of rehabilitation and scope of the proposed scheme along with the concept would have been formed.

After collecting the field data, approximate sizes are arrived at an approximate cost for investment and O&M are worked out for various technology options for providing water supply, sanitation and drains. Approximate rates for pipelines, water storage tanks, filtration units, ground water recharging structures are considered while preparing the line estimates based on the previous experience structures are considered while preparing the line estimates based on the previous experience. Hence a near reasonable line estimate for capital cost and O & M cost can be arrived at so that the Community knows its required contribution and likely O & M cost. After which a PSR is prepared consisting of the executive summary, salient features, line estimates, capital cost and O&M cost for various technology options, schematic sketches and village map. The PSR will be presented to the community in a Gram Sabha, where various technology options will be discussed and the community will choose the most suitable options which is affordable to them (with respect to water supply and village sanitation). At the end of Gram Sabha, the land required for the implementation of the scheme should also be identified and acquisition if necessary shall be completed before detailed scheme report is to be done.
CHAPTER-6
DETAILED ENGINEERING FOR
A RURAL WATER SUPPLY SCHEME

This chapter contains the methodology adopted for detailed engineering for a rural water supply scheme. Field survey, design calculations, detailed plans and estimates etc are described. The preparation of detailed engineering commences only after approval of the PSR and therefore the designs and estimates will be prepared for the chosen technology option only. The various components of a rural water supply scheme based on surface source and groundwater source are discussed here.

6.1 Surveys:
The first step in detailed engineering is a field survey to find the levels at source, at OHSR/UGSR and along the road network. In addition, lengths and alignment (bends) shall be recorded. If any village map is readily available it will be up dated. Usually methods of survey applicable for villages are chain and compass survey, level survey, plane tabling and total station survey. Possibility of using GIS base maps may also be explored.

6.1.1 Total station survey System (TSSS):
It is a modern method, which provides accurate and fast field information on levels, distances, angles and landmarks. The TSSS is a system that includes an electronic theodolite, electronic distance measuring instrument (EDMI), and an electronic data collecting system. The system also includes tripods, tribrachs, prisms, targets and prism poles. The TSSS system is used to perform the conventional survey methods of traverse, network, resection, multiple ties, and trigonometric leveling. This will be useful for planning all future village developmental activities. Survey control points established with TSSS can be linked with Geo-coordinates and the data obtained is directly transferred to a personal computer and digital maps are generated. This process will yield highly accurate survey field data. Survey using GPS and Total station ensures Millimeter accuracy. Compared to the traditional method of survey, Total Station survey results in lot of savings in terms of time, money and man days while ensuring more accuracy and lending itself to easy access, retrieval and utilization of data.

The levels required shall normally be co-related to Mean Sea Level. Permanent as well as temporary benchmarks shall be established at prominent places within the village for future requirements.

a) Detailed ‘L’ section survey should be carried out along the existing roads for all pipelines and distribution system network. Levels shall normally be taken at 15 m intervals. If necessary, additional levels may be taken at road junctions, bends or peaks and valleys. Typical details to be included in a ‘L’ section and cross section are presented in Fig. 12.

b) Net levels (Grid levels) are taken usually at 5m intervals for block survey of OHSR/UGSR sites, treatment plant sites, pumping stations and intake structures.

c) The trial pits for pipelines shall be of size 1m x 1m and for a depth of about 1m to note the nature of soil preferably at 500m intervals.

d) However, trial pits for other structures shall be taken to a depth of up to 2m to note the nature of soil and subsoil water if any. Bearing capacity of the soil is determined by SPT method and soil samples collected and tested in laboratory to co-relate the results obtained in the field. For exceptional cases such as very loose soils or filled up soils, detailed soil analysis may be required.
6.2 **Selection of Source:**

The origin of all sources of water is rainfall. Water can be collected as it falls as rain before it reaches ground; or as surface water as it flows over the ground; or it can be collected in ponds/lakes; or as groundwater as it percolates down to aquifers. However, in Punjab state the main sources of water for irrigation and drinking purposes is ground water and surface water from irrigation canals. Depending upon the availability of potable water in the region the source of water supply is selected as surface or ground water.

6.3 **Groundwater based Schemes:**

Ground water based water supply schemes shall have generally following components.

6.3.1 **Tube Wells:**

Underground water which is abundantly available in most districts of Punjab is tapped through installing Tube Wells. Tube Wells shall be drilled in accordance with Indian Standard IS:2800 (Part- I )-1979 with latest amendments, developed in accordance with IS:11189-1985 with latest amendments and tested in accordance with IS:2800 ( Part-II )-1979 with latest amendments.

**General Requirements:**

Size of Tube well - M.S housing pipes confirming to IS:4270- 1983 with latest amendments of nominal bore dia. 200 mm to 250 mm shall generally be provided in most districts of Punjab. Length of Housing pipe shall depend on depth of water table, draw down and submergence requirements of pump.

Strainer - Steel strainer, Screens and slotted pipes shall be as per IS:8110 – 2000 with latest amendments of nominal bore dia. 200 mm shall generally be provided. Slot size of the strainer shall be arrived at from grain size analysis of aquifer to be tapped.

Depth - Depth of Tube well shall depend on availability of potable water.

6.4 **Water Works Structures:**

6.4.1 **Pump Chamber cum staff quarter**

Pump Chamber cum Staff Quarter at water works shall be constructed as per departmental standard design. Drawing attached as Fig. 2 (of Drawings).

6.4.2 **Storage Tank**

Elevated R.C.C. storage tank shall be constructed to supply water to the consumers at water works site. In a multi village Rural water supply scheme OHSR can be constructed at individual villages and a transmission line shall be laid from central water works to storage tank to fill the water in the individual water storage tanks. The capacity of water tank shall be calculated by using the mass curve. The height of tank shall be so adjusted as to keep a minimum residual pressure of 12 m (water column) at consumer end. Tank shall be designed as per IS:3370 (part 1 to 2)-1965, IS:3370 (part 3 to 4 )-1967. The staging of tank will be as guided by IS:11682-1985. Foundation design shall depend on bearing capacity of soil.
6.4.3 Pumping Machinery

In a rural water supply system, pumping machinery serves the purpose of pumping water from bore wells or for pumping raw water from source to treatment plant and treated water to the service reservoir. In water supply schemes the pumps may be centrifugal or submersible pumps used for pumping water from sumps to Overhead tanks. The centrifugal pump essentially consists of one or more impellers equipped with vanes mounted on a rotating shaft and enclosed by a casing. Centrifugal pumps commercially available have a speed range of 980 to 2900 rpm and the most common speed is 1440 rpm. High-speed pumps have smaller life span due to increased wear and tear though the size of the pump set is small. Some times Vertical turbine pumps are used for pumping water from jack wells.

Generally Submersible pump set conforming to IS:8034-1976 (Refer annexure H for detailed specification) shall be provided. The pumping hours shall be determined keeping in view availability of electricity. Capacity of pump shall be sufficient to fill the elevated tank with in the stipulated pumping hours. In the submersible pumps, the bowl assembly is directly connected to a submersible vertical electric motor suitable for working under water and the compact assembly thus formed operates below the surface of the water in the well. Delivery of water to the surface is through the riser pipe on which the assembly is suspended. The power is supplied to the motor through a flat type cable designed for working in under water condition. These pumps are usually operated at a motor speed of about 2900 rpm.

To minimize the suction head, submersible pumps may have to be lowered inside the well. In most of the rural water supply schemes the source is a bore well hence submersible pumps are preferred for which suction head is zero. Star rated pumping machinery should be used to save energy and increase efficiency.

6.4.4 Criteria for pump selection

Prior to the selection of a pump for pumping station, detailed consideration has to be given to various aspects. The hours of pumping are decided and the quantity of water available in the source is also calculated. Then the discharge of the pump set is calculated in terms of the lps (liters per second). Friction head and the total head for the pump set are calculated for the given diameter of the pumping main. Assuming a suitable efficiency and knowing the discharging head the horsepower of the pump set is calculated by referring to the pump manufacturer’s catalogue. After the required HP/KW is calculated; if water is to be lifted from the tube well submersible pump is chosen or if a centrifugal pump is chosen for other locations, reference is to be made to the relevant (either submersible or centrifugal) catalogue of the commercially available pump sets.

The final selection of the pump shall be based on the commercially available KW/HP for the given discharge (Q) and Head (H). Selection tables 6.1 & 6.2 based on above referred consideration are given below:

### Water rating Table 6.1 : Outer Diameter of Pump =150 mm

<table>
<thead>
<tr>
<th>HP/KW</th>
<th>Discharge in LPM</th>
<th>Total head in meters</th>
<th>Out let dia mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>240</td>
<td>480</td>
<td>720</td>
</tr>
<tr>
<td>5.0/3.7</td>
<td>22</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>6/4.5</td>
<td>35</td>
<td>31</td>
<td>26</td>
</tr>
<tr>
<td>7.5/5.5</td>
<td>47</td>
<td>35</td>
<td>32</td>
</tr>
<tr>
<td>10/7.5</td>
<td>60</td>
<td>52</td>
<td>45</td>
</tr>
<tr>
<td>12.5/9.3</td>
<td>72</td>
<td>63</td>
<td>54</td>
</tr>
<tr>
<td>15/11</td>
<td>85</td>
<td>74</td>
<td>64</td>
</tr>
<tr>
<td>17.5/13</td>
<td>96</td>
<td>84</td>
<td>72</td>
</tr>
<tr>
<td>20/15</td>
<td>108</td>
<td>96</td>
<td>82</td>
</tr>
</tbody>
</table>
Water Rating Table 6.2 :Outer Diameter of Pump =200 mm

<table>
<thead>
<tr>
<th>HP/KW</th>
<th>Discharge in LPM</th>
<th>Total head in meters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>600</td>
<td>900</td>
</tr>
<tr>
<td>7.5/5.5</td>
<td>22</td>
<td>21</td>
</tr>
<tr>
<td>12.5/9.3</td>
<td>39</td>
<td>36</td>
</tr>
<tr>
<td>15/11</td>
<td>44</td>
<td>41</td>
</tr>
<tr>
<td>20/15</td>
<td>57</td>
<td>52</td>
</tr>
<tr>
<td>25/18.5</td>
<td>66</td>
<td>62</td>
</tr>
<tr>
<td>30/22</td>
<td>88</td>
<td>82</td>
</tr>
<tr>
<td>35/25.7</td>
<td>110</td>
<td>103</td>
</tr>
<tr>
<td>20/15</td>
<td>108</td>
<td>96</td>
</tr>
</tbody>
</table>

Star labeled pump set are available in 2-25 HP and head of 29-317 m.

6.4.4.1 Limitation on Suction Head:

For centrifugal pump sets suction head shall be limited to 4.50 m. In case where suction lift exceeds 4.5m, the centrifugal pump may be installed at suitable elevation with reference to the water level to restrict suction lift to 4.5 m. Where the suction lift exceeds 6m, it is preferable to provide submersible pump or turbine pump depending on the site conditions.

6.4.4.2 Pump Efficiencies:

The efficiency of pump sets depends on the friction and turbulence within the pump set and mechanical and leakage loss. A pump set is chosen depending on the discharge and head i.e. Q and H. Pump performance curves are provided by the manufacturers. Choice of pump set from among the various manufacturers shall be such that the pumpset has the highest efficiency for the given duty conditions. Though the pump is chosen for the design duty conditions, in practice the head may vary depending on the actual water level in the source and friction head on the delivery point. Such a condition will result in the pump delivering more water due to reduction in the head. This will decrease the efficiency of the pump set and may also increase the power consumption. Some times, the variation may be so high that the amperage of the motor will also increase resulting in failure of motor winding. Hence, it is desirable to avoid over design of the pump sets and it is suggested that the pump chosen shall work within plus 5% or minus 25% of the range of the maximum efficiency point of O & H given in the family curve.

Fig 4 (of drawings) annexed with this manual presents characteristics of a pump under a constant operating speed. It can be seen from the figure that each pump has a maximum discharge at a minimum head, below which the pump will not work. Similarly at zero discharge (when discharge valve is closed), the head developed is maximum and is known as shut off head. Also it can be seen that maximum efficiency is obtained at a particular discharge. This point is nearer to the middle of the range of head and discharge of the pump. Normally, performance curve for each type of pump will be given in the pump manufacturer’s catalogue. In some catalogue instead of performance curve, water-rating charts will be given. These indicate range of head and discharges applicable to the particular type of pump. Hence, for a known head and discharge, from the range of pumps available, the most efficient one is the pump in which the required head and discharge lies near the middle of performance curve or water rating table. This also ensures satisfactory performance of the pump under varying head and discharge during pumping. Efficiency of pumps increases with higher star rating of pumps.

6.4.4.3 Pump Installation: Submersible Pumps:

Submersible pumps shall be installed in a bore well such that the motor assembly is always submerged in water. Hence, normally they are installed at 1.5- 2.0 m below the lowest safe yield
level during summer under continuous operation. Hence it is necessary to install Electronic water level indicators to read the water level in the bore well ensuring the required minimum submergence (1.5m) also to avoid drawing of the silt/sand from bottom it is preferable that lowest part of the pump is 3.0m above bottom of the well. The motor assembly is suspended through the riser pipe, which in turn is clamped at the top of the casing pipe. The insulated cable is tied to the riser pipe at regular intervals. The casing pipe is taken to height of about 0.45 m above the ground level and is covered in order to prevent misuse.

6.4.4.4 Accessories

Indoor control panels where pump chamber are provided or out door type control panel for bore well pump sets will have provision for energy meter, main switch, starter, single phase preventer, capacitor, etc.

a) Switches: A main switch of adequate capacity to disconnect power supply shall be provided after the meter. This will enable to disconnect the service immediately in case of any emergency or for maintenance purpose.

b) Starter: Starter with over load relay is provided to start and stop the motor and to protect it against any over load. Over load may be either electrical or mechanical.

c) Capacitor: Installation of capacitor of suitable rating in the motor circuit will improve the power factor and reduce energy consumption. The running cost of the motor will also be reduced. The recommended capacitor ratings are given below. It is essential to provide capacitor to avoid penal action from the PSEB. Typical components for starter and power capacitor rating for different range of motors are presented below.

d) Single phase preventer : - In three phase circuit, three fuses are provided (1 for each phase). If in any one phase fuses were to blow or any one phase is disconnected form service during running of the motor, the motor keeps running drawing excess current from the two lines and hence causing damage to the motor. If a single phase preventer is provided in the circuit, it will sense the operating coil and trips the starter and protects the motor from burning.

e) Voltmeter and three phase ammeters: - These meters will indicate whether system voltage is within permissible range for the motor or to know whether motor is drawing current equally on all three phases. The functioning of Voltmeter is very important, voltage being low in villages damaging the motors.

(f) Selector Switch: Selector switches of adequate capacity shall be used wherever more than one pump is installed. The selector switches will enable to operate any one of the pump or both the pumps from a single switch board.

Components for starter and power capacitor for different range of motors are given in Table 6.3:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Range of Motors</th>
<th>Starter Type</th>
<th>Cables (copper conductor wires)</th>
<th>Capacitor KVAR</th>
<th>MCB Ams</th>
<th>Volt meter</th>
<th>Ammeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Upto &amp; inclusive of 3 HP</td>
<td>D.O.L</td>
<td>2.5 Sq.mm</td>
<td>1</td>
<td>20</td>
<td>0 to 500 V</td>
<td>0-15A</td>
</tr>
<tr>
<td>2</td>
<td>Above 3 HP upto and inclusive of 5HP</td>
<td>D.O.L</td>
<td>2.5 Sq.mm</td>
<td>2</td>
<td>20</td>
<td>0 to 500 V</td>
<td>0-15A</td>
</tr>
<tr>
<td>3</td>
<td>Above 5 HP upto and inclusive of 7.5HP</td>
<td>Star delta</td>
<td>4.0 Sq.mm</td>
<td>3</td>
<td>32</td>
<td>0 to 500 V</td>
<td>0-30A</td>
</tr>
<tr>
<td>4</td>
<td>Above 7.5HP upto and inclusive of 10HP</td>
<td>Star delta</td>
<td>4.0 Sq.mm</td>
<td>4</td>
<td>40</td>
<td>0 to 500 V</td>
<td>0-30A</td>
</tr>
<tr>
<td>5</td>
<td>Above 10HP upto and inclusive of 12.5HP</td>
<td>Star /delta</td>
<td>6.0 Sq.mm</td>
<td>5</td>
<td>40</td>
<td>0 to 500 V</td>
<td>0-60A</td>
</tr>
<tr>
<td>6</td>
<td>Above 12.5HP upto and inclusive of 15HP</td>
<td>Star / delta</td>
<td>6.0 Sq.mm</td>
<td>5</td>
<td>63</td>
<td>0 to 500 V</td>
<td>0-60A</td>
</tr>
</tbody>
</table>
6.4.4.5 Electrical Connection

Use of underground cable is usually made for service connection from PSEB supply point to energy meter fixed inside the control board. Internal connections from meter to switch to starter to capacitor and to single phase preventer etc. are done using suitable P.V.C. insulated copper wires of 440 volts grade. From load side terminals of starter to submersible pump, suitable water proof PVC insulated copper cable of 3 core type has to be laid. Use of under ground cable of 4x105mm dia aluminum conductor, PVC insulated, PVC sheeted 1.1 kV class is usually used from PSEB supply point to energy meter upto 15 HP loads. Use of 3 core PVC insulated PVC sheathed copper conductor, water proof cable is used from starter terminals to pump terminals (inside bore). All the electric installations including transformer if any is checked by Chief Electrical Inspector before release of electric connection by PSEB.

6.4.4.5.1 Safety Procedures

a) After installation, it shall be tested to ensure that the wires / cables used are sufficiently insulated to avoid leakage of current.

b) For safety, all the metallic casing of enclosure of switches etc. must be solidly connected to earth. The body of the out door kiosks shall have a separate and efficient earth connection.

6.4.4.6 Pump Operation:

1. Trial Operation:
The operation of centrifugal pumps is quite simple and safe. There are relatively few valves to operate and the pump will not be damaged even if the discharge valve is closed for short periods of time.

2. Starting:
The pump must be primed before it will deliver any water. Failure to prime the pump may cause the wearing of rings rub and seize or the shaft may be scoured at the packing boxes. During starting it is desirable to have the vent cock in the casing open slightly to remove any dissolved air in the water. It is necessary to have the discharge valve closed so that the least load is thrown on the driver when the pump is started. The valve should be opened gradually to avoid over load on the motor and to prevent a sudden surge in the discharge line.

3. Shuttting Down
When shutting down, the discharge-valve should be in the same position as when starting up by closing the discharge valve gradually so that less power is dropped from the line and any sudden pressure surges in the pipe system are avoided.

3. Inspection and Maintenance

Manufacturers supply instruction books that give directions for the operation and maintenance of each pump.

If the base is not too rigid the shaft alignment should be checked occasionally.

6.4.4.7 Trouble shooting and remedial measures:

Normally a centrifugal pump does not start pumping water immediately after switching on due to failure of priming. This may be due to a clogged foot valve or entrapment of air on the
suction side. It is suggested that the pump is reprised by allowing more water to fill the suction line by opening the by-pass valve on the delivery side. Usually this may be sufficient. If the pump still does not deliver water then detailed inspection has to be done for any mechanical clogging of the foot valve or due to visible leaks on the suction side. In case of submersible pumps since suction head in zero, the above problems will not arise.

If the pressure gauge on the delivery side does not register a gradual increase it means that the water is not being delivered at the desired pressure or at the desired quantity. This may be due to any leakage on the pumping main or burst of the pipeline due to the closure of any valve on the pumping main. In such case, the pump has to be shut down and inspection undertaken on the delivery side for any leakage.

If the motor itself does not start or if the speed is slow it indicates electrical problem due to single phase current, low voltage or no power supply to the main switch or any fuses might have been blown. In such case, the main switch is to be switched off and verification done for the required voltage or replace any burnt fuses. During running of the pumps the ammeter should always show the designed value of consumption of power. If the pump is over loaded for any reasons and if the voltage is lower, it will indicate a higher value of amperage in which case also the motor is to be switched off and resumed only after the required voltage is observed. If all the above problems persists, if any vibrations are noticed and if any unusual noise is observed the manufacturer is to be contacted.

In case of submersible pumps, if there is no discharge it may be due to:

i) Choked strainer
ii) water level in the well being lower than the pump level
iii) single phase current, low voltage or no power supply to the main switch or any fuses might have been blown.

If the problem is with the power supply the remedial measures as discussed above shall be followed.

If the water level in the well is below the pump level, then sufficient time shall be allowed for recuperation to raise the water level above the pump level. If this problem persists it may be necessary to lower the pump. Hence it is essential to maintain the record of water table in bore well and pump capacity observed to see whether pump needs to be lowered. When none of the above are the causes for no discharge, the pump shall be removed and checked for the fault.

6.4.5 Disinfection Plant

Disinfection of water shall be carried out using chlorine or silver ionization based plant.

a) Silver Ionization Process:

The Silver ionization is a cold sterilization process using special silver electrodes which discharge silver ions into the water by means of low power direct electric current. As the water passes through the sealed chamber, metallic ions are generated to purify the water. The microscopic action of the ions with bacteria are twofold. First, the bacteria are destroyed through a change in their enzyme processes. The ions maintain a stable sanitizer residual in the water until they are used up by this process.
Major Benefits

- Effective protection against reinfection after sterilization
- Conservation of the water is maintained over prolonged storage periods
- The process ensures constant disinfection of conduits and storage tanks
- The silver ionization process entails no risk of corrosion in pipes or storage tanks
- The treated potable water is completely tasteless and odourless
- Silver ions are non-volatile and retain their residual effect within a wide temperature range
- No moving parts in the unit ensure long system life and keep maintenance to a minimum

b) Disinfection By Chlorination

Chlorination has become the most common type of drinking water disinfection. It should be noted that it is designed to kill harmful organisms, and generally does not result in sterile water (free of all microorganisms). Two types of processes are generally used: hypochlorination, employing a chemical feed pump to inject a calcium or sodium hypochlorite solution, and gas chlorination, using compressed chlorine gas.

**Hypochlorination.** Calcium hypochlorite (Bleaching Powder) is available commercially in either a dry or wet form. High-test calcium hypochlorite (HTH), the form most frequently used, contains about 30% available chlorine. Because calcium hypochlorite granules or pellets are readily
soluble in water and are relatively stable under proper storage conditions, they are often favored over other forms. Figure below shows a typical hypochlorite installation.

Sodium hypochlorite is available in strengths from 1.5% to 15%, with 3% available chlorine as the typical strength used in water treatment applications. The higher the strength of the chlorine solution, the more rapidly it decomposes and the more readily it is degraded by exposure to light and heat. It must therefore be stored in a cool location and in a corrosion-resistant tank. Typically, 30 minutes of chlorine contact time is required for optimal disinfection with good mixing. Water supply treatment dosages are established on the basis of maintaining a residual concentration of chlorine in the treated water.

Water-based solutions of either the liquid or the dry form of hypochlorite are prepared in predetermined stock solution strengths. Solutions are injected into the water supply using special chemical metering pumps called hypochlorinators. Positive displacement types are the most accurate and reliable and are commonly preferred to hypochlorinators employing other feed principles (usually based on suction). Positive-displacement-type hypochlorinators are readily available at relatively modest costs. These small chemical-feed pumps are designed to pump (inject under pressure) an aqueous solution of chlorine into the water system. They are designed to operate against pressures as high as 100 psi, but may also be used to inject chlorine solutions under ambient (atmospheric) or negative head conditions. Hypochlorinators come in various capacities ranging from 3.8 to 227 l/day. Usually, the pumping rate is manually adjusted by varying the stroke of the pump's piston or diaphragm. Once the stroke is set, the hypochlorinator accurately feeds chlorine into the system at that rate, maintaining a constant dose. This works well if the water supply rate and the output of the pump are fairly constant:

c) **Dosatron Technique:**

Dosatron technique of disinfecting drinking water is a non-electricity based disinfection dosing system. It is installed directly on the water supply line, the Dosatron operates by the using the flow of water as a power source. The water activates the Dosatron, which takes up the required percentage of concentrate directly from the container and injects it into the water. Inside the Dosatron, the concentrate is mixed with the water, and the water pressure forces the solution downstream. The dose of concentrate will be directly proportional to the volume of water entering the Dosatron, regardless of variations in flow or pressure which may occur in the main line.
Chlorine Dioxide (CDD-5000) is used as disinfectant. The benefits of CDD-5000 (Chlorine Dioxide) are as under:-

1. Residual remain for 72 hours.
2. Easy to transport to water works because it comes in powder from and 2kg CDD_5000 (Chlorine Dioxide) is enough to make 100 liter solution.
3. CDD-5000 comes in powder form.
4. Shelf life of sealed box is 5 years.
5. 100 liter solution is sufficient for disinfect more than 90 Lac liter of water.
6. Contact time with water for disinfection by CDD – 5000 with 2-5 minute at spource.
7. Residual can be tested at site by existing kits.
8. Effective on all types of bacteria which creates water born disease.
9. CDD-5000 does not form any ill effect on health like cancer etc.

6.5 Transmission:

Conveyance of water may be by gravity flow and/or pressure. Pipelines used for transmission of water, normally follow the profile of the ground surface closely. Gravity pipelines have to be laid below the hydraulic gradient. PVC Pipes are normally used for rural water supply schemes. MS/CI/GI pipes shall be used at all road crossings and in hard rocky strata regions.

6.5.1 Hazen-Williams Formula

The Hazen- Williams formula is most widely used for estimation of velocity, discharge and the loss of head due to friction.

\[ V = 0.849 \, C \, r^{0.63} \, S^{0.54} \]

Where:

- \( V \) = Velocity in metres per second
- \( r \) = Hydraulic radius of the pipe which is equal to \( D/4 \) where \( D \) is the Inner Dia of pipe in m
- \( S \) = Slope of hydraulic gradient m/m
- \( C \) = Hazen- Williams Co-efficient of roughness

6.5.2 Co-efficient of roughness:

The values of Hazen- Williams co-efficient ‘C’ for different pipe materials and the values adopted for design purposes are given in Table 6.4.

<table>
<thead>
<tr>
<th>Conduit Material</th>
<th>New Pipes</th>
<th>Design Purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic pipes (PVC)</td>
<td>150</td>
<td>145</td>
</tr>
<tr>
<td>Cast Iron, Ductile Iron and Mild Steel Pipes of dia. up to 500mm.</td>
<td>130</td>
<td>110</td>
</tr>
</tbody>
</table>

6.5.3 Resistance due to specials and appurtenances:

In pipelines there will be several transitions and appurtenances, which will add to the loss of head in addition to friction loss. These are normally expressed as velocity heads i.e., \( K \, V^2/2g \)

Where

- \( V \) = Average velocity in a pipe of corresponding diameter in m/s
g = Acceleration due to gravity in m/s²
k = A specific resistance co-efficient for the specials or appurtenance.

The values of K to be adopted for different fittings are given in the manual on water supply and treatment published by CPHEEO. However, in a rural water supply system it is recommended to calculate the head loss due to specials and appurtenances at 10% of head losses in pipeline.

6.5.4 Pipe Materials:
Out of the several of pipe materials available in the market, the most commonly used pipes in rural water supply schemes is PVC pipes.

PVC pipes:
These are most economically suited for rural water supply schemes. These have certain advantages over metal pipes, such as resistance to corrosion, light weight, easy jointing

Specification - IS : 4985-2000
Class - 2.5 kgf/sq.cm, 4kgf/sq.cm, 6 kgf/sq.cm and 10kgf/sq.cm
Size - 20 to 315 mm (outer diameter)
Jouting - Solvent welded joints, flanged joints, rubber ring joints
Wall thickness of uPVC pipes are given in Table 6.5

<table>
<thead>
<tr>
<th>Outside Diameter (mm)</th>
<th>Tolerance On Outside Diameter (mm)</th>
<th>Wall thickness for working pressure in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2.5 kgf/sq.cm</td>
</tr>
<tr>
<td>50</td>
<td>+0.3</td>
<td>-</td>
</tr>
<tr>
<td>63</td>
<td>+0.3</td>
<td>-</td>
</tr>
<tr>
<td>75</td>
<td>+0.3</td>
<td>-</td>
</tr>
<tr>
<td>90</td>
<td>+0.3</td>
<td>1.3</td>
</tr>
<tr>
<td>110</td>
<td>+0.4</td>
<td>1.6</td>
</tr>
<tr>
<td>125</td>
<td>+0.4</td>
<td>1.8</td>
</tr>
<tr>
<td>140</td>
<td>+0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>160</td>
<td>+0.5</td>
<td>2.3</td>
</tr>
<tr>
<td>180</td>
<td>+0.6</td>
<td>2.6</td>
</tr>
<tr>
<td>200</td>
<td>+0.6</td>
<td>2.9</td>
</tr>
<tr>
<td>225</td>
<td>+0.7</td>
<td>3.3</td>
</tr>
<tr>
<td>250</td>
<td>+0.8</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Note : Average thickness may be considered for design purpose for arriving at internal diameter .

6.5.5 Depth of cover
The pipeline shall be protected against damages due to external influence. Hence, the pipeline shall not be laid at surface, they shall be laid at sufficient depths to avoid damages. A minimum cover of 1.0m above the pipeline is to be laid to avoid damage by superimposed load. When heavy traffic is anticipated, depth of cover has to be worked out after taking into consideration the structural and other aspects. However in narrow streets 1-1.5 mt wide where no vehicular traffic is expected and digging deep may cause danger to the stability of adjoining structures it may be reduced to 60 cm . Distribution mains and pumping mains can be laid along the road berm to avoid load due to vehicular traffic on the pavement of road. When road is to be crossed, GI/CI pipes are preferred to PVC pipes.
6.5.6 Hydraulic testing of the pipe line

After a new pipeline is laid, hydrostatic test shall be done to ensure that pipes and joints are sound enough to withstand the maximum pressure likely to be developed under working conditions.

The completed pipeline may be tested either in one length or in sections. Each section should be properly sealed off with special stop ends and secured by adequate temporary anchors. All permanent anchors should be in position and concrete should develop adequate strength before the commencement of test. The section under test should be filled with water, taking care that all the air is displaced either through vents at the high points or by using a peg or a sphere.

In a pumping main the total head for which the pump to be designed is the maximum working pressure. However, in the case of submersible pumps, by the time water comes out of the pump up to the ground level near the bore well the total head will be reduced by the depth of water in the bore well. Hence, PVC pipes at the bore well location, shall withstand a resulting static head above ground level plus the head due to water hammer effect. In gravity main the maximum static head is equal to the hydraulic gradient line minus the lowest ground level along the alignment of the pipeline.

The test pressure for pipe lines shall be as per following :

- Pumping Mains = 50% of Pipe test pressure class or working pressure which ever is higher
- Gravity Lines = 2/3 rd of the Pipe test pressure or working pressure which ever is higher

After filling, the pipeline should be pressurized to the specified operating pressure and left for a period of time to achieve stable conditions. The pipeline is pressurized upto the full test pressure gradually and the section under test completely closed. The test should be mentioned for a period not less than 10 minutes to reveal any defects in the pipes, joints or anchorage. The test pressure should be measured at the lowest point of the section under test or alternatively, an allowance should be made for the static head between lowest point and the point of measurement, to ensure that the required test pressure is not exceeded at the lowest point.

The leakages/ burst if any should be identified and rectified there after the test is again carried out.

6.6 Appurtenances

Appurtenances are valves, which are installed in a pipeline to isolate and drain pipeline sections for test, inspection, cleaning and repairs, and for expulsion of air. For all appurtenances provided on line like Sluice valves, Butterfly valves, flow meters etc. be preceded with dismantling joints which will facilitate their removal for repairs or replacement. A few of the commonly adopted appurtenances are discussed herein.

6.6.1 Sluice Valves

Sluice valves on main line are provided to stop and regulate the flow of water in the course of ordinary operations and in an emergency. The principle considerations in location of the valves are accessibility and proximity to special points such as branches, stream crossings, major summit points etc.

Sluice valves of the same size as per diameter of the main line pipe are normally used for isolating sections of pipe. Sluice valves are sometimes used for continuous throttling which may cause erosion of seats and lead to body cavitations. Wherever small flows are required, the bypass valve is more suitable for this purpose as compared to throttling the mainline valve Fig. 5 presents the details of a sluice valve.

6.6.2 Butterfly Valves

This valve contains a circular disc which rotates in the direction of flow in pipe. It is a type of flow control device that is used to regulate flow of fluid through a section of pipe. This valve is
similar to ball valve in operation. A flat circular plate is fixed in the center of pipe. These valves are:

- Rigid and sturdy design with minimum loss of head across the valve
- Compact, light weight, low operating torques
- Eccentric seat geometry results in less wear and tear and longer life
- Self cleaning and non jamming seat design

Valve should be confirming to IS 13095:1991 (Reaffirmed 2003). Typical flanged and wafer butterfly valves are given in Fig. 3 (of drawings).

### 6.6.3 Scour Valve

Scour Valves are located in valley portions in the alignment of pipe lines, so as to facilitate emptying of the pipe line whenever required for maintenance of the pipeline. The outlet of the scour valve has to be connected to a natural drain. However, precautions must be taken to ensure that the wastewater from the drains does not enter the water supply pipelines. During installation of the valve, it should be ensured that it is always accessible for operation. A proper valve chamber with locking arrangement is required to protect the valve and prevent misuse. The size of scour valve shall be normally equal to half the diameter of the main line.

### 6.6.4 Air Valves

Air release valves are designed to expel air automatically from the pipe lines, which tends to accumulate at the high points in the pipeline. Normally in gravity flow pipelines, when the pressure in the pipe falls below the atmospheric pressure, air has to be drawn in to prevent collapsing of the pipes to prevent the pipe from such collapse (vacuum). Additionally Air Valve have also to release any entrained air which might accumulate at high points in the pipe line during normal operations. For most cases in water works and pumping practice, two types of air valves are required. These are known as

A) Large Orifice Air Valve: The purpose of this type of valve is to discharge air during filling or charging of mains and to admit air to mains while they are being emptied. They pass air at high rates of flow with small pressure difference either in to or out of the pipes on which the valve is fixed. The ball which forms the valve element although buoyant is rigid being covered with vulcanite. During normal service condition this ball is maintained in contact with its seating usually of leather backed rubber by the pressure in the main and cannot leave this seating except when the pressure falls practically to that of atmosphere. This occurs at various sections of a main when it is either being charged or emptied. when the pipes carrying a large orifice air valve are empty, the valve is open and remains in that position until the ball is carried on to its seating by the arrival of water. once on this eating and under pressure the valve cannot open and remains in that position even if the pipe is full of air until the pressure drops. It will be seen there fore that this valve will not release air accumulations under conditions of normal working pressure. when such a valve is discharging at a high rate, as during the filling of main of a main there is a risk that the ball although lying in a fully open position in the absence of water may nevertheless suddenly be caught in the escaping air stream and closed when it may refuse to open again until the pressure has been reduced. The ball of the valve in such a case would have to be held down during filling operation. This defect has been over come in a large orifice air valve of the advanced design known as kinetic air valve. In this air valve water or air enters from the bottom side of the ball and the air rushing around the ball exerts the pressure and loosens the contact with the top opening and allows he ball to drop down. When the solid water reaches the ball, however it is at once displaced and instantly closed.
Typical Sizes of Kinetic Air Valve

<table>
<thead>
<tr>
<th>VALVE SIZE</th>
<th>A</th>
<th>B</th>
<th>WIDTH</th>
<th>SUITABLE FOR MAIN SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>370</td>
<td>440</td>
<td>210</td>
<td>Up TO 100</td>
</tr>
<tr>
<td>50</td>
<td>410</td>
<td>440</td>
<td>210</td>
<td>125 TO 200</td>
</tr>
<tr>
<td>80</td>
<td>430</td>
<td>505</td>
<td>235</td>
<td>225 TO 350</td>
</tr>
<tr>
<td>100</td>
<td>500</td>
<td>635</td>
<td>280</td>
<td>400 TO 500</td>
</tr>
<tr>
<td>150</td>
<td>620</td>
<td>860</td>
<td>430</td>
<td>600 TO 1200</td>
</tr>
<tr>
<td>200</td>
<td>735</td>
<td>990</td>
<td>505</td>
<td>100 TO 1200</td>
</tr>
</tbody>
</table>

B) Small Orifice Air Valve: The purpose of this valve is to discharge air which may accumulate in sections of a main under working conditions, that is under the running pressure in the main. The orifice is relatively quite small and is sealed by a floating rubber covered ball at all pressures above atmospheric pressure except when air accumulates in this valve chamber. When air has accumulated to depress the water level sufficiently the ball falls away from outlet orifice and the air escapes through this orifice until the water level rises again causing the ball to reseal the orifice. The diameter of the ball in a small orifice air valve is related to maximum working pressure and for a given size of orifice increase with this pressure. The orifice is not less than 2.5 mm in diameter.
C) Double Air Valves: In many instances both large and small orifice air valves are required at the same point on a main and it is usual in such cases to fit a combined air valve in a single fitting.

Air inlet valves are used at peaks. A manually operated sluice valve is introduced between the air valve and the main pipe to isolate the air valve for the repairs. Normally, air valves are used with size equal to D/4 where D is the diameter of the main pipe on which the air valve is placed. Fig 6. is a typical sketch showing location of air Valves and scour valves.

6.6.5 Reflux Valves
Reflux valves are also called check valves or non-return valves, which automatically prevent reversal of flow in a pipe line. They are useful in pumping mains when positioned near pumping stations to prevent back flow when the pump is shutdown. The reflux valve is normally provided on delivery side of each pump to prevent back flow into pump impeller and to avoid rotation of impeller in reverse back flow into pump impeller and to avoid rotation of impeller in reverse direction. The size of the valve is equal to the same size as the pipeline on which it is installed. Reflux valves shall have by pass valves, which can be used for priming of the suction line before starting of the pumps.

6.6.6 Anchor Blocks:
Internal pressure including water hammer creates transverse stress or hoop tension. Bends and closures at dead ends or gates produce unbalanced pressure and longitudinal stress. When pipes are not permitted to change length, variations in temperature like-wise create longitudinal stress. External loads and foundation reactions (manner of support) including the weight of the full conduit, and atmospheric pressure produce flexural stress. Bends end closures at dead produce unbalanced pressure and longitudinal stress in the pipeline. Further when pipes are not permitted to change length due to variations in temperature, pipes also expand and create longitudinal stress. Anchorages are necessary to resist the tendency of the pipes to pull apart at bends and restrain or direct the expansion and contraction of rigidly joined pipes under the influence of temperature changes. Figure 7 presents the details of a typical anchor/thrust blocks for a rural water supply scheme.

6.6.7 Water Hammer
The pump set is shut off only after the delivery valve at the outlet of the pump is closed gradually so as to prevent the velocity rise in the pumping main. However, sudden power failure causes the sudden stoppage of pump set. Such sudden stoppage of pumps prevents the forward flow of water, which creates a separation of water column. Hence the water column ahead of the pump set rushes
towards the pump set (with a reversal of the direction) and velocity increases by several times causing water hammer. This pressure rise or water hammer results in a series of shocks, sounding like hammer blows, which may be of sufficient magnitude to rupture the pipe. The pressure due to water hammer depends on the elastic properties of the pipe material.

\[ \text{H}_{\text{max}} = CV \]
\[ C = \frac{1425}{1+Kd} \cdot EC_1 \]

Where

- \( \text{H}_{\text{max}} \) = maximum pressure in the closed conduit above the normal pressure in m.
- \( C \) = velocity of pressure wave travel m/sec.
- \( g \) = acceleration due to gravity in m/sec\(^2\) (9.81/m\(^2\))
- \( V_0 \) = normal velocity in the pipeline before sudden closure in m/sec.
- \( K \) = bulk modulus of water (2.07 x 10\(^8\) Kg/sq.m)
- \( D \) = Inner diameter of pipe in m
- \( C_1 \) = wall thickness of pipe in m
- \( E \) = modulus of elasticity of pipe material

<table>
<thead>
<tr>
<th>For D.I pipes</th>
<th>=1.7 x 10(^{10}) Kg/ sq.m</th>
</tr>
</thead>
<tbody>
<tr>
<td>For PVC/HDPE pipes</td>
<td>= 3.0 x 10(^8) Kg/ sq.m</td>
</tr>
<tr>
<td>For C.I pipes</td>
<td>= 7.5 x 10(^9) Kg/sq.m</td>
</tr>
<tr>
<td>For steel pipes</td>
<td>= 2.1 x 10(^6) Kg/sq.m</td>
</tr>
</tbody>
</table>

The actual water hammer head can be calculated and added to the working pressure to arrive at the class of the pipe which shall be able to withstand the total head on account of water hammer plus the working head. Water hammer is contained in small size pipe lines by operating them at lower velocities (not more than 1 m /sec.) Since water hammer head is a function of velocity, choosing a higher diameter pipeline reduces the velocity and hence reduces the water hammer head. However, cost effect has to be studied for choosing higher diameter pipe to minimize water hammer head or charging the pipe material or increasing the pressure class of pipe to withstand the water hammer head.

### 6.6.8 Economical size of pumping main

For a given discharge, if smaller diameter of the pipes are selected the velocity of flow increases. However the increased velocity results in higher frictional loss and hence increases total pumping head, which requires increased HP of the pump. This leads to higher pumping cost and may offset the reduction in initial cost due to the smaller diameter pipe. Normally, the combined effect is a net increase in cost. On the other hand if too large a diameter of the pipe is used the cost of pumping will be less, but the initial investment in cost of pipeline and pumps has an annuity, which depends on the rate of interest and period of repayment of loan taken for capital investment. The annual operating cost of the pumps will vary depending on HP/KW of pumps (dependent on size of pipeline). For the most economical condition we must choose such a pipe size, whose annuity due to initial cost together with the annual pumping cost will make the total annual expenditure minimum. The size of such a pipe is called economic size of the pipe’. The optimum velocity for most economical sizes of pipes is likely to be about 1 meter/ second.

The most economical size for conveyance shall be based on proper analysis of the following factors:
a) The period of design considered or period of loan repayment.

b) Different pipe sizes against different hydraulic slopes.

c) Different pipe materials, which can be used for purpose and their relative costs as laid in position.

d) The duty, capacity and installed cost of pump sets required against the corresponding sizes of pipelines under consideration.

e) The recurring costs on

   ii) energy charges for running pump sets.
   iii) staff for operation of the pump sets
   iv) cost of repairs and renewals of pump sets
   v) cost of miscellaneous consumable stores

While selecting the class of the pipe higher of the following shall be considered

i) Twice the working pressure at the top of the bore well.
ii) Working pressure at the top of the bore well water hammer pressure.

Note: Economical size of Pumping main can be calculated by using the software in MS Excel available with DWSS. Example of such design is enclosed at annexure – O-6

6.7 Environment Management Framework

The Updated Environmental Management Framework (EMF) will provide well-defined performance indicators for addressing the identified issues, through various activities/task under the proposed project, and strategy for its implementation to achieve sustainable sources for water supply and sanitation benefits within the proposed project districts for compliance of World Bank’s operational policies and environment acts.

Sector Environment Assessment (SEA) for PRWSS project was prepared by Feedback Turnkey Engineers in September 2006. The main focus of the report was water supply schemes. In 2010, Consulting Engineers Services updated the 1st EMF in the light of sewerage schemes. The present study includes updation of existing EMF on environmental issues in the context of PRWSS Project- II, including environmental sanitation and rain water harvesting techniques and its integration with water supply and sewerage schemes, proposed Institutional Arrangements, water quality monitoring, water and waste water sampling procedure, environmental concerns and management proposals, capacity building etc. In line with state policy, demand responsive approach, active involvement and participation of PRIs and beneficiary communities through all stages of the project implementation and its sustained operation and maintenance will be the key features of this EMF.

In order to ensure that the environmental issues are systematically identified and addressed in the various stages of the implementation of the schemes, an Updated Environmental Management Framework (EMF) has been developed for this project. EMF activities in the pre-planning, planning, implementation and O&M phases of the proposed project cycle for the project sponsored schemes are given in respective tasks. The key elements of EMF are as follows:

6.7.1 Environmental Data Sheets on Water Supply and Sewerage Schemes - The EMF requires the basic environmental data pertaining to the proposed schemes be compiled at the field data collection stage. For this purpose, a simple Environmental Data Sheet (EDS) has been formulated on water supply, sanitation/ sewerage schemes. Refer Annexure-L.

6.7.2 Environmental Categorization of the Schemes - At the Detailed Scheme Report (DSR) preparation stage, the available environmental information in the EDS will be evaluated and based on the level of expected environmental and public health impacts, the proposed
scheme would be classified. In case of water supply schemes, the schemes shall be classified as either Category I (environmental data sheet to be prepared) or Category II (detail environmental appraisal is required). In case of sewerage schemes, the schemes shall be classified as either Category I (environmental data sheet to be prepared) or Category II (detail environmental appraisal is required).

### Categories of Water Supply Scheme

<table>
<thead>
<tr>
<th>Category I (Minimal Impacts where EMP not required)</th>
<th>Category II (Significant Impacts where EMP required)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Water Supply involving pumping, construction of storage tanks and piped distribution networks, with source as tube well/bore well.</td>
<td>• Water Supply involving pumping, construction of storage tanks and piped distribution networks, with Surface water as a source.</td>
</tr>
<tr>
<td>• Water Supply with water source requiring minimum treatment such as disinfection.</td>
<td>• Water Supply with water source requiring “Advance Treatment” for removal of arsenic, iron, fluoride, salinity, etc.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>• Single Village Scheme (SVS) with either surface water or ground water source.</td>
<td>• Multi Village Scheme (MVS) based on either surface water or ground water source.</td>
</tr>
<tr>
<td>• Water Supply with source in shallow aquifer in safe and semi-critical zone and with source in deep aquifer located in safe zone of exploitation.</td>
<td>• Water Supply with source located in/very close to natural habitat/sensitive ecosystems such as National Parks, Wild Life Sanctuaries (requiring forest permission/clearance)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>• No water quality issues with regard to ground water source.</td>
<td>• Water Supply with water source from critical aquifers/over exploited zones. Ground water based scheme, if the water quality testing for deep groundwater source indicates unacceptable levels of pesticides or heavy metals.</td>
</tr>
</tbody>
</table>

### Categories of Sewerage Schemes

<table>
<thead>
<tr>
<th>Category I (Minimal Impacts where EMP not required)</th>
<th>Category II (Significant Impacts where EMP required)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sufficient land for STP is available easily</td>
<td>• Advance technology is to be provided as the available area is less than the requirement.</td>
</tr>
<tr>
<td>• Location of STP is more than 200 m away from school/hospitals and residential areas</td>
<td>• Location of STP is less than 200 m from school/hospitals and residential areas.</td>
</tr>
<tr>
<td>• Water logged area.</td>
<td>• Water logged area.</td>
</tr>
<tr>
<td>• No major tree cutting is involved for sewerage system and STP</td>
<td>• Major tree cutting is involved for sewerage system and STP.</td>
</tr>
<tr>
<td>• No industrial/chemical effluent being discharged to the proposed sewerage system</td>
<td>• Clearance of Forest Department is required</td>
</tr>
<tr>
<td>• No effluent disposal problem, i.e., disposal by gravity to nearby drain or water body</td>
<td>• Industrial/chemical effluent is mixing with sewage.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>• Effluent disposal problem requiring pumping for disposal.</td>
<td></td>
</tr>
</tbody>
</table>

### 6.7.3 Environmental Appraisal and approval

Based on the Environmental Categorization of the schemes for the proposed project, appraisals and approvals have to be obtained. With regard to land availability, as per World Bank guidelines land acquisition cost would not be financed through the World Bank, and land acquisition under this project should not be there. DWSS should ensure that the Gram Panchayat has the land required in their possession prior to conceiving a scheme.
6.7.4 **Environmental Management Plan (EMP) for pre-planning, construction and O&M phase impacts** – EMP based on issues identified during the planning stage of the proposed project and necessary preventive and mitigation measures should be considered in the design. The contractor shall provide an undertaking for execution of the activities identified in the EMP. The EMP shall be initiated at the planning and design stage of the project and the process shall involve addressing relevant environmental issues ranging from household to village level with appropriate detail.

6.7.5 **Provision for Environmental Cost** - Provision of 2% of capital cost of water supply and sewerage schemes towards EMP is notional. If the cost of implementation of EMP is more than 2% then the actual cost to be factored in the cost of the scheme.

### Approximate Provision of 2% Environmental Cost

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description of Environmental Enhancement Measures</th>
<th>Budgetary Cost in % of Scheme</th>
<th>Implementations Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td><strong>Water Supply Schemes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Provision for air, noise and water quality testing during construction / Rain water Harvesting structures</td>
<td>1.75%</td>
<td>Prospective Contractor</td>
</tr>
<tr>
<td>2</td>
<td>Provision of Lawns and Tree plantation in water works</td>
<td>0.25%</td>
<td>Prospective Contractor</td>
</tr>
<tr>
<td>B.</td>
<td><strong>Sewerage Schemes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Minor Repair and Cleaning of Drains</td>
<td>0.50%</td>
<td>Prospective Contractor</td>
</tr>
<tr>
<td>2</td>
<td>Provision for air, noise and water quality testing during construction/Rain water harvesting structures</td>
<td>1.00%</td>
<td>Prospective Contractor</td>
</tr>
<tr>
<td>3</td>
<td>Provision of Lawns and Tree Plantation around the STP sites</td>
<td>0.50%</td>
<td>Prospective Contractor</td>
</tr>
</tbody>
</table>

6.7.6 **Flow chart of EMF activities** : The following environmental frame work flow chart provides the understanding of the EMF activities to be taken up at various stages of the scheme including environmental monitoring with regard to performance indicators:
Field data collection including environmental data collection for water supply and sanitation schemes

Design of Scheme

Preparation of DSR for Scheme, Admin. approval & Technical sanction

Public Awareness Campaigns (continuous)

Preparation & approval of bid document with EMP

Issue of Notice, selection of prospective Contractor & Award of Contract

Release of Funds

Implementation Completion Report (ICR)

Operation & Maintenance (O&M)

Identification of Scheme (Water Supply / Sanitation)

Completion of Environmental Data Sheet

Environmental categorization of Scheme (Refer Clause 7.4)

Environmental Appraisal and Approval

Description of environmental mitigation measures specific to the scheme (Refer Clause 6.1 to 6.6)

Compliance certificate to be included for check of environmental mitigation measures (including construction stage measures) whether implemented or not. (Refer Table 7.5, 7.6 & 7.7)

Implementing measures for O&M stage impacts & Monitoring of Performance Indicators (Refer Clause 7.5)(Refer Table 7.7 & 7.8)

Required environmental clearances to be obtained & Environmental Evaluation Sheet

Category I

Category II

Engineers of DWSS with assistance from Env. officer

EE/AE from DWSS with Division Level Environmental Officer

EE/SE/CE of DWSS with Assistance in Env. Experts (Depending upon the scheme size)

DWSS, Division and Circle Environmental Specialist, GPWSC / SLC / GPs

DWSS with assistance from Division Level Environmental Officers / Contractor

GPWSC / SLC / DWSS / PRI / contractor
6.7.7 Key Performance Indicators
The performance indicators for water supply schemes and sewerage schemes are identified and the frequency of its monitoring and personnel responsible are indicated below:

Table 1.3: Performance Indicators for various Project Interventions / Components for Water Supply Scheme

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Project Intervention / Component</th>
<th>Performance Indicators</th>
<th>Frequency</th>
<th>Monitoring Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water Availability / Water Quantity</td>
<td>Access to safe drinking water supply of a minimum of 70 lpcd to the target communities.</td>
<td>Monthly</td>
<td>State level Executive Engineer in-charge of environment cell and Environment Specialist/Environmental Officers</td>
</tr>
<tr>
<td>2</td>
<td>Water Quality</td>
<td>* Regular DWSS water quality testing</td>
<td>Monthly</td>
<td>GPWSC/SLC/Environmental Officers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Water Quality Surveillance</td>
<td>Yearly</td>
<td>At district laboratories by the state level Environment cell</td>
</tr>
<tr>
<td>3</td>
<td>Ground Water Tables</td>
<td>* Need to be monitored in the schemes where ground water is the source of water supply.</td>
<td>Yearly</td>
<td>Independent consultant</td>
</tr>
</tbody>
</table>

Table 1.4: Performance Indicators for various Project Interventions / Components for Sewerage Scheme

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Project Intervention / Component</th>
<th>Performance Indicators</th>
<th>Frequency</th>
<th>Monitoring Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sanitation</td>
<td>* Increased access of household to common sewerage / sanitation system.</td>
<td>Half Yearly</td>
<td>State Environment Specialist</td>
</tr>
<tr>
<td>2</td>
<td>Sewer Condition Assessment</td>
<td>* Interception chambers / manholes / leakage in sewers etc.</td>
<td>Yearly</td>
<td>GPWSC/SLC/Environmental officers</td>
</tr>
<tr>
<td>3</td>
<td>Influent Characteristics</td>
<td>* pH, BOD, COD, TSS, SAR, EC, RSC and Faecal coliform</td>
<td>Quarterly</td>
<td>GPWSC/SLC//Environmental officers</td>
</tr>
<tr>
<td>4</td>
<td>Effluent Characteristics</td>
<td>* pH, TSS, BOD, COD, SAR, EC, RSC and Faecal coliform</td>
<td>Quarterly</td>
<td>GPWSC/SLC//Environmental officers</td>
</tr>
<tr>
<td>5</td>
<td>Sludge quality and compost quality</td>
<td>* pH, BOD, COD, Sodium, potassium, nitrogen, phosphorous, alkalinity/acidity, and heavy metals such as Cd, Ag, Zn and Cu.</td>
<td>Six Monthly</td>
<td>GPWSC/SLC/Environmental officers</td>
</tr>
<tr>
<td>6</td>
<td>Industrial waste discharge</td>
<td>* Checking of pre-treatment of waste and its characteristics</td>
<td>Monthly</td>
<td>GPWSC/SLC/Environmental officers</td>
</tr>
<tr>
<td>7</td>
<td>Sewage flow measurement</td>
<td>* Check for leakages, additional flows if any</td>
<td>Daily</td>
<td>Operator/GPWSC/SLC/Environmental Officers</td>
</tr>
</tbody>
</table>

6.7.8 Training and Capacity Building

The Training and Capacity Building programs has been proposed for the project, the aiming of this is building environmental awareness and environmental management capacity in the project administration structure as well as in the intended target communities.
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Training Purpose of the Training</th>
<th>Participants</th>
<th>Duration</th>
<th>Resource Persons/Agencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to Environmental Management in Proposed RWSS project including EMF</td>
<td>Field Staff – EEs, SDEs &amp; JEs, SEs, EEs, SDEs, Environmental Experts – Lab Technicians</td>
<td>Orientation Workshop – 1 day at circle level</td>
<td>Services of the experts from outside agencies such as PPCB and its affiliated Training and Research Institute, National Productivity Council (NPC) Delhi/ ESCI, Hyderabad etc., may be engaged.</td>
</tr>
<tr>
<td></td>
<td>Filling of EDS, procedural &amp; technical aspects of Environmental Assessment</td>
<td>To equip with knowledge and skills necessary for undertaking environmental appraisal as per the requirements of the EMF. To undertake periodic supervision of environmental performance of schemes To prepare for planning and monitoring implementation of environmental mitigation measures identified through the appraisal process. To equip with skills necessary for water quality testing using the field testing kits under the community based system for water quality monitoring and surveillance.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Training on Environment Management Framework</td>
<td>SEs, EEs, SDEs, Environmental Experts</td>
<td>Training Programme – 5 days</td>
<td>Outside agencies such as National Productivity Council (NPC) Delhi/ ESCI, Hyderabad etc.,</td>
</tr>
<tr>
<td></td>
<td>To equip with knowledge and skills necessary for undertaking environmental assessment, appraisal, practices, water quality testing as per the requirements of the EMF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Environmental Awareness and Sensitization</td>
<td>Environmental Staff – GPWSC/SLC members</td>
<td>One day workshop at the village level One day workshop organized annually Total training programs will be about 176 for the project duration.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>To build awareness on safe drinking water, water conservation, judicious use of water sources for competing demands, environmental sanitation and personal hygiene.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Orientation for Water Quality monitoring for PRIs</td>
<td>Field Staff – EEs, SDEs &amp; JEs, Env.Staff, GPWSC/SLC members</td>
<td>One day training at the circle level One day training to be organized annually.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>To build awareness on water quality monitoring amongst implementation agencies.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 6.7.9 Environmental Codes of Practices (ECoPs)

The details of relevant ECoPs for following activities are described in the report:
- Identification of Sources of Water Supply
- Site Selection for STP
- Identification of Quarry Sites / Borrow Areas
- Selection of location for Community Toilets
- Protecting Source water supply source and Ensuring its Sustainability
– Protecting Ground Water Supply Sources and Ensuring its Sustainability
– Selection of Safe Sanitation Technique Options at individual household and community level
– Solid & Liquid Waste Management at Individual Household and Community level
– Safe Sullage Disposal and Organic Waste Management
– Rain Water Harvesting Techniques
– Management of Water Supply System
– Rehabilitation of Construction sites / Supplementary Sites
– Schemes in Forest Areas
– Water Quality Monitoring and Surveillance
– Water and Waste Water Sampling Procedure
– Construction site management/ Labour Camp
– Occupational Health &Safety
CHAPTER-7

DISTRIBUTION SYSTEM

The treated water shall be pumped into the ground level reservoir situated at elevated places in the village or to the overhead water tanks. The stored water shall be distributed through appropriate pipe network system in the designed quantity at adequate pressure. The type of storage tanks and their design and the design of distribution network system are discussed in this chapter.

7 General guide line for selection of water works and OHSR site

Site selection criteria for Water Works and OHSR site:

a. For Rural Water Schemes Based on Tube Well as source of Water:

- Site should be located at a site where there is possibility / indication of getting adequate yield of potable water from underground source on sustainable basis. Resistivity method can be used to determine adequate availability of Ground water where ever required
- Site should have independent approach
- Site should be adequate so as to adjust proposed as well as future extensions structures. It should be preferably located in such a way that adequate space is available between OHSR (Over Head Water Tank) and adjoining structures / private buildings.
- Site should not be flood prone and should not be low lying and there is no flow of sullage / sewage towards it. Site should normally be away from ponds to avoid leaching action of pond water into Tube Well water.
- Site should normally not be abutting or adjoining cremation grounds and dumping site of rubbish from village. In case it is not possible locate site away from cremation ground adequate green cover / boundary wall shall be provided to isolate the water works site from the cremation ground.
- Site should not be located on recently filled / made up ground / mound or on edge of rock where soil erosion can take place with rain water or otherwise. It should be preferably a firm ground.
- Site should be located such that working of Tube Well proposed on it is not affected by working of private irrigation / government Tube wells if any installed in near vicinity.
- Site should be located at such a place so the there is no hindrance / objection from defence authorities / security agencies for the construction of OHSR. It should be free from over head electric / Tele phone cables.
- In case of multi village schemes site should be so selected that it is most economical also as regards to length of rising main to UGSR / Height of OHSR and sizes of distribution main pipes to villages.

7.1 Planning and Design Over Head Services Reservoirs

The water from the ground water source or treated water from surface shall be stored properly and then distributed through network of pipes by gravity. Elevated service reservoirs are the most commonly adopted structures for the above purpose as they can be constructed at a suitable location within the village. Following are the parameters to be considered in design of such overhead water tanks.
7.1.1 Capacity and Location

Capacity of OHSR shall be calculated by Mass curve method keeping in view the realistic availability of Electricity and water supply hours. Two number typical mass curves are enclosed at annexure O (5) as sample for different types of conditions of availability of electricity. The storage capacity of service reservoir shall be taken on the basis of mass curve plotted as per actual availability of electricity and the actual water supply hours or 30% of the daily requirement. Hence before fixing the capacity of OHSR mass curve should be plotted for all the three shifts and OHSR capacity should be worked out for worst case scenario. The tank shall be located such that the minimum residual pressure at the remotest point in the village is at least 12 mts. If elevated lands are available at a reasonable distance, ground level reservoirs can be proposed for storage of water. If such location is not available, an elevated service reservoir can be proposed with staging such that it gives a minimum residual pressure of 12 mts after counting for loss of head during peak hours due to simultaneous opening of the all the taps on the distribution system.

7.1.2 Staging

The staging height of the tank shall be such that, a minimum residual pressure of 12m of water is maintained at the farthest/ highest point in the distribution system. The staging height of reservoir is normally kept at 15m (Generally the staging height varies between 15m to 35m). It is desirable to locate the reservoir at the highest point in the village so that the staging height is minimized.

7.1.3 Shape

The overhead water tanks should be made of Reinforced Concrete and can have shapes preferably circular and intze type.

7.1.4 Standardized Capacity and sizes of Pipes:

Through the capacity of tank required varies from village to village for rural water supply systems to be installed in this project, it is preferable to have standardized capacity. Following standardized capacities along with sizes of pipes shall be used:

(As per CE circular no 42449-51 dt 31.10.90 and 56127-29 dt 16-12-93)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Capacity in Cum</th>
<th>FSL in metre</th>
<th>Size of Pipes in MM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inlet Pipe</td>
</tr>
<tr>
<td>1</td>
<td>25</td>
<td>15</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>75</td>
<td>22</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>25</td>
<td>150</td>
</tr>
<tr>
<td>5</td>
<td>150</td>
<td>28</td>
<td>150</td>
</tr>
<tr>
<td>6</td>
<td>200</td>
<td>28</td>
<td>150</td>
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<tr>
<td>7</td>
<td>250</td>
<td>30</td>
<td>200</td>
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<td>8</td>
<td>300</td>
<td>30</td>
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<td>9</td>
<td>400</td>
<td>30</td>
<td>200</td>
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<tr>
<td>10</td>
<td>500</td>
<td>30</td>
<td>250</td>
</tr>
<tr>
<td>11</td>
<td>1000</td>
<td>35</td>
<td>300</td>
</tr>
</tbody>
</table>

7.1.5 Pipe connections for inlet, outlet, scour, over flow etc.

The inlet pipe to the over flood service reservoir OHSR shall be preferably of the same diameter as the pumping main feeding the tank and the inlet shall be taken above the maximum water level of the tank.
The outlet from the OHSR shall be equal to the diameter of the first pipeline in the distribution system starting from the OHSR. The outlet shall be placed at least 150mm above the floor level/bottom of the OHSR.

The overflow pipe shall be equal in diameter to the inlet pipe so that the water coming into the reservoir and overflowing quantity will be equal. The overflow pipe is located with its invert at maximum water level of the OHSR.

The scour/washout pipe in the OHSR will be located at the lowest point in the floor of the OHSR. It is desirable to lead off both the overflow water and the scour-washout water towards the nearest drain. The hence these two pipes must be located adjacent to each other. Some times the overflow pipe and scour (washout) pipe are joined to the same chamber near the OHSR at ground level and later drained by a single gravity pipe to the nearest available drain. At times the overflow water will be wasted for long periods due to lack of communication between pump house and water tank locations. To avoid such wastage the overflow pipe of the OHSR is joined to the outlet pipe of the OHSR so that the overflow water is used in the distribution system instead of wasting.

It is desirable to provide bell mouths for inlet, outlet and overflow pipes to ensure smooth flow and strainers to the outlet pipe to ensure that no undesirable particles enter distribution system. The overflow and scour pipes are also provided with strainers at the termination points in the masonry chamber to avoid entry of insect etc. Fig.8 (of drawings) gives a typical sketch of elevation of an ELSR and arrangement of pipe connections for an OHSR. In addition, Fig.9 (of drawings) gives the typical sketch of fencing details.

Vertical piping provided for reservoir for inlet, outlet, and scour cum overflow should be cast iron double flanged pipes. The flanges shall be machined to ensure that the pipes are true to plumb and the joints with bolts and nuts are leak-proof. All the pipes entering the tank and coming out of the tank shall be located at the floor of the tank. It is desirable to keep the puddle flanges in the floor slab of the OHSR before concreting. However, while embedding the same, care must be taken to ensure that the flanges are true to plumb so that the vertical pipes connected to the OHSR are also plumb; sometimes it may be necessary to fix the flanges after the concreting of the floor slab is done. In such cases it is suggested that suitable grouting compounds may be used to ensure that no leakage occurs through the floor slab at pipe locations.

The vertical pipes may be marked with direction of flow and to identify the inlet, outlet, scour and overflow. Color scheme be adopted

1) Inlet :- Green
2) Outlet :- Blue
3) Overflow :- Red
4) Scour :- Yellow

Similarly the Control Valves also shall be identified by proper marking. Control valves are provided below the ground level in suitable masonry chambers and shall be vertical and true to plumb. Sometimes a bypass connection is made between the inlet into the OHSR and the outlet from the OHSR. This will facilitate supply of water directly to the distribution system when the OHSR is taken out of service for cleaning. Supply from bypass may affect the pressures in the distribution system.
7.1.6 Accessories

The standard type design drawings for the OHSR have provision for RCC. Spiral stairs with RCC handrails, which terminate at the roof. The access from the rooftop into the tank shall be with aluminium ladder to avoid corrosion. The roof of the OHSR shall be provided with ventilators covered with GI fly proof mesh. An access manhole is provided just at the entry point of the RCC ladder below which the aluminium access ladder is provided. Lightning arrester along with GI/ aluminium strip conductor is provided. The conductor is run vertically along one of the columns. A water level indicator shall be installed and located just above the ground level and connected to the water level in the tank with GI wire and aluminium pulleys with an anti corrosive float ball in the tank. Care should be taken that the Indicator is not accessible to the miscreants.

7.1.7 Design Principles

Type designs for RCC reservoirs are provided with this manual. However some basic principles are noted: The designs of the OHSR are done to cater for gravity loads (i.e. wt. of structure plus wt. of water stored), wind load on the structure and earthquake loads. The components of an OHSR’s can be classified as be are:

Foundation system- It may be raft foundation, pile foundation or individual footings depending upon the safe bearing capacity of the soil at the site.

Staging- Comprising of columns and braces

Container – comprising of top cover, vertical side wall, bottom slab and dome. All these components are to be designed giving due consideration to the various factors affecting their behaviour. The RCC for all components of ELSR shall be as per IS 456- 2000.

The type design of ELSRs are provided for maximum safe bearing capacity (SBCs 8.75T/m2). However, the actual SBC at the location of the OHSR may vary. It is necessary to make a trial pit of 2mx2mx2m deep and collect the soil sample at each location and determine the SBC. Based on the capacity, staging and actual SBC the suitable type design will be used. However amendments in latest IS codes be strictly incorporated with special regards to earthquake resistance. The OHSR of various capacities and staging heights are being designed for various safe bearing capacities by an external consulting agency. These designs and drawings shall be followed.

7.2 Distribution System:

The purpose of distribution system is to convey wholesome water to the consumer at adequate residual pressure in sufficient quantity at convenient points. The requirements for the distribution systems are network of pipes connected to reservoirs with valves at suitable locations for efficient operation and maintenance. Adequate residual pressure at maximum demand depending upon the hydraulic capacity of the system should be provided. Normally, water supply is intermittent in a rural water distribution system. As electricity situation has improved some schemes have been made 24x7. Hence the distribution system is to be designed for a peak factor of 3 giving due allowance to higher demand in morning nothing (assuming demand to be 2/1.5 times the normal supply). The road network pattern in a village is normally with dead ends and rarely the roads are connected. Though ideally a grid network is desirable, in a rural water supply system, dead end pipe systems are common. In a
dead end system, a single trunk main takes off from the OHSR with smaller mains branching off from the trunk main. A single trunk main may be sufficient where elevation difference between highest and lowest point in the village is not more than 4.5m. When the difference in elevations is more than 4.5m, two trunk mains taking off from the outlet main at OHSR may be required, one to serve the high level areas and the other to serve the low level areas. Wherever, it is possible the distribution system of the high level and the low level may be interconnected to provide emergency supplies. However, the interconnection valves between the zones shall normally be kept closed.

Note: Depending upon the profile of the village either a dead end or a loop system of distribution net work may be adopted, for all practical purposes.

**Bulk Meters:**

Bulk meters shall be provided to measure the quantity water supply to the communities /habitations. Normally Bulk flow measuring meters shall be provided at Water works site and at the entry point of each village /habitation. Readings taken from Bulk meters will help in equitable distribution of water supply and identify loses of water in transmission and consumption pattern can also be ascertained. Bulk meters shall be installed for each zone also where network is divided into zones. Mechanical flow meters upto 250 mm size are economical compared to electromagnetic flow meters, IS-2373 for mechanical meters gives information on range of registration with minimum and maximum flows required for registration. (i) First a meter of appropriate size is to be selected based on the flow rather than pipe size to enable accurate functioning of the meter (ii) Provide up to 250 mm size mechanical flow meters capable of generation of 4x20mA signals. These signals are required to transmit online through web based system at a later date. Generation of signals and transmission through web requires an energy pack good enough for about five years. (iii) install Electromagnetic flow meters with sufficient energy backup, only if the required size is more than 250 mm and (iv) Irrespective of the type of meter selected, meters shall be procured with at least five years guarantee.

**7.2.1 Hydraulic Network Analysis:**

A pipe network map corresponding to the road network of the village is prepared for hydraulic analysis. The total length of present pipe network is calculated. The estimated population/households for the design period is arrived at. From this data the households per running meter of network is calculated and hence the demand per running meter of the pipe network is calculated. The demand for each pipe section is arrived calculating from the end point as per the number of the households per running meter. The cumulative demand is calculated for each branch and for the trunk main.

This demand is average demand, however, the network is to be designed for the peak flow. The pipe network is then analysed for the estimated demand using the suitable peak factor. Drawings should be digitized or prepared in Auto Cad. Design should be done on the basis of hardy cross method or any other new method using software programmes as design based on manual calculation may not incorporate all the practical commandments. The design principles to be the followings :-

1) The algebraic sum of pressure around a closed loop not be zero i.e there can be no discontinuity in pressure.
2) The flow entering a junction must be equal to the flow leaving the same junction, the law of continuity not be satisfied.
Softwares which will enable hydraulic modeling will be used for larger networks to enable performance monitoring. Simple SCADA for large Multi Village Water Supply Scheme may be installed.

### 7.2.1.1 SCADA

SCADA to be provided where more number of overhead tanks are to be provided and hence manual control is not possible.

**Objective** is to ensure designed supply of water is done at ESR of each habitation. ESRs located at highest elevation and or farthest end will often receive lesser water compared to those ESRs located at lowest elevation and or nearer. Similarly adequate pressures may not be available at households located in highest elevation which results in pit taps. Hydraulic design of all networks is done on the premise that all pipelines flow full. System is likely to function as per design if there is continuous flow from the feeder mains into the ESRs and from ESRs into the distribution system. Every time the flow is stopped in the feeder mains or in distribution system, the network drains resulting in air entering into the system and when again flow is resumed the air is to be expelled fully which requires more time and if air is not expelled fully the pipes flow in part which affects the hydraulic design. It is desirable that the water supply is continuous instead of limiting supply hours to prevent draining of pipelines and associated problem of expulsion of air and likely pollution.

**Design Aspects:** The design cannot be made so perfect as to have uniform residual heads at all points. Further though the system is designed for ultimate flows, it has to serve the present demand which will progressively increase. Hence the hydraulic design done for ultimate demand is to be checked for residual heads for present demand and intermediate demand also. The residual heads (pressures) are also to be regulated and need to be adjusted for progressive changes in demand. The inflow into ESRs has to be controlled to the required rate of flow and also to control the cumulative flow. Whenever there is no demand in distribution system the ESRs will overflow and hence the level is to be sensed and the flow into ESR is to be stopped.

**Controls required:** System requires to have flow control (both rate of flow and cumulative flow), pressure control and ESR level control. To achieve this control with manual operations is infeasible and not desirable. In order to supply water at required design flow and pressure and to overcome the above situation it is necessary to provide flow and pressure measurement & control device. Apart from the above the flow measurement also helps in analyzing the water losses and water auditing in the system.

**Main Components of Flow and pressure measurement and controls are:**

- Ultrasonic Level (ESR) Sensor & Transmitter
- Pressure Sensor and Transmitter and pressure reducing valve if required
- Turbine flow meter with signal generation
- BF valve with Valve Actuator Motor and Valve Actuator Drive
- Programmable Logic Controller/Remote Terminal Unit
- Battery power Backup system including for Motor actuator and with solar back up
- The flow and pressure are monitored through the flow and pressure measured device and it will be transmitted to RTU.

**Control Philosophy:**

- When the flow varies from the set point of flow then the MOV will operate by automatic command from the RTU to regulate and achieve the required design flow at inlet of the ESR
- When the pressures vary from the set point of pressure then the MOV will operate by automatic command from the RTU to regulate and achieve the required design
pressure set at corresponding inlet of the ESR. This is better done by a Pressure reducing valve (PRV) than with BF valve.

- When the power failure occurs at pumping station and there is no flow to the MBR MOV in the inlet of ESR closes by automatic command from the RTU to avoid emptying the pipeline.
- When the power resumes at pumping station and flow to the MBR is resumed the MOV in the feeder main location and inlet of ELSR and intermediate sump will open by automatic command from the RTU.
- The level in the ELSR will be monitored and transmitted to RTU. When the maximum water level reaches in the ELSR MOV at inlet will close by automatic command from RTU. When the water level falls below maximum water level in the ELSR MOV at inlet will open by automatic command from RTU. The battery back-up system shall consist of 12V/60AHr capacity battery with charger facility with minimum 24 hour battery back-up. Solar Connectivity enabled.
- Instrumentation such as Flow meters, level sensors, actuator operated BF valves, PLC panels etc require prompt servicing arrangement. Hence the DSR/bid document shall have cost of SCADA with at least five years of O&M.

7.2.2 Input data

In the Hydraulic Network Design one of the important criteria is the head loss allowed in the distribution system. This is also an important constraint required in the optimization of pipe sizes required in the linear programming model. The use of smaller diameter pipes results in higher head losses, which calls for higher staging heights of OHSR to ensure desired residual pressure at the farthest delivery point. On the other hand, use of higher diameter pipes results in lower head losses but increases the cost of the pipeline. Hence the pipe sizes selected shall be optimized using the maximum and minimum and minimum head loss that can be permitted. Usually a minimum head loss of 0.1-0.5 m/km and maximum head loss 5-10 m/km are adopted in a rural water supply system.

The minimum head loss a calculated as the drop in elevation from the LWL or the OHSR to the lowest point in the village divided by the distance from the OHSR to the lowest elevation point along the network. The maximum head loss is calculated as the drop in elevation from the MWL of OHSR to the highest point in the village divided by the distance from the OHSR to the highest elevation point along the network.

Next important input to the analysis is the Hazen-Williams’s coefficient ‘C’ for design purpose is to be given as input based on the type of pipe material used in the network. The design value of ‘C’ for GI pipes is 100 and the design value of ‘C’ for PVC pipes is 145.

The diameter in a rural water supply distribution system vary from a minimum of 63 mm to a maximum of 200 mm. The distribution system will be designed for a peak factor of 3 at a minimum residual pressure of 12 meters.

Software programs are available for solving the dead end network and loop system for rural water supply system. The output diameters may give at some points residual head of more than 8 meters. This may be due to the low ground levels at that point. In such case, the particular diameter of the branch is further reduced and another analysis is carried out to verify the residual head. Sometimes the diameter of that particular branch may be a minimum diameter which cannot be further reduced. In such case the diameter of pipe in the main line just prior to the branch or the diameter of the pipe at the starting point of the OHSR is to be
reduced and another analysis carried out. This kind of trial and error procedure is carried out
till residual head at all the points of the network is more or less near to 12 meters. However if
residual head at some points is more than 10 meters, and cannot be reduced, a throttling valve
is to be used at the off-take of the branch.

7.3 Types of valves & their location

**Sluice valves:** The size of SV is same as the size of the main upto 300 mm and for
bigger diameters the size of valves is about 2/3 the size of mains subject to a min of 300 mm.

Sluice valves are not used for continuous throttling as there wise erosion of the
scales & body cavitations will occur. It is recommended the change the frequently when the
working is affected.

**Butterfly valves:**
The size of butterfly valve varies from 40mm to 2000mm. Disc is turned substantially through
90° from the closed to the open position, on an axis transverse to that of the valve ports.
Butterfly valves should conform to IS 13095:1991 (Reaffirmed 2003).

**Scour valves:** In pressure conduits, small gated take-offs known as blow-off or scour
valves are provided at the low points in the line such that each section of the line between
valves can be emptied and drained completely. They discharge into natural drainage channels
or empty into a sump from which the water can be pumped to waste. There should be no direct
connection to sewers or polluted water courses but through a specially designed trapped
chamber or pit. Their sizes depend upon local circumstances especially upon the time in which
a given section of line is designed to be emptied and upon the resulting velocities of flow.
Calculations are based upon orifice discharge under a failing head equal to the differences in
an elevation of the water surface in the conduit and the blow-off less the friction head.
Frequency of operation depends upon the quality of the water carried especially on silt loads.
In the distribution system scour valves are inserted in the scour branch from the main at low
points and at all dead ends. The size of the scour valve depends upon the length of the main to
be scoured. It is, however, about half the size of the main which is to be scoured. The scour
branch takes off from the main through a scour tee which is a special tee with its branch
connection having its invert at the same level as the main with a view to drain out the bottom
sediments.

**Reflux valves:** Reflux valves are valves through which flow can proceed in one
direction only. Any tendency for the flow to reserve causes a reflux valve to close and to
remain closed until flow is re-established, in the unique direction. It should close without
causing shock. They are also called non return valves, check valves and retaining valves. In
one application, a reflux valve can be described as a foot valve. The term check valve is
generally restricted to small size mains and which are of the disc type. Check valve can be had
for the vertical as well as horizontal flow conditions. They are used in the house plumbing
system as well as in industrial installation. It has the advantage of rapid closure but has
simultaneously the disadvantage of causing water hammer associated with rapid closure and
causing high resistance to flow. Single door type reflux valves should conform to IS : 5312

**Pressure Reducing Valves:**
Pressure reducing valves shall be provided at the entry point of distribution system to the low
lying areas to control excessive flow of water to the low lying areas
**Air valves** :- These are sited to release the air automatically when a pipe line is being filled and also to permit air to enter the pipe line when it is being emptied.

In an intermittent system the distribution pipes are becoming empty when the supply is stopped and draw in air and expel air when the water supply is resumed. Since the house service connections/ public taps are above the ground level air is expelled or drawn in through the open taps since these taps are usually kept open in an intermittent system even after the supply hours are over. However, to cater for situations wherein air has to be expelled or drawn in, Air Valves are sometimes provided at the highest point in the network. The highest point is normally at the OHSR premises where an air valve is essentially required. Air valves may have to be provided in the network, if the network pipes are having several valleys and ridges. In such case the smallest diameter air valve available are provided at the peaks. However, for these air valves to function effectively they have to be mounted above the road level and hence the pipe connecting the main pipeline to the valve is taken away upto the road boundary and housed in a secured chamber. In view of the complicated arrangement required for air valves in a rural water distribution system, it is recommended that instead of providing Air Valves. This will take care of the expulsion of air from the distribution system. While designing the distribution network, the stand post at the highest level shall be marked distinctly for using as Air Valve.

7.3.1 **Location of the Air Valves**

Air Valves are provided at all peaks. Peaks are not judged solely w.r.t. to horizontal datum but also with respect to the maximum hydraulic gradient. Air valves are necessary at all points where the pipe line approaching the hydraulic gradient changes its slope to recede from this gradient.

7.4 **House Service Connections**

The supply from the main pipeline to the individual houses is made through a house service connection. For a house service connection, ferrule is used on the main line either to control the flow or for permanent disconnection. The ferrule is sufficiently throttled to deliver required flow at the contemplated pressure. The size of the ferrule shall be 1/8inch and also be less than the diameter of the connecting pipe. In case of main pipe being GI, gunmetal or bronze ferrules are screwed onto GI pipe. If the main pipe is of PVC, special screwed saddles are fixed onto the pipe. In addition, a stop cock will be provided in the beginning of house connection pipe to control the supply or to facilitate temporary disconnection. Sometimes the connecting pipe to the consumer house may pass through a drain then there is a possibility of the contamination with drain water through any leakage in the consumer pipe. If the consumer pipe is with GI, it may corrode over a period of time and allow the wastewater into the main pipeline. Further the PVC consumer pipes also may be damaged when exposed in the drain portion, which may cause similar contamination. Hence it is recommended that the casing pipe be provided around the consumer pipe when drain is to be crossed.

7.5 **Distribution of Water**: Water shall be transferred to OHSR by installing bulk meters conforming to IS:2373-1981 (third revision) at inlet point in a village. Individual house connections shall be given through ferrules confirming to IS:2692-1978 and domestic water meters$ conforming to IS:779-1978 (fifth revision) shall be installed at consumer end. Refer detailed specification for Domestic
water meters at Annexure –D and for Bulk Meters at Annexure –E. House Service meter connection has been depicted in figure no13(of drawings).

7.6 **Design Approach for Water Supply Schemes in Severe Power Shortage areas:**

It has been observed that in some Rural areas there is severe shortage of power and it results in lower pumping hours and thus availability and reliability of water supply to the community falls below the design level. At the time of designing such schemes separate design approach shall be adopted so that water supply to the community does not get affected. Following critical parameters shall be modified as per below

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Design Parameter</th>
<th>Value for Severly Electricity shortage area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pumping Hours</td>
<td>“T”</td>
</tr>
<tr>
<td>2</td>
<td>Design safe yield for Tube well</td>
<td>Daily demand x T e.g. for T= 3 hours it is 3 times the daily demand</td>
</tr>
<tr>
<td>3</td>
<td>Pump discharge</td>
<td>Average hourly discharge x24/T</td>
</tr>
<tr>
<td>4</td>
<td>OHSR capacity</td>
<td>To be designed by using mass curve</td>
</tr>
<tr>
<td>5</td>
<td>Peak factor for distribution network</td>
<td>24/T</td>
</tr>
<tr>
<td>6</td>
<td>DG set</td>
<td>May be provided if supply is highly erratic</td>
</tr>
</tbody>
</table>
CHAPTER-8
WATER TREATMENT

The chapter provides various methods of water treatment applicable for rural water supply system. In some parts of Punjab the ground water which is the main source of water supply to the villages is having quality problems. Most of the water is having excessive concentrations of fluorides, TDS, hardness, nitrates and iron. Further there are instances of bacterial contaminations. Where the water quantity & quality problems are severe ground water cannot be relied upon and hence surface water with minimum treatment may be the only option. Normally rural water supply systems provide for plain sedimentation followed by slow sand filtration and disinfections with bleaching powder.

8.1 Water Treatment Processes applicable in rural water supply system are shown below.

<table>
<thead>
<tr>
<th>Activity number</th>
<th>Treatment process for Canal water based Water Supply Schemes</th>
<th>Treatment process for Tube well based Water schemes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intake of raw water through Intake structure and carried to water through Inlet Channel</td>
<td>Pumping of water from Tube well</td>
</tr>
<tr>
<td>2</td>
<td>Storage in Sedimentation tank and addition of Alum for flock formation to facilitate sedimentation.</td>
<td>Chlorination</td>
</tr>
<tr>
<td>3</td>
<td>Gravity flow to underground to Suction and scour well</td>
<td>Storage in OHSR</td>
</tr>
<tr>
<td>4</td>
<td>Pumping to High level tank</td>
<td>Distribution</td>
</tr>
<tr>
<td>5</td>
<td>Gravity flow to Slow sand filter beds/ continuous sand pit</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Gravity flow to Clear water Tank</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Pumping to Over head service Reservoir after chlorination/Ionization</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Distribution from OHSR</td>
<td></td>
</tr>
</tbody>
</table>

8.1.1 Water Treatment Processes applicable in rural water supply system are shown below.

1. Ground water
2. Pump
3. Disinfection
4. Storage
5. Distribution

Treatment process -A

a) Normally ground water available in Punjab does not require any extensive treatment and can be supplied with disinfections alone and hence option (a) shown in the above sketch is applicable. Fluorides, TDS and Iron from ground water cannot be removed easily as treatment plants for their removal require skilled operational personnel and constant attention apart from very high Capital cost and O&M cost. Such treatment plants provided elsewhere for removal of fluorides have become non-functional. The presence of nitrate, in water is due to agricultural pollution and fecal pollution. There is no economical treatment method available for removal of nitrates in domestic water supply. Hence it is suggested that the point of
contamination of the source with nitrates shall be identified and remedial measures taken to prevent contamination rather than providing treatment process for removal of nitrates.

8.2 Intake structures for surface water:

When surface water is decide to be the technology option, it calls for specific structures for the drawl and transmission. The normal units are intake well, collection sump and pumping arrangements (jack well), raw water rising main. In addition to the above, the setting tanks, slow sand filters, clear water sump are the other structures required.

8.2.1 Intake works:

These are the structures placed in a surface water source to permit the withdrawal of water from the source. These are essentially used in rivers etc., where wide fluctuations in
water level are expected. Also these works help in drawing water from the most desirable depth.

Location and Design Considerations:
1. It shall be located such that the raw water can be withdrawn continuously over the year.
2. It shall be nearer to the raw water sump.
3. The location shall be free from the water currents and swirls.
4. The entrance of large objects shall be prevented by screens.
5. The capacity of the conduit and depth of suction well should be such that the intake ports to the suction pipes do not draw air. A velocity of 60-90 cm/sec. will give satisfactory performance.
6. The intake conduit shall be laid in a continuous rising or falling grade to avoid accumulation of gas or air.

Normally intake structure is made of:
1. Pipe Outlet for discharge up to 0.5 Cusec
2. APM outlet for discharge more than 0.5 cusec but less than 5 cusec and where large variation in canal water level are expected
3. Open Flume Outlet discharge more than 0.5 cusec but less than 5 cusec and where large variation in canal water level are not expected.
4. Siphon Out let where canal is of perennial source and it is running in excavation

8.2.2 Inlet channel:
Raw water is carried to the sedimentation and Storage tank from the surface water source through inlet channel. It is so designed as to fill the storage and sedimentation tanks completing within seven days which is assumed to running days of the canal distributing “Its normal capacity is taken as three times the daily requirements.

8.3 Storage and Sedimentation of surface water: S&S tanks serve dual purpose of storage and sedimentation
In sedimentation the water is allowed to settle in sedimentation cum storage tank for a minimum detention period of 3-4 hours so that the heavier suspended particles settle down and the turbidity of water reduces to 10NTU and below. Normally sedimentation tanks are rectangular in nature with length to width ratio 3:1 to 5:1 and the depth of the water will be between 2.5 to 5.0m these tanks will be provided with sloped bottom for easy removal of settled solids. Proper inlets and outlets must be provided for uniform distribution of the flow and collection of settled water. Usually baffles are provided at the inlet and outlet of the settling tanks. Storage capacity is kept as 15 days requirement where raw water is taken from canal via distributory, minor etc. and 3 days requirement where connection is taken from main canal. Evaporation and percolation losses are assumed as 25%.

8.3.1 Suction and scour wells: Scour and suction well s should be located in such a way that number of bends is reduced to minimum. For rural population above 15000 persons these should be of 2.50m diameter and for population less than 15000 persons their diameters may be reduced to 1.5mtr.

8.3.2 Pumping Units: For Rural water supply schemes a population less than 15000 persons the pumping units of raw water and clear water shall be designed for 8 hours daily
working. If the population exceeds 15000 person the working hours may be increased to 16. In any case a pumping set of equal capacity both for raw water and clear water may be provided as stand by. It should be so arranged that one of raw water and one of clear water pump should also be capable of being run by a source alternate to electricity.

8.3.3 **High level tank:** Capacity of high level tank shall be determined by using mass curve based on actual supply hours and rate of filtration.

8.4 **Filters:** The rate of filtration in slow sand filters should be assumed as 50 gallons per 8ft (2500 liters per sqm.) per day while fixing the dimensions of filters, economical, sizes should be worked out as per example given below. About 25% additional filters should be provided as stand by i.e. for every four filter beds calculated one extra should be provided. This practice should be followed for all urban water supply scheme. The case of water supply scheme for small villages, the stand by provision should be added in the filtering area and two filter beds for equal capacity should be provided.

Example: Assuming that for every 4 beds, an additional spare bed is provided and the total area to be provided is 2400 sq.m. then area of the filter bed = 600sqm.

If L is the length of each bed the Breadth, b = 600/L

Therefore total perimeter of walls P = \(10 \times 600 + 6L\)

\[
\frac{6000}{L^2} = 6 \text{ or } L^2 = 1000
\]

\[
b = 600/32 = 19 \text{ meter}
\]

so the dimensions of each bed will be 32m x 19m.

8.4.1 **Filtering media:** The size and depth of filtering media to be provided should be as under:

The filter should consist of 30” to 36” (750 mm to 900mm) sand, supported on 9” to 12” (225mm to 300mm) gravel. The gravel shall be under laid by a system of open jointed under drainage. The sand shall have an effective size 0 to 3 mm and uniformity coefficient =2.00

The gravel is usually placed in four layers for a depth of 12” (300mm) graded from No.10 mesh to 2 ½” (6.3 mm to 63mm)
The grading should be such that the voids in any layer are less in size fine particles of gravel in the larger immediately above the supporting layer.

8.4.2 : **Pressure Filters:** A single village canal based water supply scheme shall be designed by using pressure filters to reduce cost as slow sand filters are economical for multi village schemes. However due care must be taken to train the community for operation and maintenance of pressure filters.

A pressure sand filter shall have following salient features:

- It shall have single valve operation to eliminate leakage from individual valves.
- Give visual indication as to the present operation of the filter.
- It shall have Multi port valve with quick connect threaded barrel unions.
- It shall have Hydraulically balanced laterals to maximize water flow and automatic air bleed.
- Tank of the pressure sand filter shall be made of Fibre Glass.
8.5 Clear Water Reservoir: As in case of high level tanks the storage capacity of clear water tank shall be worked out on the basis of the filtration and pumping schedule. Since the save water and clear water shall be pumped out according to the same pumping schedule the capacity of clear water reservoir shall be equal to the capacity of high level tank determined by using mass curve method.

For small installations such as small rural water supply schemes, the high level tank, filter beds and clear water tanks should be provided of circular section.

8.5.1 Over Head Service Reservoir (OHSR) The capacity of over head service reservoir, in the case of canal based water supply scheme shall also be fixed considering the pumping schedule and draft pattern as in the case of Tubewell based schemes.

8.5.2 Disinfections: Chlorination with Chlorine gas using a vacuum chlorinator is a very effective disinfections process for water treatment. However, the availability of gaseous chlorine and maintenance of the chlorinator are the constraints to adopt this type of chlorination practice of the rural water supply system. Hence, addition of bleaching powder is usually practiced for disinfections of rural water supplies. Availability of good quality bleaching powder with the required amount of available chlorine and prompt addition of bleaching powder in adequate quantity and at required interval is also essential. In order to achieve maximum destruction of bacteria a minimum contact period of 30 minutes between the bleaching powder solution and the water is required. If the bleaching powder is added in the OHSR the addition has to be done before stopping of pumps since the turbulence due to pumping will enable mixing of bleaching powder solution and the incoming water. However, the distribution system outlet must be opened only after a minimum period of 30 minutes after stoppage of pumping.

Normally the bleaching powder contains 30 to 35 % of chlorine when it is fresh. Since bleaching powder loses its chlorine content with time, it is desirable to assume that bleaching powder contains 25% of chlorine while determining dosage of bleaching powder. Hence, in order to give a chlorine dosage of 1mg/ltr. Bleaching powder of 4mg Per liter is to be dosed. After addition of the bleaching powder the residual chlorine in the OHSR water has to be about 1mg for liter to ensure minimum residual chlorine of 0.2 –0.3 mg/ltr at the consumption point. Any abnormal changes in the residual chlorine level or absence of residual chlorine will indicate the contamination of water. A chloroscope shall be used to check the residual chlorine content. Chloroscope consists of a colour comparator kit. Orthotoladine solution is used to check the residual chlorine content. Chloroscope consists of a colour comparator kit. Orthotoladine solution is used as reagent in finding residual chlorine. A sample of water is taken in a test tube and a few drops of the reagent is added to the water and shaken. If residual chlorine is present, the water in the test tube will turn to yellow. The concentration of residual chlorine is indicated by the intensity of the yellow colour i.e. the deeper the yellow; higher will be concentration of residual chlorine. The comparator kit provides accurate comparison of colours and hence assess quantity of residual chlorine. Chlorination shall be done by using metering Pumps based on Teflon diaphragms to ensure accurate dosage and long life. The storage tank shall be FRP lined and body of the pump shall Glass reinforced plastic to avoid corrosion. Ceramic balls shall be used as valves and no MS ball shall be used. As cost of silver is high therefore instead of silver ionization unit dosatron unit may be used for disinfecting.
water. It is non electricity based unit, hence saves electricity charges. Difference between Dosatron and Electric Pumps is given in Annexure – F.

8.6 Priority levels for Technical Options for water quality: The priority level for treatment of various constituents like fluorides, nitrates, total dissolve solids, iron and coliform bacteria shall be as below:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameter</th>
<th>Available options</th>
<th>Available Options Accepted/ Recommended Options in order of priority</th>
</tr>
</thead>
</table>
| 1       | Fluoride  | a. Alternate local/ distant ground water source (with appropriate ground water recharge arrangements)   
           b. Local recharge arrangements.  
           c. Blending with non-fluoride water wherever feasible.  
           d. Dual supply with different service level (drinking, cooking and other purposes)  
           e. Household defluoridation units  
           f. (i) Nalgonda Technique (using Alum).  
           (ii) Ion Exchange Process (using Activated Alumina) | a. Where isolated small number of habitations are affected  
           b. Where large number of contiguous villages are affected.  
           c. Where fluoride concentration is marginally higher (1.5-2mg/l) and fluoride free water is available.  
           d. Where community is aware and able to distinguish the difference (on pilot basis)  
           e. Can be tried on an experimental basis.  
           f. Can be tried on an experimental basis. |
| 2       | Nitrate   | a. In areas affected with Nitrate, open well sources shall be avoided  
           b. Alternatively, bore well with atleast 10 meters casing is recommended. Flushing is to be done first, before commissioning the supply | a. In areas affected with Nitrate, open well sources shall be avoided.  
           b. Alternatively bore well with a minimum of 10 meters casing is recommended. Flushing is to be done first. |
| 3       | TDS       | a. Alternate distant source/ ground water  
           b. Alternate local/ distant surface source  
           c. Blending, if possible. | a. Alternate distant source/ ground water  
           b. Alternate local/distant surface source.  
           c. Blending, if possible. |
           b. Regular use of bore wells to avoid accumulation of corrosion products from iron pipes. | a. Creating awareness to avoid long idling of bore wells.  
           b. Store water longer and strain through cloth.  
           c. Change the GI pipe to PVC pie casing.  
           d. Use PVC pipe for new bore holes. |
| 5       | Bacteria  | a. Disinfections | a. Continuous chlorination of water supply to maintain a minimum residual concentration of 0.2mg/lt. |

(Bacteria (Coliforms))
CHAPTER –9

ASSESSMENT OF EXISTING SYSTEM

In Punjab most of the villages are provided with water supply in one form or the other. The technology options for these schemes vary from simple hand pump, mini water supply scheme, piped water supply schemes with ground water source and a few piped water supply schemes with surface water source. These schemes have been executed by the WSSD Punjab and have been handed over to the respective GP’s and O&M. Due to constrains of funds the GPs are not able to pay even the electricity bills and are unable to maintain the schemes optimally. In some instances lack of skilled labour is also contributing to this situation. Hence most of the rural water supply systems are not functional or working below their designed capacity. Failure of sources, water quality problems, leaking pipelines & ESR, inefficient motors coupled with lack of management support are some of the common problems. The community is not paying the user charges towards the water consumed by them and the GP has no independent source of income. In view of this, there is a need to assess the status of the existing water supply system and to estimate the rehabilitation needs so that the systems will become fully functional.

Rehabilitation works have to be identified so as to facilitate integration of the proposed water supply schemes with the existing water supply system. Rehabilitation works can be divided into immediate needs and long term needs. In the immediate needs, there is no major investment but small additions and proper management may certainly revive the schemes. Some of the works that could be included shall be

a) Provision of required type of Valves at appropriate places.
b) Rectification of leakages in pumps, pipelines and reservoirs.
c) Immediate repairs to pumps and motors.
d) Effective supervision.
e) Establishing independent feeder main lines and disconnection of service connections on main lines to ensure equitable water distribution.

In the long term needs, additional investments are made so as to upgrade the existing system to the desired level. Some of the works that could be included shall be

a) Selection of additional sources where quality/ quantity of water available in the existing system is inadequate.
b) Modifications to existing pipelines/ pumps or provisions of new pipelines/ pumps in case existing pipelines and pumps are inadequate.
c) Strengthening/ restoration of existing storage tanks or provision of new higher capacity tanks/ additional tanks to cater for additional storage capacity to meet the designed demand.
d) Additions and extensions of the existing distribution system or provisions of new distribution system where there is no pipeline network/ existing pipeline network is inadequate and pipe are crusted due to hard water.
e) Scope & extent of ground water recharging measures required for ensuring the sustainability of the existing and proposed sources.

For a comprehensive assessment of existing system and proposals, essential enclosures and a sample checklist for DSR are given below:
**Essential Enclosures to DPR:**

i. Commitment of irrigation department is obtained for supplying required water to the proposed scheme or if it is other than surface source, source sustainability report from Geologist or analysis based on available reports is enclosed.

ii. Resolution for Availability of land is ascertained for construction of all the units of the Peri urban WSS.

iii. Water quality analysis report of the source is enclosed.

iv. Location plan, schematic drawing and hydraulic flow drawing are enclosed GIS / Total station survey base road maps of each habitation/ village served by the scheme.

v. Scheme designs (Hydraulic) including economical pumping main calculations for pumping mains and EPANET or other suitable software/Hydraulic statement for Gravity transmission lines, Structural Designs & Drawings are enclosed to the DSR.

vi. EPANET or other suitable software Input & Output Drawings and reports including soft copies are enclosed to the DSR.

vii. LS of pipelines is shown along with alignment plan with roads, drains, crossings, horizontal bends, road boundary etc.

viii. Location of air valves, scour valves and valves at branch off takes are marked on the LS and pipe route plan.

ix. All drawings for house connection with saddle and meter, valve and meter chambers

x. Capacity calculation for proposed OHSR

xi. Design of OHSR to conform to latest IS.

xii. Drawings for OHSR, Detailed description of the RCC OHSR with piping connections and accessories and reference to type design drawing.

xiii. Performance assessment of existing assets: (i) existing head works, (ii) Structural soundness and water tightness of the existing Service Reservoir, (iii) Status of existing appurtenants at existing OHSRs, Provision for replacement of the non-functioning appurtenances, (iv) hydraulic performance of the existing distribution system is ascertained or existing distribution is not functional make provision for replacement of the existing distribution lines is made.

xiv. Provision for 100% metered house connections is made in the DSR.

xv. Nearest source of power supply identified and Detailed estimate on power requirement and supply is enclosed to DSR.

xvi. Provision for Mechanical Turbine flow meter suitable for the water INLET pipe line size with display of meter readings with signal generation of 4x20mA.

xvii. Provision for valve actuators with Remote RTU/PLC panel and motorized butterfly valves (with AC motor, suitable gear box arrangement, for Controlling of rate of FLOW, cumulative flow at inlet of all Service Reservoirs.

xviii. Ultrasonic Water Level sensor, signal transmitter in each ESR.

xix. Provision for Control Panel, power, signal, antenna and communication cable suitable for the field instruments like, level transducer, turbine flow meter, valve actuators,

xx. GSM-GPRS communication unit for transmission of data to and from control center to ESR site.

xxi. All components shall be designed, drawings be prepared for all designed components, detailed and cost estimates be prepared for all components and Bid documents shall
contain all items in the DSR, relevant technical specifications and drawings shall be provided for all items in BOQ.

**WSS DSR Checklist:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Requirement/Activity</th>
<th>Yes/No</th>
<th>Remarks</th>
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<tbody>
<tr>
<td></td>
<td>Status of Existing Water supply</td>
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<tr>
<td>i)</td>
<td>Type of scheme and present service level lpcd</td>
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<td>ii)</td>
<td>Quality of present water</td>
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<td>iii)</td>
<td>Rehabilitation needs - specifically distribution system</td>
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<td>iv)</td>
<td>Feasibility for water and energy audit</td>
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<td></td>
<td><strong>Planning</strong></td>
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<tr>
<td>i)</td>
<td>Community and household survey</td>
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<td></td>
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<tr>
<td>ii)</td>
<td>Availability of water in source confirmed</td>
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<td>iii)</td>
<td>Is engineering survey done by using Total Station</td>
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<td>iv)</td>
<td>GIS base map prepared for the village</td>
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<td>v)</td>
<td>Availability of land for all components</td>
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<td></td>
<td><strong>Designs for</strong></td>
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<tr>
<td>i)</td>
<td>System hydraulic design</td>
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<tr>
<td>ii)</td>
<td>Economical size of pumping mains</td>
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<td>iii)</td>
<td>Process design of WTP</td>
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<td>iv)</td>
<td>distribution system design output for each village</td>
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<tr>
<td>v)</td>
<td>SBC determined for Pump houses, OHSR sites and WTP site</td>
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<td>vi)</td>
<td>Structural designs of intake well and pump houses</td>
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<td>vii)</td>
<td>Structural designs of WTP components</td>
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<td>viii)</td>
<td>Structural Designs of OHSR revised to latest IS codes.</td>
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<td></td>
<td><strong>Drawings prepared for</strong></td>
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<tr>
<td>i)</td>
<td>Intake works</td>
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<td>ii)</td>
<td>Key Map / Index map</td>
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<td>iii)</td>
<td>Longitudinal section along pipeline route</td>
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<td>iv)</td>
<td>Road network within each village</td>
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<td>v)</td>
<td>Distribution system network drawing</td>
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<td>vi)</td>
<td>Pump houses for raw water and clear water</td>
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<td>vii)</td>
<td>WTP site plan and tentative layout</td>
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<td>viii)</td>
<td>Site plans for all OHSR s</td>
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<td>ix)</td>
<td>Detailed drawing for OHSR</td>
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<td><strong>Estimate provision made include</strong></td>
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<td>WTP</td>
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<td>ii)</td>
<td>OHSR</td>
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<td>All electro mechanical works</td>
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<td>Power discom's woks for obtaining dedicated power connection</td>
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<td>v)</td>
<td>Disinfection</td>
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<td>vi)</td>
<td>Mechanical bulk-flow meter at entry to each ESR</td>
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<td>S. No.</td>
<td>Requirement/Activity</td>
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<td>vii)</td>
<td>House connections to all households with saddle piece, MDPE/GI pipe &amp; consumer meter.</td>
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<td>viii)</td>
<td>O&amp;M cost.</td>
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<td>ix)</td>
<td>Separate estimate for consumer and bulk meters</td>
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<td>x)</td>
<td>Separate estimate for simple SCADA (for large MV Scheme)</td>
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<td><strong>Enclosures to DSR</strong></td>
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<td>i)</td>
<td>Population calculations</td>
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<td>iii)</td>
<td>Water quality analysis report from proposed source</td>
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<td>iv)</td>
<td>Drawings for all components</td>
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<td>v)</td>
<td>Rate analysis worked out for all items</td>
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<td>vi)</td>
<td>Detailed estimates for all components</td>
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<td>vii)</td>
<td>Cost estimates for all components</td>
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<td>viii)</td>
<td>Per capita cost worked out</td>
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<td>ix)</td>
<td>Cost of production of water Rs / KL</td>
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CHAPTER –10
SEWERAGE SYSTEM

10.1 Present scenario of wastewater disposal:

The wastewater generated from various household activities in villages overflows into open surface drains and is ultimately disposed into ponds, thus making them highly polluted cesspools. Cow Dung also contributes to high BOD in these ponds. Seepage from pit latrines may also affect the underground water. This is leading to a serious health risk where villagers are drinking water from hand pumps located near soak pits or ponds, besides frequent occurrence of water borne epidemics like cholera, hepatitis, malaria, diarrhea etc.

The World Bank has estimated that water-and excreta related diseases in 1979 were responsible for loss of around 400 billion working days in Africa, Asia & Latin America which amounted to US$ 200 billion. Hence investments in improved water supplies and improved sanitation can bring benefits not only to individuals, but also to National economics. Governments need, therefore, to invest in their water supply and sanitation sector. If they do not, their economies will not develop as productively as possible, and people will continue, in the words of the Barbara Ward- to defecate themselves to death.

Keeping the above facts in view, International agencies in the field carried out extensive R & D for developing low cost water supply & sanitation technologies during the International drinking water supply and sanitation decade (1981-1990) and now safe water 2000.

Realizing the consequences of excreta related disease transmission in rural areas, Pb. Govt. on its own in 2001 took initiatives in developing and demonstrating workable and low cost sewerage system and sewage treatment technologies. As per the learnings during implementation of 97 schemes in PRWSS-I, it has been experienced that beneficiaries are hesitant to construct individual intercepting chambers. Case study of few schemes also indicate that water supply even if designed at 70 lpcd, actual supply availability vary from 120 to 150 lpcd which also include individual sources. Therefore, possibility of conventional sewer may also be considered.

10.1.1 Preparation of a Gram Panchayat/village wise Liquid Waste Management PLAN(LWM)

Planning and Implementation of LWM Works by GP/ Village: Planning and choice of technology option will be decided by the Gram Sabha or GP. Provision of land for community sanitation facilities will be provided by the GP. Implementation of all environmental sanitation works will be done by GP with community participation and technical support of ZP. Funds can be accessed from Swachh Bharat.

Preparation of Village wide Master Plan: A Gram Panchayat (GP)/village wide master plan for LWM is to be prepared by the GP with the help of DWSS/rural development/ zilla parishad (ZP) officers/consultants along with community consultation and, implemented by the GPs. The LWM Plan will include environmental sanitation facilities (both on onsite and offsite).
Scope of Work of LWM Plan: The scope of work of “preparation of LWM Plan in a village/GP for creating onsite and offsite facilities as appropriate for liquid waste management” is described below:

i. Conducting detailed engineering survey (by Total Station Method) along the roads of entire GP and prepare a base road map with levels, lengths and widths of the various roads and lanes.

ii. Total station survey need not be used for preparing the plans for small villages.

iii. After the plan is ready conduct a household community survey

iv. First item in survey is to find whether the house has a toilet or whether there is space for constructing a toilet.

v. In case the house has no space for toilet find a common place in the village for a group toilet.

vi. Depending on service levels of water supply, soil percolation rates and ground water table, decide whether a household soak pit is a feasible option for sullage disposal and whether the house has space for a soak pit.

vii. Assess the status of open drains in the village; whether they are clogged with solid waste and silt, and whether the disposal is happening or whether the sullage is getting stagnated. If open drains are misused examine feasibility of pipes for carrying sullage.

viii. If provision of soak pits is not a feasible option, examine feasibility and propose small bore(pipes) sewerage system in place of open drains for collection and disposal of sullage after treatment. Piped sewers are preferred for larger villages.

ix. Assess scope and availability of space for toilets in anganwadis ad schools. Community sanitary complexes.

Small bore /Solid free Sewerage system: Since all households are provided with toilets, only liquid waste will be generated for which huge open drains are not required. If the community awareness is created on proper use of the facilities, small bore pipe sewers are likely to be a better option for conveyance of sullage. Sullage from Households is collected via 100 mm feeder line and sewer lines are laid at slope (between one in 167 to 200) and Manholes are kept at 15 or 30 m. About 100 households are connected to one 100 mm dia PVC feeder lines, Houses connect to the feeder lines through small concrete collection or inspection boxes of about 40 cms in diameter. Since no vehicular traffic passes over the feeder line in the lanes, it can be laid at shallow depth, reducing the amount of trenching and number of manholes. Feeder lines are laid at a minimum depth of 30 cms to 40 cms and rarely exceed one meter in depth. When these lines cross the roads they are protected from vehicle loads by appropriate encasing.

Sullage Treatment: (i) Effluent is usually collected outside the GP into any existing pond where it can be treated by oxidation pond. (ii) Alternatively the effluent can be aligned along the borrow area of the approach road and treated through suitable treatment technology.
Contents of a LWM Plan: The LWM plan will contain following:

i. GP Base road map with levels and lengths and widths of roads and existing nature of paving

ii. Households with toilets and without toilets with those with space and without space for toilets. Space for group toilets, community biogas and waste stabilization ponds.

iii. GP base road map with proposed layout of small bore sewers with manholes, inspection boxes

iv. Number of Households requiring soak pits

Preparation of drawings and cost estimates for (a) individuals, Households, Soak pits and (b) for the community environmental sanitation infrastructure including water supply for community sanitation complex, group toilets, Toilets in anganwadis and schools and, Providing small bore sewers, Providing sullage treatment facility with any simple technology. Cost estimates will be based on latest Schedule of rates.

10.2 What is small bore/ Solid free sewerage system:

Solid free sewerage system is a cost effective sustainable technology which is designed to receive only the liquid portion of household waste water and troublesome solids are retained in intercepting chamber installed up stream of every house connection to sewer. As such, the sewer requires less velocity for flow of waste water and reduced flow requirements (less than 50% of conventional system).

In the Solid free sewerage system, PVC pipes of minimum 100mm o/d should be adopted. To prevent choking of sewerage system, inspection chambers are provided in each individual house to retain the solids and partially decompose the organic matter. Even the animal excreta are also contained into inspection chamber after preliminary treatment. Thus, there would be no overflow of waste waters onto streets. A novel syphonic system is incorporated for automatic flushing of sewer at regular intervals. In this system, the conventional man holes have been omitted which are normally never operated and are rather a source of dumping of garbage. Intercepting chambers are required to be cleaned once in 3-5 years using trolley mounted vacuum pumps. Instead cleanouts are provided for flushing and cleaning of sewerage, if needed, in case of unforeseen choking of sewerage. These cleanouts are again buried below ground level to avoid tampering. These features along-with the relative imperviousness of HDPE / PVC pipes totally foreclose any possibility of infiltration of ground water or ex-filtration of sewage contaminating the surrounding strata. Benefits of the technology have been reported as:

- The open drains have been eliminated and the streets are absolutely dry and clean.
- No embarrassment to ladies and children due to open defecation.
- Distinct hygienic quality of life visible even in weaker section.
- People have become aware about the benefits of safe wastewater disposal.
- Minimum Operation & Maintenance cost.

10.3 TREATMENT TECHNOLOGIES:

The waste waters are ultimately collected at the last point and pumped for subsequent treatment through various low-cost technologies which do not require any mechanical parts and minimal power. Various technologies for treatment of sewage / waste water are enlisted as:
i) Stabilization Ponds.
ii) Duckweed Ponds.
iii) Treatment by Forestry/Tree Plantation (Karnal Technology).
iv) Root Zone Technology/Artificial Wetlands
v) Aerated Lagoons
vi) Decentralized Wastewater Treatment System (DEWATS)

10.3.1 Stabilization Ponds:

Stabilization ponds are open flow through basins, specifically designed and constructed to treat sewage and wastewater. These provide long detention periods extending from a few to several days in which, organic matter in the waste is stabilized through a symbiotic relationship between bacteria and algae. The facultative ponds are best suited and most commonly used for treatment of sewage. In these ponds, at the surface, aerobic conditions prevail while there are anaerobic conditions at the bottom. Sewage organics are stabilized by both aerobic and anaerobic reactions. For further treatment of microbial pollution, maturation ponds as per characteristics of the sewage & required level of treatment are also provided, which are similar to facultative ponds.

Stabilization pond is comparatively simple and easy to construct. It does not require skilled operation and is easy to maintain. It gives consistently good and high level of performance in terms of pathogens removal and reliability, which is not attained by other process. Thus these are most suitable for treatment of sewage for the rural areas as it requires practically no maintenance and involves no moving parts. Moreover these are universally accepted and have stood the test of time.

10.3.2 Duckweed Pond Technology:

Duckweed pond is an earthen pond or a lined pond where duckweed plants are grown. These duckweeds cover the entire water surface and eliminate growth of algae and also suppress the odours and eliminate mosquito breeding. In these ponds, both anaerobic reactions and activity of duckweed growth are responsible for treatment of sewage and wastewater. Duckweed is still at development stage and is situational specific and recommended to be used depending upon the specific situation.

10.3.3 Treatment by Tree Plantation/Forestry (KARNAL TECHNOLOGY):

In this method, nutrient potential of raw sewage and wastewater is utilized for forestry. Suitable ridges and furrows are made on the land and tree species such as eucalyptus and poplar etc, which can grow fast, transp-evaporate huge quantity of sewage and at the same time are able to withstand high moisture content in the roots are planted on the ridges. Each tree acts as a small bio-pump absorbing liquid through the surrounding soil and releasing it to the environment through transpiration. Nutrients like NPK and micronutrients are supplied to soil and plants, thus building soil fertility. The amount of sewage to be applied depends upon type of plant, climatic conditions, soil texture and quality of effluent. Sewage treatment by tree plantation is situational specific and recommended to be used depending upon the specific situation.”
10.3.4 Root Zone Technology/ Wet Land System (RZ):

This is basically a manmade wetland, where waste water is kept at or above the soil surface for enough time during the year to maintain saturated conditions and appropriate vegetation like reeds. Reeds have an oxygen transport system from the leaves to the roots that permits the roots to survive in the anoxic conditions prevailing in a wetland. The oxygen supplied to the hollow roots called rhizomes is available to the aerobic bacteria growing in wastewater. Wastewater is pumped directly into the upper end of the reed bed surrounded by impermeable walls. The reed bed may require considerable time, several months to grow and develop root system to achieve full treatment efficiency. This is a natural process of treatment of effluents, economical and efficient at places where wasteland is available. On the basis of experiments in Europe, USA and India, it has been found that by adopting this process pollution load can be reduced by 80 to 90%.

Like duck weed technology, root zone technology in India is still at development stage and is situational specific and recommended to be used depending upon the specific situation."

10.3.5 Aerated Lagoons (AL):

Aerated lagoons are simple earthen basins, which act as a settling cum aeration basins in which artificial aeration replaces algal oxygenations. It has inlet pipe submerged in liquid to avoid odour and short-circuiting. Outlet at the other end is sufficiently wide to enable the wastewater to flow through while aeration is provided to stabilize the organic matter. Scum baffle is also provided at outlet. These are normally of facultative type in which some solids may leave with the effluent stream and some settle down in the lagoon since aeration power input is just enough for oxygenation. Lower part of such lagoons is anaerobic, while the upper layers are aerobic. It is adopted at places where land space is limited, sufficient power is available and enlargement or re-location is possible in the near future.

Aerated lagoons are not natural processes and require artificial aeration, which involves regular power supply, moving parts and strict supervision and attendance. As such, these are considered only in cases where electric power supply is assured.

10.3.6 Decentralized Wastewater Treatment System (DEWATS):

These are locally organized systems that are typically comprised of a settler, anaerobic baffle tank, filter beds of gravel and sand and an open pond. DEWATS applications are based on the following basic treatment modules, which are combined according to specific requirements including post treatment methods in the shape of reed beds and ponds as below:-

- Pretreatment & sedimentation in settlement tank or in a septic tank
- Secondary anaerobic treatment in baffled reactors
- Anaerobic/aerobic treatment in reed beds
- Aerobic treatment in ponds

An indicative flow diagram is given below:-

![Indicative Flow Diagram](image-url)
Primary treatment is carried out in a septic tank in which liquid part is separated from solid matter. Settled sludge gets partially stabilized by anaerobic digestion, whereas dissolved and suspended matter leaves the tank untreated. BOD removal is in the range of 35-40%.

Secondary Treatment is provided in the baffled reactor wherein several tanks (upflow chambers) are built in a series to digest degradable substance. Baffle Walls direct the water stream between chambers from top to bottom and up again. During the process fresh influent gets mixed and inoculated for digestion with active blanket deposit of suspended particles and microorganism occurring naturally at bottom of each chamber and because of physical separation various organism are at various stages allowing high treatment efficiency. At the end of chamber, an upflow anaerobic filter is provided to improve further the efficiency of the reactor. Tertiary Treatment is provided through a reed bed with horizontal filter. Treated effluent, as obtained from the reed beds, can be finally treated in polishing ponds where it gets exposed to atmosphere and wherein both aerobic degradation and pathogen removal takes places. Fish farming can be carried out in case of large and low loaded polishing ponds.

The treatment process is simple and desirable with high treatment efficiency if properly constructed and maintained. A few plants have been set up at various locations in the country. DEWATS system has been practiced and promoted by Centre for Scientific Research (CSR), Auroville, Tamil Nadu. CSR operates about 50 plants of capacities upto 150 persons. Treated effluent is used for recycling.

A 30 cum capacity plant has been constructed within campus of an Engineering College in Ghaziabad, UP.

Vigyan Vijay Foundation has established a 40 cum capacity plant based on DEWATS technology in Delhi.

Performance records of these plants as available shows BOD & COD reduction by 80% and Faecal Coliform reduction by 85%. The technology though is with minimal power requirement is highly land intensive, requirement is about 6 Ha/MLD and therefore, suitable for very small capacity applications. The plants have to be added with appropriate disinfection arrangements to make treated effluent safe for discharging into environment.

0.3.7 Soil Biotechnology:
Soil Biotechnology (SBT) is a bioconversion process where fundamental reactions of nature namely respiration, photosynthesis, mineral weathering take place in a media housing micro and macro organisms which bring about the desired purification. CAMUS-SBT or CSBT is an advanced and superior version of SBT which uses only local supplies and is an oxygen supplying biological engine and so the process can treat all types of water - domestic, municipal and industrial. CAMUS-SBT uses the ecology of soil type media and biological reactions within a constructed bioreactor to treat waste water.

Features of the technology

- No external aeration
- Low power consumption
- All green process
- No moving parts
- No bio-sludge formation
- Efficient removal of pollution
- Garden like ambience
- One time media installation
- Long life
- Unskilled personnel sufficient to operation
- Low space footprint via designs for below roads, in traffic islands, boundary wall, above settling and storage tanks.

The technology is covered by two US patents (patent no 6890438 B2 dated 5 May 2005 and 7604742 B2 dated 20 October 2009) and 2 Indian patents (patent no - 203744 and 203425) all assigned to IIT Bombay.

Figure 10.1

Figure 10.1 depicts Typical Process Flow for CAMUS-SBT Sewage to Water Recycling System. Single Stage 1) Raw sewage is collected in Raw Water Tank (RWT) after initial screening and settling. 2) The raw sewage is pumped on top of a CAMUS-SBT Bio Reactor where it percolates through a patented media.

The treated water is collected at the bottom of the Bio Reactor and stored in a Treated Water Tank (TWT). Any further purification if required is achieved by recycling the treated water through the BioReactor as shown. Incase as per site a two stage design is required then an intermediate sump is required. Some other features are summarised below:
- SBT/CAMUS-SBT allows user start-stop mode of operation and the plant can be run in intermittent mode, batch mode and continuous mode as per site conditions allowing 100% mission availability under varying conditions.
- SBT/CAMUS-SBT can easily handle 150% peak loads for a few days by increasing running times as the situation demands.

- SBT/CAMUS-SBT is capable of tertiary treatment (removal of Nitrogen, Phosphorous and heavy metals). Treated water is antiseptic due to high Dissolved Oxygen levels unlike other treatment technologies.
- Most other technologies require users to ship the sludge generated to a disposal station such as a landfill at significant cost not to mention much hassle. SBT/CAMUS-SBT avoids sludge generation and treats all of it within the process itself. However a provision for a bio-fertilizer from the process can be arranged should the customer need such a facility for other landscaping use.
- No moving parts unlike typical aerobic biological treatment processes such as membrane bio Reactor (MBR), and Activated Sludge Process (ASP) based STPs’ numerous motors, stirrers, blowers, clarifier’s pumps etc.
- CSBTs can be operated well even if power is available intermittently. This feature enables plant to be operated in situations wherein due to variable load plant is operated as and when required. In this process, sewage is treated in the natural environment engineered to remove pollution load in the water. Being a natural process the ecology is able to sustain itself for long time and provide treatment desired.

The effluent from **Small bore sewerage collection system** after passed through fine screens is taken to wet well by gravity and pumped and distributed over Bio reactor 1 (BR1). The waste
water is percolated through CAMUS SBT media which removes pollutant and collected the percolated water into Collection Tank 1 (CT) by gravity and discharge to nallah or reuse for gardening and flushing purpose.

10.4 : Merits and Demerits of various technologies:
As given in Volume-II (Sewerage) of Report on Standard Design Specifications and Rate Analysis prepared by M/s CES (I) Pvt. Ltd. under PRWSS Project, Merits and Demerits of various technologies are given below in Table 10.1:

Table No. 10.1: Merits / Demerits of Various Treatment Technologies

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Technology</th>
<th>Merits/ Demerits</th>
<th>Where Recommended</th>
</tr>
</thead>
</table>
| 1.    | Stabilization Pond | Merits.  
• No power requirement as the treatment is based on natural sunlight.  
• Simple to construct and no skilled labor is required at any stage of construction.  
• Operation and maintenance is negligible.  
• Much cheaper than other waste water treatment technologies.  
• Quite suitable for Indian conditions where lot of sunshine is available throughout the year.  
• BOD removal efficiency was found to be in the range of 80-90%.  
• Performance is fairly stable.  
• During winter season the treatment process shall be slow but more number of sunny days will compensate for these.  
Demerits:  
• Larger area of land is required.  | The technology is very much suitable for villages where sufficient land is available for sewage treatment at cheaper rates.  
• Non availability of regular power.  
• Non availability of trained and skilled manpower.  
• Non availability of proper resources for maintenance.  |
| 2.    | Duckweed       | The plant grows rapidly and shows an efficient nutrient uptake under a wide range of environmental conditions.  
It has been able to absorb heavy metals efficiently.  
It has a high protein content and relatively low fiber content, making it suitable for use as a high quality feed.  
A completed duckweed cover on the wastewater may effectively prevent the development of algea in the  | Where land is readily available and is comparatively cheaper.  
• Non availability of regular power.  
• Where weather is fairly stable and wind velocity is less.  |
water body and therefore result in a clear effluent with low TSS content.
- The presence of duckweed cover has been reported to decrease the development of mosquitoes in the water body.
- It has been reported to have positive effect on odour control when covering a wastewater body.
- Harvested duckweed may have an easy local market for chicken, cattle or fish feed.
- With utilization for aquaculture, this process is capable of generating revenue.
- No moving parts and no energy requirement except that requires for pumping station.
- BOD reduction is 80-90%.
- Duckweed based treatment system is suitable only for waste water having lower organic strength.
- Duckweeds are sensitive plants, which are affected by weather conditions. Cold regions are not suitable for the duckweed based treatment system.
- Duckweeds are sensitive to organic shock loads.
- Duckweeds can be easily swept off from water surface to one side by wind.
- Regular attendance and care is required.
- Microbial pollution reduction is rarely within safe limits.

<table>
<thead>
<tr>
<th>3. Tree Plantation</th>
<th>Merits:</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>• Relatively cheaper involving less capital &amp; recurring cost.</td>
</tr>
<tr>
<td></td>
<td>• Economically viable as it generates monetary returns from the sale of trees.</td>
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<tr>
<td></td>
<td>• Restores environment.</td>
</tr>
<tr>
<td></td>
<td>• Highly skilled manpower is not required.</td>
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<tr>
<td></td>
<td>• Suitable for imparting fertility to less fertile land.</td>
</tr>
<tr>
<td></td>
<td>• No power requirement and moving parts.</td>
</tr>
</tbody>
</table>

**Demerits:**

- Where treatment site is available away from the population.
- Fertility of waste land is required to be improved.
- It is appropriate for the rural areas where bio mass forest can be raised.
- It is applicable for villages where sufficient land is available.
<p>| | | |</p>
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<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>The technology is not applicable where ground water table is high (in depth)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improper application of sewage to the forestry may cause soil sickness.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Possibility of ground water pollution during non irrigation period.</td>
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</tr>
<tr>
<td></td>
<td>Large chunk of land is required.</td>
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</tr>
<tr>
<td></td>
<td>Difficulty in controlling odour, fly and mosquito breeding problems.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td><strong>Root Zone</strong></td>
<td></td>
</tr>
<tr>
<td>Merits:</td>
<td>No requirement of energy and mechanical equipment for aeration.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-regeneration of reed bed and virtually maintenance free.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>System can prove natural habitat for fauna.</td>
<td></td>
</tr>
<tr>
<td>Demerits:</td>
<td>Large land areas are required.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Difficulty in controlling fly and mosquito breeding problem.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Microbial pollution reduction is rarely within safe limits.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Where swamp (wetlands) is available nearby.</td>
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</tr>
<tr>
<td></td>
<td>Where water table is high and is likely to create swamp during rainy season.</td>
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<tr>
<td>5.</td>
<td><strong>Aerated lagoon</strong></td>
<td></td>
</tr>
<tr>
<td>Merits:</td>
<td>Land required is less.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nominal Power requirement.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>It is simple to operate and maintain.</td>
<td></td>
</tr>
<tr>
<td>Demerits:</td>
<td>Moving parts (aerators) and regular power is required as aeration is done by artificial means.</td>
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</tr>
<tr>
<td></td>
<td>Regular attendance is required. Microbial pollution reduction is rarely within safe limits.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regular power supply is assured. Land area available is limited.</td>
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</tr>
<tr>
<td></td>
<td><strong>Filtration &amp; Polishing Ponds</strong></td>
<td>Merits:</td>
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<tr>
<td>---</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>• Land requirement is medium.</td>
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<tr>
<td></td>
<td></td>
<td>• Leads to reasonable microbial pollution reduction if used with polishing pond or UV radiation or chlorination.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Demerits:</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Regular attendance is required.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Frequent washing is required.</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th><strong>Oxidation Ditch</strong></th>
<th>Merits:</th>
<th>Demerits:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>• Less land area is required.</td>
<td>• Where regular power supply is available.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Demerits:</strong></td>
<td>• Availability of land is limited and costly.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Regular power supply is required.</td>
<td>• Skilled manpower is available.</td>
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<tr>
<td></td>
<td></td>
<td>• O&amp;M cost is high.</td>
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<tr>
<td></td>
<td></td>
<td>• Skilled supervision is required.</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>• Regular de-sludging from sludge drying beds is required.</td>
<td></td>
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<thead>
<tr>
<th></th>
<th><strong>DEWATS</strong></th>
<th>Merits:</th>
<th>Demerits:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>• Provides treatment for domestic and industrial wastewater</td>
<td>• Where sufficient land is available at cheaper rates.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Moderate initial investment costs</td>
<td>• Non availability of regular power.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Modular design of all components</td>
<td>• Non availability of trained and skilled manpower.</td>
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<tr>
<td></td>
<td></td>
<td>• Tolerant towards inflow fluctuations</td>
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<tr>
<td></td>
<td></td>
<td>• Low maintenance costs</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td><strong>Demerits:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Large land areas are required.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Difficulty in controlling fly and mosquito breeding problem.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Microbial pollution reduction is rarely within safe limits.</td>
<td></td>
</tr>
</tbody>
</table>

### 10.5 Peak factor:
For intermittent water supply peak factor of 3 and for continuous supply peak factor of 2 should be adopted.

### 10.6 Disposal standards:
Disposal of effluent should meet Punjab Pollution Control Board /Central pollution control board standards.

### 10.7 Environment Management Framework:
Refer clause 6.7.

### 10.8 Cost of the Solid free sewerage system:
Average Per capita cost of sewerage system including sewage treatment (based on WSP Technology) comes out to be Rs 11350/- per capita as per approved estimates under PRWSS Project. However depending upon population and site conditions range varies from Rs. 7,028/- to Rs. 26,070/-. Provision of DG set should be made mandatory while preparing estimates. Possibility of installation of solar pumps shall also be explored.
CHAPTER-11
RURAL SANITATION

This chapter provides for planning designing and construction of environmental sanitation facilities in the villages to provide a healthy environment to the community. Provision of adequate sanitation facilities in the form of safe disposal of sullage and human excreta from the residential houses is one of the essential requirement of environmental sanitation. In addition, proper collection and disposal of solid waste generated is of prime importance to minimize environmental pollution. Traditionally in the rural areas, people are used to defecation in open areas due to lack of household toilets. Govt . of India issued Guidelines for Swachh Bharat Mission in December 2014. One of the objective of the mission is to bring an improvement in the general quality of life in the rural areas, by promoting cleanliness, hygiene and eliminating open defecation. It encourages cost effective and appropriate technologies for ecologically safe and sustainable sanitation. Procedures for making rural areas open defecation free given in these guidelines should be followed.

11.1 Use of locally available material for household toilets and drains.

In order to economise the cost of construction of the household toilets and drains it is necessary to prepare the plans and estimates using locally available material such as bricks and stones for construction of toilets, stone slabs for lining for drains, etc, to the maximum possible extent. Locally available artisans, masons, plumbers, unskilled made materials such as CI pipes, PVC pipes, FRP/ceramic water closet to be procured.

11.2 Twin Pit Pour Flush Latrine (TPPFL)

Twin pit pour flush toilets to the rural communities, since these toilets require less water and also do not pollute the ground water table. Further these toilets are economical and easy to construct and maintain.

TPPFL consists of a squatting pan, a trap with water seal, footrests, a connecting drain and two leach pits. The principle is that small quantity of water is used for flushing the toilet so that this water leaches easily into the surrounding soil and leaving the solids alone for digestion.

The squatting pan is of special design with steep bottom shape bottom slope 25-28° with a trap having 20 mm water seal set on a cement concrete floor. The slope of the toilet pan is such that pouring small quantity of water (about 1.5 to 2 litres of water per use) can flush human excreta.

The squatting pan is connected to twin leach pits through a trap and a pipe or covered drain. The flushed contents from the squatting pan flows and fills the connected leach pit. When one pit is full, the excreta are directed to the second pit. The filled up pit can be conveniently emptied after 1½ to 2 years, when most of the pathogens die off. The sludge can be safely used as a manure. Thus the two pits can be used alternately and continuously. A typical twin-pit pour flush water seal latrine is shown in Fig. 10 a and 10 b (of drawings).

Pour-flush water seal latrine is a very satisfactory and hygienic sanitation system and hence it can be located yards since the water seal prevents odour and insect nuisance.
11.2.1 TPPFL pits in Water Logged, Flood Prone and High Sub-soil Water Areas and Rocky strata.

**Pits in Water Logged, Flood Prone and High Sub-soil Water Areas**

In high sub-soil, water logged of flood prone areas, the pits should be raised above the ground level to a height such that the invert of the incoming drains/pipes is just before the likely flood water or sub-soil water level. Raising the pipes will necessitate raising the latrine floor also.

In pits located in water logged or flood prone areas, earth should be filled and well compacted all around the pits in 1000mm width and up to the top. It is not necessary to raise the pits by more than 300 mm above the plinth of the house because if water rises above the plinth, the residents will anyway vacate the house.

In high sub-soil water areas, about 300mm filling all around the pits may be done depending on site conditions.

In these situations, the pits should be designed as wet pits, taking into consideration the infiltration rate of the type of soil.

**Pits in Rocky Strata**

In rocky strata with soil layers in between, leach pits are designed on the same principles as those for low sub soil water level taking the long term infiltration capacity of the soil as 20 litres per sq.m per day. However, in rocks with fissures, chalk formation, or old roots channels, pollution can flow over a long distance; hence these conditions demand careful investigation and adoption of pollution safeguards.

In impervious rocky strata, since there will be no infiltration of liquid, the pits will function as holding tanks. In such situations, a PF latrine with leaching pits is not a suitable system.

**Pits in Soils with Low Infiltration Capacity.**

Leaching capacity tends to be limiting factor when the infiltrative capacity of soil is low. In these circumstances, there are two options; construct a larger pit, or increase the critical leaching area the former option is costly, while the latter can be accomplished by backfilling and compacting with brick ballast, gravel, sand etc., in the required width all around the pit, since the leaching area is the vertical surface of the excavation of the pit rather than the external wall of the pit.

Pits in Black Cotton soil are designed on the basis of whether the pit is wet or dry, taking the infiltration rate as 10 litres per sq. meter per day. However, a minimum 300 mm* vertical fill (envelope all around the pit) of sand, gravel or ballast of small sizes should be provided all round the pit, outside the pit lining, to separate the soil and the pit lining as well as well as to increase the infiltrative surface area.

**Pits Where Space is a Constraint**

Where circular pits of standard sizes cannot be constructed due to space constraint, deeper pits with smaller diameter (not less than 750 mm), or combined oval, square or
rectangular pits divided into two equal compartments by a partition wall, may be provided. In case of combined pits, the partition wall, as well as the adjoining side wall up to 225 mm width, should not have any holes. The partition wall should be 225 mm deeper than the pit lining. Both faces of the partition wall should be plastered in cement mortar 1:6.

**What are the Pollution Safeguards:**

Proper information and investigation of both geological/hydrogeological conditions of sites where pits are to be located, and the location of drinking water sources, size, all are pre-requisites in planning, designing and construction of on-site low cost sanitation systems to ensure that pollution risk to ground water and water distribution mains is minimal. Faulty construction and wrong data/information regarding hydrogeological conditions may lead to pollution of drinking water sources.

To ensure that the risk of polluting ground water and drinking water sources is minimal, the following safeguards should be taken while locating the pits:

a. Drinking water should be obtained from another source or from the same aquifer but at a point beyond the reach of any faecal pollution from the leach pits.

b. If the soil is fine (effective size 0.2mm or less), the pits can be located at a minimum distance of 3m from the drinking water sources, provided the maximum ground water level throughout the year is 2m or more below the pit bottom (low water table). If the water table is higher, i.e. less than 2m below the pit bottom, the safe distance should be increased to 10m.

c. If the soil is coarse (effective size more that 0.2mm), the same safe distances as specified above can be maintained by providing a 500 mm thick sand envelope, of fine sand of 0.2 mm effective size, all around the pit, and sealing the bottom of the pit with an impervious material such as puddle clay, a plastic sheet, lean cement concrete, or cement stabilized soil.

d. If the pits are located under a footpath or a road, or if a water supply main is within a distance of 3m from the pits, the invert level of the pipes or drains connecting the leach pits should be kept below the level of the pipes or drains connecting the leach pits should be kept below the level of the water main, or 1m below the ground level. If this is not possible due to site considerations, the joints of the water main should be encased in concrete.

**11.2.2 Operation and maintenance of TPPF Latrine**

**How to operate and maintain a TPPF Latrine?**

Operation and maintenance of TPPF latrine is very simple but it is necessary to educate the users regarding its proper use and maintenance.
**Diversion of Flow from One Pit to Another**

Only one of the two pits is to be used at a time. It is very important to completely seal the entry to the pit which is not in use. This is done by blocking one of the branches of the drain or in the case of the pipe, by blocking the mouth of one pipe at the junction chamber. When water does not flow out of the pan, either there is chockage or the pit in use is full. If by rodding, the chokage is not removed, then the pit in use is full and the flow needs to be diverted to the second pit. For this, remove the cover of the drain or junction chamber and take out the blockage to allow the flow to the pit not in use and block the flow to the pit which is full. Cover the drain or the junction chamber properly so that foul smell is not emitted.

**Removal And Disposal of Pit Sludge**

When the filled pit is allowed to rest for a minimum of one and a half years, the pit contents are completely digested and free of foul smell. The pit can then be safely emptied manually, without being hazardous to health, by the householder himself or through the local authority or a private agency. However, in the case of combined pits and pits located in water logged and high sub-soil water areas, de-sludging of pits should be done carefully because the sludge might not be completely safe and dry to handle due to travel of pathogents from the pit in use to the pit to be desludged. After the pit is emptied, the pit cover should be placed in position and the joint made air tight. The humus collected has rich manure value and is a good soil conditioner. The humus from dry pits can be used be directly either in the kitchen garden or the fields, but from wet pits it can be used only when it is sun dried.

**Do’s and Donot’s**

The following Do’s and Don’t’s should be explained to the users:

- Keep a bucket full of water outside the latrine.
- Keep a 2 litre can in the latrine filled with water for flushing.
- Before use, pour a little quantity of water to wet the pan so that excreta slide smoothly into the pit.
- Flush the excreta after use.
- Pour a little quantity of water, say half a litre, in the squatting pan after urination.
- The squatting pan should be cleaned.
- Use minimum quantity of water in washing the pan and latrine floor.
- Wash hands, using soap or ash, after defecation at the assigned place.
- If any construction defect is observed during the guarantee period, report the matter to the local authority or the construction agency.
- When the pit in use is full, divert the flow to the second pit as discussed on page 11.2.2
- If the trap gets choked, rodding should be done from the pan side as well as from the rear side by means of a split bamboo stick, after removing the cover of the drain or junction chamber.
- Care should be taken when desludging the pits located in water logged or high sub soil water areas and in the case of combined pits, as the humus may not be safe for handling.

**DON’T’s**

- Do not use both the pits at the same time.
- Do not use more than 2 litres of water for each flushing (if the waste is not flushed with 2 litres, pour more water at the specific sports for flushing the waste)
- Do not use caustic soda or acid for cleaning the pan.
- Do not throw sweepings, vegetable or fruit peelings, rags, cotton waste, and cleaning materials like corn cobs, mud balls, stone pieces, leaves etc. in the pan or the pits.
- Do not allow rain water, kitchen or bath waste water to enter the leach pits
- Do not provide water tap in the latrine.
- Do not throw lighted cigarette butts in the pan
- Do not desludge the pit before one and a half years of its being out of use

**Observations to be made during construction**

During construction, one should check whether the following conditions have been met:

- The depth of the pit below the invert level of connecting pipes or drain shall be as given in relevant drawings.
- If the maximum ground water level throughout the year remains 2m or more below the pit bottom, and if the soil at site is fine (effective size 0.2 mm or less), the pits have been located maintaining a minimum distance of 3 m from the drinking water sources. If the water table is higher, a minimum 10 m distance be kept to minimize the chances of pollution.
- If the soil at the site is coarse (effective size more than 0.2mm), a 500 mm thick envelope of fine sand of (0.2 mm effective size) has been provided all around the pit, its bottom sealed, it is located at a minimum distance of 3 m if ground water table is higher, a minimum distance of 10 m has been kept to prevent pollution of drinking water sources.
- The pit size conforms to be geological and hydrogeological conditions and the likely number of users, and adequate leaching area has been provided, if necessary, by back filling for proper infiltration of incoming liquid into the pits. In cases where the foundation is very close to the pits, holes have not been provided in the portion of lining facing the foundation, and the leaching area has been increased suitably.
- The minimum distance between the two pits shall be equal to the effective depth (depth of the pit below the invert of incoming pipe or drain) of the pits.
- The pits shall not be located in a depression where water may stagnate over the pits or in a drainage line which allows the flow of rain water over the pits.
- The bottom of the leach pit has been left in a natural condition except where it is necessary to seal it to prevent pollution.
- The RCC cover is as per designs.
- The top of the pit cover is about 50 mm above the natural ground level and the earth fill is well compacted all around the cover sloping to avoid a step being formed.
- The drain is “U” shaped, cross-sectionally and its inner surface is smooth.
- Drains with benching have been properly provided in the junction chamber to divert the flow to one of the two pits.
- A minimum gradient of 1:15 has been provided in the connecting drains or pipes.
- The mouth of the drains or pipe is projecting nearly 75 mm past the pit lining in the pits.
- The flow has been restricted to one pit by blocking the mouth of one of the drains or pipes.
- The materials used are of the quality specified in the design, or relevant standard specifications and the workmanship is good.
- The specifications laid down have been followed and the work has been finished nearly.
- The floor surface is smooth and sloping slightly towards the pan.
- The foot rests have been fixed at the proper place and at an angle, as in the drawing.
- 50 mm wide holes (honey combing) have been provided in the pit lining in alternate layers up to the invert of the pipe or drain, and the lining above is in solid brick work (no holes). If the soil is sandy, or if a sand envelope has been provided, or there are chances of damage by field rats, the width of the holes has been reduced to 12 to 15 mm. If the foundation of the building is close to the pits, holes have not been provided in the portion of lining facing the foundation. In cement concrete ring lining, rings below the invert of pipe or drains should have 50 mm circular holes suggested about 200 mm apart.
- The covers over the pits, drains and junction chamber have been placed properly.
- The pan and trap used are of a design specified for pour flush and these have been fixed properly so as to provide a 20 mm water seal, and that the joint is water tight and the top of the pan is flush with the latrine floor.
- No Vent pipe has been provided.
- A well ventilated superstructure has been provided to enable use of the latrine.
- All surplus material have been removed and the site cleared and dressed.
- The users have been educated on the use and maintenance of PF latrines.

**Materials:**

The squatting pan can be of ceramic, glass fibre reinforced plastic (GRP), high density polyethylene (HDPE) or polyvinyl chloride (PVC) polypropylene (PP), cement mosaic or even concrete superstructure. However, the ceramic pans are favored in this project due to the better non-sticking & non-staining properties.

A minimum latrine size of 750 x 900 mm is recommended. The superstructure of latrine cubical could be brick or stone in mud or in cement mortar.

**11.3 Institutional and group toilets**

Where individuals do not have adequate space a group of TPPFL toilets can be constructed in a common area owned by individuals and used exclusively by the owners duly providing locking arrangement. In institutions such as schools, primary health centers etc., similar group of TPPFL toilets can be provided. A typical sketch of an institutional latrine is given in Fig 11 (of drawings).

**11.4 Soak pit**

Soak pits are used dispose the effluents of the drain into ground where cannot discharge the effluents in a natural stream. These are ideally suitable for the regions where the terrain is flat and no nallah is available near the village. Normally, soak pits are provided next to stand posts, hand pumps and washing platforms so that wastewater does not get accumulated in the vicinity.

In general, the disposal of effluent may be either underground or over ground. Normally, underground disposal either in the form of soak pits or dispersion trenches is practiced. Satisfactory disposal depends on porosity and percolation characteristics of the soil.

When black cotton soil is encountered, we have to conduct percolation field test on the soil near the proposed disposal site. Normally permeability value for the black cotton soil will be very less. This Value has to be taken for designing the disposal system. Most of the time it is desirable to adopt a battery of dispersion trenches depending on the rate of percolation obtained from the field test and providing larger length of dispersion trenches.

The procedure to be followed to arrive at the size of the soak pit depending upon the soil conditions for a known effluent quantity is as follows:
The important parameter to be determined is the rate of percolation of filter media. For this, the following procedure shall be adopted. This is most important in clayey soils, which are relatively impervious.

Drill a hole of dia 300 mm to the required depth of soak pit / dispersion trench at the site chosen for constructing the soak pit. Remove all loose materials from the hole and fill up coarse sand or fine gravel to 50 mm depth to prevent scouring of the bottom. Fill up water to a depth of 300 mm in the hole and allow 24 hour duration soil to get saturated with water by pouring water on subsequent days till some water remains in the tested hole after the overnight swelling period. Now top up the water to get a depth of 150 mm of water over the sand in the hole. Now the hole is ready for carrying the test.

From a fixed reference point, measure the drop in water at 30 mm intervals for 4 hrs. If necessary, water can be refilled to 150 mm depth over the gravel. The drop in water level that occurs during the final 30 mm period shall be used to calculate the percolation rate.

**Note:** In case of sandy soils, water seeps away in less than 30 minutes. Hence, the time interval between measurement may be taken as 10 minutes and the test run for 1 hr. The drop that occurs during the final 10 minutes shall be used to calculate the percolation rate.

**Calculation of Percolation Rate:**

Based on the final drop during the period of 30 minutes (for sandy soils, 10 minutes) the time in minutes required for water to fall by 25 mm shall be calculated which is the percolation rate. A typical percolation chart is illustrated in Fig 34.

For example, we observe that during the 30 minutes period, drop in water level is found to be 100 mm.

The percolation rate =

\[ 25 \times \frac{30}{100} = 25 \times 0.3 = 7.5 \text{ minutes} \]

From the chart-27, for the percolation rate of 7.5 minutes, the maximum rate of effluent application =751/sq.m/day

Assuming total quantity of effluent = 750 litres/day

Surface area of soak pit required = \( \frac{750}{1} = 10 \text{ Sq.m} \)

\[ \frac{75}{118} \]
Hence a soak pit or dispersion trench of surface area 10 sq.m shall be provided.

11.5 Pucca drains

These are drains lined with brickwork and concrete. Even though lining is costly, they are functional and easy to maintain. Preferably local available material is be used. Type of drain are Punjab standard drains of type I, II, III & IV according to the discharge and depth.

Layout of drains :

Surveying and Data Collection

Drains have to be provided in the lanes and then off to the disposal point. Hence survey of the internal lanes in a village is the first step to decide the layout of the drains. During the survey the available width and the length of each lane and the gradient are also noted. The drains provided under the project will closely follow the network of lanes. In the absence of sufficient space for drains on either side of the lane, the paved surface itself has to be designed to act as a drain for storm water. The center of the lane will act as drain portion. This prevents water entering the sills of the houses.

The layout of drains has to be suitable to dispose the sullage/storm water in to natural drainage course. Generally, slope of terrain has to be followed and adopted so that the drains to be provided will have uniform depth. Also, it has to be ensured that there is no stagnation of water, which may result in a breeding of mosquitoes causing health hazard. Hence where there is no natural slope of terrain minimum slope of 1 in 240 may be provided for 200 mm wide drain and 1 in 375 for a drain of 250 mm wide. Whereever possible the drains may be lead to rainwater harvesting structures so that general ground water table is recharged and increase the sustainable yield of wells in the vicinity.
CHAPTER-12
OPERATION AND MAINTENANCE OF WATER SUPPLY SCHEMES

The infrastructure created in any scheme should satisfactorily last for the entire design period of the project. To ensure this, the various components of the project need maintenance during the project period for deriving maximum services out of them. Without planning both technically and financially for the proper maintenance and operation of the systems, these will not function correctly after commissioning and the anticipated benefits will not be realised. In rural areas of developing countries, a key to ensuring proper O & M is the participation of community from the conceptual stages of project and their performances been taken fully and seriously into consideration. Therefore user should know the most likely cost of O & M. The operation and Maintenance cost of a scheme depends on the capital cost, fixed cost and variable cost. For O&M of water supply schemes CPHEEO Manual on O&M of water supply systems could be referred.

The various maintenance works for a water supply scheme are listed as below:

1. Maintenance of the source.
3. Maintenance of treatment units, if any.
5. Maintenance of OHSR/UGSR.
6. Maintenance of distribution system.
7. Maintenance of structures Lawns & Clean environment

12.1. Maintenance of source:

In most of the cases tube well forms the source of rural water supply scheme. Waste materials should not be disposed near the source. This will prevent health hazards due to water borne diseases.

The following point should be deserved :-

a) There should be periodic development of T/W after a period of 3 years. This will rejuvenate the source. Otherwise the discharge of T/W may decrease with time.

b) There should be continuous monitoring of water level charges. Over a fixed interval of time, which would indicate the health of the source.

12.2. Maintenance of pumps :- Maintenance of pumps is explained in Chapter-6 and annexure -G

12.3. Maintenance of treatment units -

A layout plan of the entire plant indicating the flow pattern shall be maintained.

a) Maintenance of Slow Sand Filter :
For cleaning:

i. Close the inlet valve.
ii. Allow water to deplete about 10 to 20 cm below the sand surface.
iii. Allow the drying of sand bed.
iv. Remove the top 1-2 cm of sand layer by manually. Manual operations is preferred till labour is cheap.
v. After cleaning, level the sand surface.

For re-commissioning

i) The filter after cleaning allow water from under side so that dissolved gas or air entrapped. When bed was exposed to escape and also to provide water cushion so that when inlet valve is opened, sand bed is not disturbed.
ii) Opening inlet valve and ripening of filter is required. Dissolved oxygen (D.O) in the treated water should not be less than 3 mg/lt. If D.O is less than 3 mg/lt then recirculate the water treated through cascade aerator to increase the D.O. level in the effluent.
iii) After several years of operation-by means of cleaning, sand depth may reach minimum. Part of this removed sand has to be replaced back while resanding.
iv) For replacing the old sand when removed while cleaning, if decided to be used again, it should be washed immediately after taking out from the filter otherwise sand will become septic due to oxygen demand by micro organisms present in sand.

(Ripening of filter = to allow the growth of micro organisms for purification process,

time allowed to develop micro organism not less than 4 weeks.
(Range 2 – 8 weeks).

b) Maintenance of setting tanks:

In setting tanks, the basic maintenance is in the form of painting the surfaces and removal of sludge at the bottom. If any damp patches or leakage’s are noticed the same shall be rectified immediately.

C. Operation and Maintenance of Disinfection systems:

C1) Differential pressure chlorinator:

The most frequently expected problem is development of holes in the rubber bag. In such cases the rubber bag needs to be replaced, as a preventive maintenance, it is preferable to change the rubber bag once a year. The inlet and outlet pipe joints, control valves, drain valves and air release cock are to be maintained watertight. The MS container shall also be painted at least once in two years. The diaphragm should be replaced periodically, the rubber washer should be replaced. The container must be cleaned at least fortnightly so that there are no encrustations on container walls & logging of pipes.

C2) Dosing Pumps:

a) Diaphragm of the dosing pump shall be replaced after 3000 hours of operation or as recommended by manufacturer.
b) Chemical storage tank shall be cleaned once in month and it shall be covered with proper lid  
c) Dosing pump valves shall be cleaned with weak acid once in month to prevent clogging  
d) Settings of dosing pump shall not be disturbed when power supply is off as it will disturb the calibration  
e) Electronic solenoid is prone to burning due to sudden voltage fluctuations hence it should be provided with constant voltage stabilizer  

C3) Silver ionization plant :  
a) Regular cleaning of electrodes shall be ensured  
b) Silver electrodes of the Silver Ionization plant shall be replaced after 9-12 months of operation.  

12.4 Maintenance of pumping main :  

The pumping mains are often very long and generally laid along the road hence damage to pipe may be caused due burst in pipe lines, tampering by unauthorized persons, temperature variations, vehicular traffic, etc. Such unauthorized persons, temperature variations, vehicular traffic, etc. Such damages should be observed and attended to immediately. Ready made pipe sleeves, rubber sheets, and pipe clamps, etc shall be always be kept in stock to stop the leakages in cracked pipes temporarily. If the pipes have developed major cracks or severely damaged such pipes need to be replaced with good ones.  
The appurtenances in the piping main such as sluice valves, scour valves, air release valves, etc shall be protected against tampering by unauthorized persons by always closing the lid and locking the valve chambers.  

12.5 Maintenance of OHSR/UGSR :  

To prevent bacterial contamination of water and to maintain hygienic condition of water it is necessary that clear water storage tanks are periodically cleaned and disinfected. It may be necessary to clean them once in three months or more frequently (if required). A program shall be prepared and display boards shall be exhibited near the tank indicating last cleaning date and the next cleaning date. Men entering the tank should use clean pair of gum boots, which are washed just before entering the water tank. Brushes used must also be in clean condition, preferably they should be soaked in bleaching powder solution at least for one hour before use. Also hand gloves shall be used in cleaning.  
i) Cleaning operation :  
The water level in the tank may be got depleted by consuming the water on previous day before taking up cleaning to avoid wastage of water. About 75 mm of water can be kept in the tank to which decanted, clear bleaching powder solution having concentration of 10 mg/lit chlorine may be added and the bottom and side walls of the tank scrubbed well using the brush and thoroughly cleaned. Dirty water can be added to the tank and the bottom and side walls of the tank cleaned and washed thoroughly. On completion of the
cleaning, it is necessary that the side walls and the bottom of the tank is disinfected using a strong solution of decanted clear bleaching powder solution having a strength of 50 mg/Lt of chlorine. Solution may be splashed on the side walls and bottom of the tank by means of small cans and the entire wall surfaces and bottom of the tank drenched by the solution. About one hour of reaction period may be allowed to complete disinfection to take place. The tank may be recommissioned after one hour and put in to normal use.

ii) Safety Precautions

Proper tools and implements as indicated above must be used. Usage of gum boots and hand gloves are necessary in order to prevent contamination of the tank and also to prevent skin irritation to workmen due to chlorine solution. Tank must be properly ventilated by keeping all manholes in open position when the cleaning operation is in progress.

Un-trained workmen shall not be engaged for cleaning. Workmen shall not be permitted into tank containing water more than 15 cm depth. Water level should be reduced prior to allowing men inside to prevent accidents. Guard bars may be provided an outlet/scour opening provided at the bottom and side walls of the tank may be checked frequently and covers are to be replaced in position and locked.

12.6 Maintenance of Distribution system:

Distribution system has the likelihood of getting contaminated causing secondary pollution of once treated water before it reaches the consumers. Hence, the distribution system needs and deserves a careful maintenance.

A complete inspection of the distribution system and pumping mains shall be made once and the survey must be made for leakages in the distribution system, sluice valves, fire hydrants, scour and air valves. Underground leakages in a distribution system is generally indicated by dampness. Flooding of water and extra growth of vegetation above the pipe line at the place of leak. Leakage frequently occurs in house service ferrule connections. A record shall be maintained to indicate the major repairs and leakages occurred with reasons for the same which can be used to check unaccounted water loss in the system and to have close check on these leakages prone points. Scour valves shall be operated and dirty water let out once in a month. Gland packing in sluice valves should be replaced once in 3 to 6 months or more frequently depending on the leakage in gland, frequency of operation of valve etc. Excess leakages in air valves shall be attended to in time.

In this project as the operation and maintenance of all the above units are to be managed by the community without any financial contribution from the government it is essential to educate the beneficiary community about the cost involved. The following example is presented to arrive at the approximate cost and contribution by the beneficiary.

12.7. Maintenance of Structures, Lawns & Clean Environment :

The main structures are pump chamber and staff quarter. The structures should be painted after every 3 years. Besides the Sluice Valve haudies etc. should also be kept
clean. The leakage in S.V’s are valves leads to standing water & causes in sanitary conditions.

12.8 Duties of Pump Operator & Maintenance of records

Pump operator is the most important functionary in the set up since it is he who is in direct contact with the people all the time. The higher officers can maintain contact only periodically. The pump operators primary responsibility is to run the machinery and keep it in proper order. Besides he has to act a link between the consumers & the officials of the department. The pump operator should maintain the following record :-

I) **Log Book** :- The log book should be maintained on a daily basis & incorporate the following things

1. Date  
2. Time of start of pumping set  
3. Time of switching off  
4. Total hours of pumping  
5. Volt meter reading  
6. Ampere meter reading  
7. Depth gauge reading  
8. Spring Level at time of start  
9. Spring Level at time of switching off  
10. Time taken to restore water level  
11. Signature of P.O.  
12. Signature of Inspecting Officer  
13. Remarks Columns

   If diesel engine or a generating set is used then an account of oil consumed should be given. Besides entry should be made in log book about all the repair work.

   The log book should contain the details of the machinery on the first page clearly specifying the make, discharge capacity & head proper maintenance of log book helps in keeping a check on the health of T/Well.

II) **Complaint Register** :- Complaint register should be properly maintained and all the complaints should be entered chronologically along with the remedial measures taken. The complaint should be self specific & the following should be clearly mentioned :-

1. Date of Complaint  
2. Nature of Complaint  
3. Time for which the complaint is witnessing it  
4. Place of Complaint  
5. Complainants name & address  
6. Date on which noted by the field staff (if any)  
7. Date of Compliance  
8. Any Special Remarks  
9. Remarks or Comments by the Senior Officers
The J.E. should check the complaint register at least once a week and after solving the complaints problem must made on entry. If there is no complaint recd. during a month, a certificate regarding this should be entered by J.E/A/E.

III) **Movement Register** :- The P.O. should maintain a movement register. So that the inspecting officers are able to check the attendance.

IV) **Meeting register with Panchayats** :- The P.O. should meet the village Panchayat once a month & enter the minutes of meeting in the register. The J.E/A.E should personally attend these meeting once in two months. This would help in proper coordination between the department & the consumers.

V) **Chlorination Register** :- The register should have the following pts.

1. Date
2. Qty. of bleaching powder added
3. Pt. at which residual chlorine checked
4. Amt. of residual chlorine
5. Sign of P.O. and consumer in whose presence residual chlorine is checked
6. Sign of inspecting officer

The J.E/A.E should check the residual chlorine once a week and make an entry himself.

12.9 **Annexure of Model O & M Calculations for a Village Water Supply Scheme.**

The following inputs are assumed for the calculation of O & M cost.

(a) Cost of a borewell - Rs 50,000
(b) Cost of a Pumping Machinery - Rs 50,000
(c) Cost of PVC Mains
   All Diametres Average Cost - Rs 250/Mtr
(d) Cost of Storage Tanks - Rs 6 per Ltr
(e) Cost of Disinfecting Unit - Rs 20,000
(f) Electrical Works - Rs 2,00,000
(g) Salary of Operators - Rs 1500/Month

12.10 **O & M COST ESTIMATE**

**GENERAL:**

For preparation of O & M estimate scheme, it is necessary to have details of scheme components to assess the cost of operation and maintenance. In order to make things
clear, brief details of the scheme for illustration of O & M cost is furnished in the example below.

1. **SALIENT DETAILS OF SCHEME**

a) **Requirement of Water**

Population served by scheme (Present) - 1041 persons –2001 AD
Population served by scheme - 1500 persons
(Considering the growth at 20% per decade)
No. OF households at 5 person 1041/5 = 210 households
Per capita W/S - 55 Lpcd
Daily water requirement 1500 x 70 - 10,50,000 ltr/day

b) **Source**

Tube well (assuming) yield. - 32140 ltr/hour
Sustainable yield 60% to be considered
And safe yield should be decreased by 30% to cover the decline in discharge over a period of time.
i.e. 18,000 x 0.7x0.3 = 13,500.00
13500/3600 = 3.75 Lps
Pumping hours - 10hrs/day
13500 x 8 = 108000 ltr/day
No. of Tube wells = 105000/108000 = 0.97 or 1 No.

Depth of bore well = 150 m
Pump installed at 45 m in bore well
Head on pump set
Depth of tube well = 45 m
Delivery head - 10 m
Line losses for 75 –mm PVC pipe
of 6 KSC – for 250 m length at
6.40 M/km 250 x 6.4/1000 = 1.6 m
Add 10% for losses in Valves, etc. -0.16m
Total Head -56.76 m or 57m
HP = \( \frac{WQH}{75 \times \eta} \)
\( = \frac{1 \times 3.15 \times 57}{75 \times 0.60} \)
= 3.99 or 5 BHP

Energy losses for elevation through frictional losses
Add 10% for losses in Valves, etc. -0.16m
Total Head -56.76 m or 57m
HP = \( \frac{WQH}{75 \times \eta} \)
\( = \frac{1 \times 3.15 \times 57}{75 \times 0.60} \)
= 3.99 or 5 BHP

Energy losses for elevation through frictional losses
Add 10% for losses in Valves, etc. -0.16m
Total Head -56.76 m or 57m
HP = \( \frac{WQH}{75 \times \eta} \)
\( = \frac{1 \times 3.15 \times 57}{75 \times 0.60} \)
= 3.99 or 5 BHP

**c) Storage**

Elevated tank over 15 m staging
(Equal to half day requirement) - 50,000 ltrs

**d) Distribution System**
Pipe sizes –110 mm to 63 mm PVC 4 KSC
Supply through stand post for 50% at
1 No. Per 150 persons.
No. of stand post 1500/2 = 750/150 = 5 Nos.
No. of house connection = 1500/2 = 750/5 = 150 Nos.

2. **COST OF SCHEME**

a) Tube well - 1 No - 3,50,000.00
b) Pump chambers - 1,20,000.00
c) Pump set and piping in bore well 50,000.00
d) Pumping main from tube well to
   Elevated tank – 75 mm PVC 6 KSC 62,500.00
   250 m long @ Rs 250/- m
e) Elevated Tank 50,000 ;lttrs/15m
   Staging 5,00,000.00
f) Distribution System
   110 mm to 63 mm PVC 4 KSC
   1200 mtrs. @ Rs 250/- per m 3,00,000.00
g) Disinfections arrangement 20,000.00
h) Electrical works 1,00,000.00
i) Development of water works 50,000.00
   15,52,500

3. **O & M Cost per year for schemes maintained by DWSS** *

* GPWSC may decide appropriate staffing pattern

a) Salary of operating staff
   (i) Pump Operator 1 No. 148.46 x 365 Rs 54188
   (ii) Fitter 1450/30000 = 0.05 no. Rs 2628
       0.05 x 144 x 365
   (iii) Fitter Helper = 0.05 x 89.25 x 365 Rs 1629
   (iv) Patrolman cum keyman = 0.05 x 87.50 x 365 Rs 1596
   (v) Mali cum Chowkidar = 1 No. = 1 x 88.50 x 365 Rs 32303

b) Energy Charges :

   5.00 BHP Pump running 8/hour/day
   5 x 8 x0.746 x 30 = 895 kwh/month
   For 12 months  = 895 x 12 = 10740units @ 2.85/unit Rs.
   30,609
c) Bleaching powder for disinfection
   Chlorine dosage = 0.35 kg per 1,00,000 ltrs
   Requirement per year = \( \frac{105000 \times 0.35 \times 365}{100000} \) = 134 kg @ Rs 20/kg
   Requirement per year = 2680 kg

   d) Supervision of change = 100% of repair
   Supervision of change = 4200

4. Annual Maintenance and repairs

   a) Civil work ¼% of Rs 670000/-
      Rs 1675/-
   (b+e+i)

   b) Machinery 1% of Rs 52000/-
      Rs 5200/-
   (a+c+g+h)

   c) Water supply pipeline, 3/8% of Rs 362500/-
      Rs 1359/-
   (d + f)

   Total Rs 8234

Total maintenance cost (3+4) = 129843 + 8234 = 138077

Per capita Mtc. cost = 138000/1041 = Rs 132.56

Cost of water per 1000 ltrs = \( \frac{138000 \times 1000}{105000 \times 365} \) = Rs 3.60/1000 hrs

Revenue (Taxation proposed to be collected from the community)

<table>
<thead>
<tr>
<th></th>
<th>20 % for stand post connection</th>
<th>42 house holds</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>80% for domestic connection</td>
<td>168 house holds</td>
</tr>
</tbody>
</table>

Therefore Revenue to be collected from

Refer Annexure –C for Detailed water Tariff Structure issued vide Govt of Punjab Notification dated 4.10.2002
a. From stand post connection @ Rs 10 month per household  
   \[42 \times 10 \times 12 = 5040\] per annum

b. From house connection @ Rs 70 per month per household  
   \[168 \times 70 \times 12 = 141120\]

   \[
   \text{Total} = 146160 \\
   \text{SAY: Rs 146000/-}
   \]

Actual Expenditure for O & M  
= 138000/-

Miscellaneous Expenditure  
= 8000/-

\[
\text{-----------} \\
= 1,46,000/-
\text{-----------}
\]

The O & M Cost for water supply are to be explained to the users in various meetings so that community can be aware of likely pattern of sharing of the cost.
CHAPTER – 13
Construction Management

This chapter explains the actions to be taken during the progress of work. The water source is established during planning stage. Based on the yield, the project planning, design, estimate and tender action will be done. Construction sequences, procurement of materials, construction management, specifications, permissible tolerances during construction phase are elaborated.

13.1 Sequence of construction

a) Source

The source being selected during planning phase shall be flushed once again and the yield ascertained for its dependability as regards Quality and Quality before commencement of civil works. Procurement of pumps and rising main should take place only after above actions are completed. Application to PSEB electric supply should be processed telescopically so that by the time rising main and reservoirs are completed, electricity is (nearly) available.

b) Civil works.

The working levels shall be taken from the source point to service reservoir and ascertained that the levels taken with that projected in the drawings proposed during planning and preparation of DSR. If any variation is noticed the necessary action shall be taken to redesign the raising main and pump machinery in accordance with the working levels now obtained. As possibility of changes in location of OHSR are quite evident in villages for reasons necessitating acquisition of land required for construction or change of sources. Civil works construction will start once contract procurement process is over and work orders are issued. Transmission line and Reservoir works can be taken simultaneously and immediately. As per experience, Distribution works are likely to deviate from the original plans due to change in user demand. Therefore, distribution work can be taken up after finishing Rising main and Storage tanks. Accordingly procurement of distribution pipes can be phased out suitably. Ground water recharging works should be taken after rainy season and be completed before the next rainy season or at least constructed to a safe level so that it withstands the impact of the floods. Sanitation work can commence simultaneously but water supply should be available by the time sanitation works are completed and put to use.

c) Testing of Materials

All materials like sand, cement, aggregates, steel, GI pipes, PVC pipes, Pumps, Electrical goods, paints etc shall conform to not less than BIS specifications. All the materials shall be tested in laboratories.

d) Construction Management:

The works allotted to contractors are on turnkey basis i.e. all the materials will be procured by the contractors. There shall be 3 tier structure for effective construction management :

- Local level by SDE / EE of DWSS
- SE of DWSS
- Independent construction quality control at head quarter level under the control of CE of DWSS

. Water supply and sanitation department will watch progress and milestones and will take corrective actions wherever necessary. Checklists to carry out quality adherence are given
elsewhere in this chapter. The DWSS will appoint a central Construction quality surveillance team, which will carry out random checks, suggest remedial and preventive measures. Water supply and sanitation department will take appreciation action and disciplinary action on the project staff as per the need. The Contractors are expected to carry out the work in the most professional way and will be watched closely. Avoidable Time over runs will be viewed seriously. The quantities mentioned in the BOQ will be strictly adhered up to the given allowance. Any increase or decrease will be discussed with the appropriate authority and written permission will be taken before execution.

e) Payment Schedule to contractors:

Contractors prepare their bills which will be checked and recorded in measurement books by the concerned Sub Division Engineers with recommendation to GP for payment for the satisfactory works. Payments should be done to finished items only. Examples: supplying and fixing of pipelines duly tested. Reservoirs on commissioning, Groundwater recharging structures on completion or on attaining safe situation, etc. The emphasis should be to keep the Construction management at safe and healthy level.

f) Commissioning & Trial Run.

On completion of all civil works, the project will be commissioned PSEB would have sanctioned electric supply, as registration would have been done immediately after the water yield and quality test. If electric supply is not available then the contractor will provide captive power and trial run will commence. The trial run will be for 3 months preferably in lean months. GPWSC will be involved actively during this period.

13.2 Check list for Construction Quality Management at Site.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Attribute</th>
<th>Yes/ No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>MATERIALS</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Is coarse aggregate as per sample</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Is fine aggregate as per sample</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Is cement fresh &amp; free from clods.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Does the cement set within one hour.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Is sand free from silt</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Are steel bars of correct diameter</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Does the steel bend without breaking</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Are the pipes from tested consignment</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Is the pumping machinery identical to tested sample</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>FOUNDATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Are the foundation approved by the engineer including SBC</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Is sand filling provided.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>PLAIN/ REINFORCED CONCRETE</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Is concrete Mixer used</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Is water measured for concreting</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Is vibrator used</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Is slump test done</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Is bulking of sand determined</td>
<td></td>
</tr>
<tr>
<td><strong>MASONRY</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Are bricks soaked in water before use</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Are joints broken</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Whether Masonry started from corner</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Whether masonry constructed for uniform Height</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Is mortar applied to each brick before placing in position</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Is dressing of stone done before placing</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Is watering of stone done before placing</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Are bond stones dressed</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Is base of face stones more than height</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Is the masonry to plumb</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Are the joints raked</td>
<td></td>
</tr>
<tr>
<td><strong>RCC WORKS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Are cover blocks cast in CM-12</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Are centering supports spaced less than 0.6 mts and Adequate braces provided</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Are the posts resting on firm ground with wooden wedges</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Are steel plates used for centering bottoms and sides</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Are the gaps in centering closed</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Is centering level checked</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Is plumb checked for columns</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Is centering checked / approved before placing reinforcement</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Is reinforcement as per drawings</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Are chairs used to prevent disturbance of reinforcement</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Are lap lengths OK and at suitable position</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Is reinforcement checked/ approved and measurement Recorded before placing concreting</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Is water proofing done when roof slabs are green</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Is curing being done at the time of visit.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Is remolding done after the required period</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Are patches of surface touched immediately after demolding.</td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>----------------------------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>

**PLASTERING**

1. Is the sand for plastering free from silt
2. Is the surface cleaned and watered before plastering
3. Are the plumb, line and thickness checked and correct.

**PIPES, SPECIALS AND APPURTENANCE**

1. Are the locations as per plans
2. Are the flanged dimensions as per standard thickness, pitch, Circle/dia.
3. Are the faces of flanges machined
4. Is rubber insertion of required quality and thickness.
5. Are the bolts and nuts are good quality and sizes.
6. Are the pipes and specials aligned to gradient and plumb
7. Are the bolts and nuts tightened properly.
8. Are the specials and valves supported properly.
9. Are thrust blocks provided for bends.

**PIPE LAYING**

1. Is alignment of lines as per plans
2. Is trench dimensions and levels as per plans
3. Is the soil at the bottom of pipes good for laying of pipes
4. Are the pipes and specials lowered and aligned true to gradient and line.
5. Is the required cushion provided
6. Are pipe ends cleaned before joining
7. Follow manufacturers instruction for joining (PVC pipes)
8. Are the pipes cleaned inside before laying
9. Are the ends of pipelines closed before the days work.
10. Are air valves and reflex valves, scour valves provided at stipulated locations.
11. Are the pipe lines tested before commissioning
12. Is refilling done gently and consolidated

The discharge and head of pumps shall be as per the design requirement. Electrical fittings will satisfy the requirements of the PSEB.

Typical formats for testing of various materials used in the water supply scheme are presented in the following pages to have uniform data and also as a guideline for minimum tests to be conducted on the materials.
REQUEST FOR INSPECTION

<table>
<thead>
<tr>
<th>District:</th>
<th>Taluka:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of contractor:</td>
<td></td>
</tr>
<tr>
<td>Request No.:</td>
<td></td>
</tr>
</tbody>
</table>

Following works are / will be ready for inspection at _____________ (Time) on ___________ (Date).

<table>
<thead>
<tr>
<th>Description of works:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of work:</td>
</tr>
<tr>
<td>Ref drawing no.:</td>
</tr>
<tr>
<td>Type of work:</td>
</tr>
</tbody>
</table>

13.3 Formats for Test Report

Comments:
1. Remedial works listed to be completed and re-inspection is required.

This request was received ___________ (Time) ___________ (Date)

Signature

Contractor (Representative) Supporting Agency (Representative) Gram Panchayat (Representative)
Protocol for Collection of Sample

<table>
<thead>
<tr>
<th>Ref No.</th>
<th>:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>:</td>
</tr>
<tr>
<td>Name of Work</td>
<td>:</td>
</tr>
<tr>
<td>Name of Agency</td>
<td>:</td>
</tr>
<tr>
<td>Particulars of Sample</td>
<td>:</td>
</tr>
<tr>
<td>Quantity</td>
<td>:</td>
</tr>
<tr>
<td>Location</td>
<td>:</td>
</tr>
<tr>
<td>Test to be conducted</td>
<td>:</td>
</tr>
</tbody>
</table>

Contractor (Representative)        Supporting Agency (Representative)        Gram Panchayat (Representative)
**CONCRETE POUR CARD**

<table>
<thead>
<tr>
<th>Inspection No.:</th>
<th>Date:</th>
<th>Time:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AREA OF WORKS:</strong></td>
<td><strong>GRADE OF CONCRETE</strong></td>
<td></td>
</tr>
<tr>
<td>1. Setting Out</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td>2. Levels</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td>3. Shuttering</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td>4. HD Bolts</td>
<td>:</td>
<td></td>
</tr>
<tr>
<td>5. Inserts</td>
<td>:</td>
<td></td>
</tr>
</tbody>
</table>
| **Reinforcement** | :
| 1. Dia | : |
| 2. Spacing | : |
| 3. Laps | : |
| 4. Chairs | : |
| 5. Top Level | : |
| 6. Cover | : |
| **Concrete** | :
| 1. Blind concrete | : |
| 2. Quality of CA & FA | : |
| 3. Admixtures | : |
| 4. Slump | : |
| 5. Cubes taken | : |
| 6. Vibrator provided | : |

The above structure works has been checked and found ready for concrete. Note: Post concrete inspection/ Observation.

<table>
<thead>
<tr>
<th>Contractor (Representative)</th>
<th>Supporting Agency (Representative)</th>
<th>Gram Panchayat (Representative)</th>
</tr>
</thead>
</table>

1. **TYPICAL FORMAT OF TEST REPORT ON PHYSICAL PROPERTIES OF CEMENT**

<table>
<thead>
<tr>
<th>Source of Sample</th>
<th>Sample Supplied by the client</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client’s Reference</td>
<td>Letter No.................. Dated.........</td>
</tr>
<tr>
<td>Brand</td>
<td></td>
</tr>
<tr>
<td>Grade</td>
<td>43</td>
</tr>
<tr>
<td>Project</td>
<td></td>
</tr>
<tr>
<td>Identification</td>
<td></td>
</tr>
<tr>
<td>Period of Test</td>
<td></td>
</tr>
<tr>
<td><strong>Technical Reference</strong></td>
<td><strong>IS: 8112-1989</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Test conducted</th>
<th>Results</th>
<th>Requirements as per IS: 8112-1989</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NORMAL CONSISTENCY</td>
<td>Not specified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>INITIAL SETTING TIME</td>
<td>Shall not be less than 30 minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>FINAL SETTING TIME</td>
<td>Shall not be less than 600 minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>COMMMRESSIVE STRENGTH</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

136
|  | a) 72 1h (average of three results) | Shall not be less than 23.0 Mpa  
Shall not be less than 33.0 Mpa  
Shall not be less than 43.0 Mpa |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b) 168 2h (average of three results)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) 672 4h (average of three results)</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>FINENESS (by Blaine’s air Permeability method)</td>
<td>Shall not be less than 225 $m^2/ kg$</td>
</tr>
<tr>
<td>6</td>
<td>SOUNDNESS (by Le-Chatelier’s method)</td>
<td>Shall not be more than 10mm</td>
</tr>
</tbody>
</table>
2. **TYPICAL FORMAT OF TEST REPORT ON FINE AGGREGATE**

<table>
<thead>
<tr>
<th>Source of sample</th>
<th>Sample supplied by the client</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client’s Reference</td>
<td>Letter No.………….. dated………..</td>
</tr>
<tr>
<td>Date of Test</td>
<td>………………</td>
</tr>
<tr>
<td>Project</td>
<td>………………</td>
</tr>
<tr>
<td>Contractor</td>
<td>………………</td>
</tr>
<tr>
<td>Sample No.</td>
<td>………………</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IS Sieve Designation</th>
<th>Cumulative Percent</th>
<th>Specification as per IS:383-1970 (Reaffirmed 1990) for fine aggregate (%age Passing)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Retained</td>
<td>Passing</td>
</tr>
<tr>
<td>04.75 mm</td>
<td></td>
<td>90-100</td>
</tr>
<tr>
<td>02.36 mm</td>
<td></td>
<td>60-95</td>
</tr>
<tr>
<td>01.18 mm</td>
<td></td>
<td>30-70</td>
</tr>
<tr>
<td>600 microns</td>
<td></td>
<td>15-34</td>
</tr>
<tr>
<td>300 microns</td>
<td></td>
<td>5-20</td>
</tr>
<tr>
<td>150 microns</td>
<td></td>
<td>0-10</td>
</tr>
<tr>
<td>Remarks</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Conducted</th>
<th>Results</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt content</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
### 3. TYPICAL FORMAT OF TEST REPORT ON COARSE AGGREGATES

Source of sample : Sample supplied by the client
Client’s Reference : Letter No……………..dated………….
Project : ………………..
Date of test : ………………..

#### Sieve Analysis - 40mm and Down

<table>
<thead>
<tr>
<th>IS Sieve Designation</th>
<th>Cumulative Percent</th>
<th>Specification as per IS:383-1970 in Respect of 40mm nominal size aggregate (% Passing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80.0 mm</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>63.0 mm</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>40.0 mm</td>
<td>95-100</td>
<td>85-100</td>
</tr>
<tr>
<td>20.0 mm</td>
<td>30-70</td>
<td>0-20</td>
</tr>
<tr>
<td>12.0 mm</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>10.0 mm</td>
<td>10-35</td>
<td>0-5</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>0-5</td>
<td>--</td>
</tr>
</tbody>
</table>

#### Sieve Analysis - 20mm and Down

<table>
<thead>
<tr>
<th>IS Sieve Designation</th>
<th>Cumulative Percent</th>
<th>Specification as per IS:383-1970 in Respect of 40mm nominal size aggregate (% Passing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40.0 mm</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>20.0 mm</td>
<td>95-100</td>
<td>85-100</td>
</tr>
<tr>
<td>12.5 mm</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>10.0 mm</td>
<td>25-55</td>
<td>0-20</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>0-10</td>
<td>0-5</td>
</tr>
</tbody>
</table>

#### Sieve Analysis - 20mm and Down

<table>
<thead>
<tr>
<th>IS Sieve Designation</th>
<th>Cumulative Percent</th>
<th>Specification as per IS:383-1970 in Respect of 40mm nominal size aggregate (% Passing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.0 mm</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>12.5 mm</td>
<td>90-100</td>
<td>85-100</td>
</tr>
<tr>
<td>10.0mm</td>
<td>40-85</td>
<td>0-45</td>
</tr>
<tr>
<td>4.75mm</td>
<td>0-10</td>
<td>0-10</td>
</tr>
</tbody>
</table>
4. **TYPICAL FORMAT OF TEST REPORT ON BRICKS**

Source of sample : Sample supplied by the client
Number of samples tested : ………………..
Client’s Reference : Letter No.……………..dated…………..
Project : ………………..
Identification : ………………..
Period of test : ………………..

1. **COMPRESSIVE STRENGTH:**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Brand</th>
<th>Measured Size (mm)</th>
<th>Compressive Strength (N/sq. mm)</th>
<th>Average compressive strength (N/sq.mm)</th>
<th>Requirements as per IS:1077-1992 for Class Designation 3.5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>When 5 samples tested for compressive strength, average compressive strength shall not be less that 3.5 N/sq.mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

II. **WATER ABSORPTION:**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Brand</th>
<th>Measured Size (mm)</th>
<th>Water Absorption (%)</th>
<th>Average (%)</th>
<th>Requirements as per IS:1077-1992</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The average water absorption shall not be more than 20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

140
5. TYPICAL FORMAT OF TEST REPORT ON SOLID/ HOLLOW CONCRETE BLOCK

Source of sample : Sample supplied by the client
Client’s Reference Letter no : Dated:
Number of samples tested : ..................
Client’s Reference : Letter No...............dated............
Project : ..................
Identification : ..................
Period of test : ..................

1. COMPRESSIVE STRENGTH:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Measured Dimension (mm)</th>
<th>Compressive Strength (N/mm²)</th>
<th>Average compressive strength (N/mm²)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
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<td>3</td>
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<tr>
<td>4</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>5</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Requirements: When 8 samples tested for compressive strength, average strength shall not be less than 3.5 N/sq.mm for blocks used as load bearing members.

II. WATER ABSORPTION:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Measured Dimension (mm)</th>
<th>Water Absorption (%)</th>
<th>Requirements as per IS:2185-1979 (Reaffirmed-1992)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>The average water absorption shall not be more than 10%.</td>
</tr>
</tbody>
</table>

III. BLOCK DENSITY:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Measured Dimension (mm)</th>
<th>Block Density (Kg/cu.m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Requirements: The average density of solid concrete blocks shall not be less than 1800 Kg/cu.m and shall not be less than 1500 Kg/cu.m for hollow concrete blocks.
6. TYPICAL FORMAT OF COMpressive STRENGTH TEST REPORT ON CONCRETE CUBES

Number of samples : Sample supplied by the client.
No. of cubes tested : ......................
Mix Proportion : ......................
Grade of concrete : ......................
Client’s Reference : Letter No..................dated.............
Project : ......................
W.O.No. : ......................
Contractor : ......................
Dimension of Specimen : 150 x 150 x150mm
Cross Sectional Area : 22500 sq.mm

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Identification</th>
<th>Weight (Kg)</th>
<th>Date of Casting</th>
<th>Date of Testing</th>
<th>Age of test (Days)</th>
<th>Max Load (KN)</th>
<th>Compressive Strength (N/sq.mm)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Requirements as per IS:456-2000:

The 28 days compressive strength of cubes tested shall not be less than the grade of concrete specified plus 3.5 N/mm² (f<sub>ck</sub> + 3.5)
7. TYPICAL FORMAT OF REINFORCEMENT STEEL TEST REPORT

Source of sample : Sample supplied by the client
Number of samples tested : .................
Client’s Reference : Letter No...............dated .............
Date of test : .............................
Project : .................................
Identification : .............................
Grade : Fe 250 / Fe 415

a) Proof Stress

<table>
<thead>
<tr>
<th>Dia of bar</th>
<th>Wt. Kg/m</th>
<th>Proof stress N/mm²</th>
<th>Ultimate Tensile Stress (N/mm²)</th>
<th>Elongation (%)</th>
<th>Bend</th>
<th>Rebend</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b) Permissible limits for weight:

<table>
<thead>
<tr>
<th>Nominal Size</th>
<th>Range of Weight for batch (Kg/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.0</td>
<td>0.367 to 0.423</td>
</tr>
<tr>
<td>10.0</td>
<td>0.574 to 0.660</td>
</tr>
<tr>
<td>12.0</td>
<td>0.843 to 0.932</td>
</tr>
<tr>
<td>16.0</td>
<td>1.500 to 1.658</td>
</tr>
<tr>
<td>20.0</td>
<td>2.392 to 2.540</td>
</tr>
<tr>
<td>25.0</td>
<td>3.739 to 3.971</td>
</tr>
<tr>
<td>32.0</td>
<td>6.127 to 6.506</td>
</tr>
</tbody>
</table>
8. **TYPICAL FORMAT OF TEST REPORT ON ANALYSIS OF WATER SAMPLE FOR CONSTRUCTION**

Source of sample : Sample supplied by the client  
Client’s Reference : Letter No…………..dated………….  
Project : …………………  
Identification : ………………  
Period of test : ………………..  
                      IS:3025-1983 (Part 11,15,16,17,18,22,23,24,&32)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars</th>
<th>Constituents Determined</th>
<th>Stipulation of IS:456-2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Quantity of 0.02N NaoH required to neutralize 100ml of water sample using phenolphthalein as an indicator</td>
<td></td>
<td>Shall not be more than 5 ml.</td>
</tr>
<tr>
<td>2.</td>
<td>Quantity of 0.02 N H₂SO₄ required to neutralize 100 ml of water sample using mixed indicator</td>
<td></td>
<td>Shall not be more than 25ml.</td>
</tr>
<tr>
<td>3.</td>
<td>Inorganic Solids</td>
<td>3000 mg/ l max</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Sulphates as SO₄</td>
<td>400mg/lt max</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Chlorides as Cl</td>
<td>500mg/lt max for RCC 2000mg/lt max for PCC</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Suspended matter</td>
<td>2000mg/lt max</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Organic matter</td>
<td>200mg/lt max</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>pH valve</td>
<td></td>
<td>Shall not be less than 6</td>
</tr>
</tbody>
</table>
Chapter 14
Specific Water Treatment Processes:

14.0 Defluoridation of Water

Excessive fluorides in drinking water may cause mottling of teeth or dental fluorosis, a condition resulting in the discoloration of the enamel, with chipping of the teeth in severe cases, particularly in children. In Indian conditions where the temperatures are high, the occurrence and severity of mottling increases when the fluoride levels exceed 1.0 mg/l. With higher levels, skeletal or bone fluorosis with its crippling effects are observed. The chief sources of fluorides in nature are (i) fluorapatite (phosphate rock), (ii) fluorspar, (iii) cryolite and (iv) igneous rocks containing fluorsilicates. Fluorides are present mostly in ground waters and high concentrations have been found in various districts of Punjab. Removal Methods

The removal of excessive fluorides from public water supplies or individual water supplies is justifiable solely on public health grounds. This is a problem particularly in rural areas and hence the accent has to be on simplicity of operation, cheapness and applicability to small water supplies. The methods use fluoride exchangers like tricalcium phosphate or bone meal, anion exchangers, activated carbon, magnesium slats or aluminium salts.

14.1.1 Fluoride Exchangers

Degreased and alkali treated bones possess the ability to remove fluorides but have not been used on a plant scale. Bone charcoal prepared by controlled combustion of bones under limited supply of air in the presence of catalysts when treated with alkali or phosphate has been found to be useful. One cubic meter of bone charcoal is capable of removing 1.1 kg of fluoride from a water with fluoride content up to 6.0 mg/l. The spent material can be regenerated with mono or trisodium phosphate. Tricalcium phosphate in powdered form can also be used but it has a lesser capacity of 0.7 kg of fluoride /m³. The spent material is regenerated by treatment with 1% alkali solution and rinsed with dilute hydrochloric acid.

14.1.2 Anion Exchangers

Activated carbons have also been known to have the capacity for removal of fluorides. An activated carbon for Fluorides removal has been developed in India by carbonizing paddy husk or sawdust, digesting under pressure with alkali and quenching it in a 2% alum solution. This could remove 320 mg of fluoride per kilogram of the dry material. The spent material could be regenerated by soaking it in a 2% alum solution for 14 hours. The attrition and hydraulic properties of the carbon are however poor.

A granular ion-exchange material Defluoron 2, which is a sulphonated coal operating on the aluminium cycle has been developed in the country. The capacity of the material is estimated to be 500 gm of fluorides/ m³ with test water containing 5mg F/l and 150 mg/l alkalinity. The regeneration is carried out by means of a 2.5% alum solution, with replacement of two bed volumes. A flow rate of 4.8m³/m²/hr of bed area is adopted. The rinse water requirements after regeneration are 9-12 m³/m²/hr for a maximum duration of 10 minutes. The medium has a life of three years.

High alkalinity of the water considerably lowers the capacity as well as efficiency of the bed. Hydroxyl alkalinity beyond 5 mg/l has a deleterious effect on the removal efficiency of the medium. The efficiency of the medium falls down by 30% when hydroxyl alkalinity becomes 25 mg/l.
Treatment cost using Defluoron -2 varies from Rs. 1.0 to Rs. 5.0 per 1000 litres of water treated, depending upon the initial fluoride concentration and the alkalinity of water.

14.1.3 Magnesium Salts
Excess lime treatment for softening effects removal of fluoride due to its adsorption by the magnesium hydroxide floc. The fluoride reduction is given by the following expression:
Fluoride reduction = 7% initial fluoride conc. x magnesium removed \hspace{1cm} (9.1)

Sizeable Fluoride removals are possible only when magnesium is present in large quantities which may not always be the case and magnesium have to be supplemented in the form of salts. The process is suitable only when the water is being softened.

Magnesia and calcinated magnetite have also been used for removal of fluoride from water. The study established the following empirical relationships for amounts of MgO which are required to obtain 1 or 2 mg F/1 in treated water.
(a) MgO required to obtain 1 mg F/1 in treated water (F_0 > 2 mg F/1)
(b) MgO required to obtain 2 mg F/1 in treated water (F_0 > 3 mg F/1)

F_0 represents the fluoride concentration in the raw water. The pH of the treated water was always beyond 10 and its correction by acidification was essential, adding to the complexity of operations and control.

14.1.4 Aluminium Salts
Aluminium salts like filter alum and activated aluminium and alum treated cation exchangers have shown beneficial effects. Filter alum during coagulation brings about some removal of fluorides from water. The removal efficiency is improved when used along with a coagulant aid-like activated silica and clay. 300 to 500 mg/l of alum is required to bring down fluoride from 4.0 mg/l to 1.0mg/l while with coagulant aid, the fluorides were reported to be reduced from 6.0 mg/l to 1.0 mg/l with alum dose of only 100 mg/l.

Alum treated polystyrene cation exchangers and sulphonated coals have also been used successfully. A cation exchangers prepared from extract of Avaram bark and formaldehyde when soaked in alum solution has been found to have good fluoride removal capacity (800mg/kg.)

Calcinated or activated alumina in granular form can be used fluoride removal and the spent material regenerated with alkali, acid or by both alternately (removal efficiently 1.2 kg of fluoride/m^3). A dilute solution of aluminium sulphate used as the regenerated for the spent material makes the alumina four times more efficient.

14.1.5 Simple Method of Defluoridation
Deluoridation is achieved either by fixed bed media which could be regenerated or by the process of precipitation and formation of complexes. A simple method of defluoridations is employed in the Nalgonda Technique. It involves the use of aluminium salts for the removal of fluoride. The Nalgonda Technique employs either the sequence of precipitation, settling and filtration or precipitation, floatation and filtration and can be used for domestic as well as community water supply schemes.
(i) Domestic Treatment-Precipitation, Settling and Filtration

Treatment can be carried out in a container (bucket) of 40 l capacity with a tap 3-5 cm above the bottom of the container for the withdrawal of treated water after precipitation and
settling  The raw water taken in the container, is mixed with adequate amount of like or sodium carbonate, bleaching powder and aluminium sulphate solution, depending upon its alkalinity and fluoride content. Lime or sodium carbonate solution is added first and mixed well with water.

Alum solution is then added and the water stirred slowly for 10 minutes and allowed to settle for nearly one hour. The supernatant which contains permissible amount of fluoride is withdrawn through the tap for consumption. The settled sludge is discarded. The amount of alum in ml to be added in 40 litres of water at various alkalinity and fluoride level is given in Table 14.1.

Table 14.1: ALUM DOSE FOR DIFFERENT FLUORIDES AND ALKALINITY LEVELS

<table>
<thead>
<tr>
<th>Test Water Fluoride</th>
<th>Test water alkalinity, mg CaCO₃/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg F/l</td>
<td>125</td>
</tr>
<tr>
<td>2</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
</tr>
<tr>
<td>5</td>
<td>160</td>
</tr>
<tr>
<td>6</td>
<td>205</td>
</tr>
<tr>
<td>8</td>
<td>245</td>
</tr>
<tr>
<td>10</td>
<td>395</td>
</tr>
</tbody>
</table>

14.2 Reverse Osmosis:

Reverse osmosis is a membrane permeation process for separating relatively pure water from a less pure solution. The solution is passed over the surface of an appropriate semi-permeable membrane at a pressure in excess of the effective osmotic pressure of the osmotic pressure of the feed solution. The permeating liquid is collected as the product and the concentrated feed solution is generally discarded. The membrane must be highly permeable without failure. Because of its simplicity in concept and execution, reverse osmosis appears to have considerable potential for Purification of Water containing Fluorides or any other harmful dissolved solids.

14.2.1 Consultancy Support for RO Plants:

*Bhabha Atomic Research Centre, Trombay (BARC)* has actively participated in the Rajiv Gandhi National Drinking Water Mission (RGNDWM) and setup a number of small reverse osmosis plants in the villages during eighties. It also provided active support to the Mission in the water quality monitoring and analysed large number of water samples for the presence of brackishness, nitrate, fluoride, iron etc. from various affected districts of Andhra Pradesh, Karnataka, Maharashtra, Gujarat and Rajasthan. In recent years, BARC has installed a RO plant at Sheelgan village, Barmer district, Rajasthan. In January 2003, the Centre has installed another plant at Satlana village, Jodhpur district, Rajasthan. This plant will also remove excess fluoride and nitrate along with the brackishness. The cost of such plants which provide drinking water to habitation of 1000 people is around 7 lakhs. The water cost comes out to about 3 paise/litre.
BARC has been interacting in recent years with the Government of Rajasthan, Government of Lakshadeep and Tamilnadu Water Board and will further expand this contact with Government of Gujarat, Maharastra, Andhra Pradesh and Karnataka. It has been providing consultancy services to several private parties and government undertakings. The mobile/transportable desalination units based on RO & VC technology are in the advanced stage of development. Standardized modules both for RO (5-50 m3/d) and small thermal desalination units (5-50 m3/d) using waste heat (diesel or solar) specific to individual needs have been developed. Development of water scarcity areas and large coastal arid zones of the country.

RO plants are manufactured in private sector and are being installed in several places. The RO process can be used for removal of Fluoride and Iron.”

**Treatment Process:**

This plant is aimed to treat the ground water to meet the WHO and IS: 10500 Standards. It is a 7-stage purification process consisting of sedimentation, Adsorbent media filtration, activated carbon filtration, 5 and 1 micron cartridge filtration, reverse osmosis membrane filtration and UV disinfection.

The raw water from bore well is pumped in to raw water sedimentation tank and is then sent through an AMF, where Iron and TSS is removed. The water then flows to ACF where organics and excess chlorine are removed. Finer particles in water are further eliminated by flowing it through the 5 and 1 micron cartridge filters. The physically purified water now sent to RO process for the removal of Iron, dissolved solids and organics. Finally, the water is disinfected using UVW system to eliminate the pathogens. Periodically the AMF is backwashed to remove the solids collected on the filter bed.:  

### 14.3 PRESSURE FILTERS:

**General**

Based on the same principle as gravity type rapid sand filters, water is passed through the filter under pressure through a cylindrical tank, usually made of Fibre Glass with single valve operation wherein the underdrain, gravel and sand are placed. They are compact and can be prefabricated and moved to site. Economy is possible in certain cases by avoiding
double pumping Pretreatment is essential. The tank axis may be either vertical or horizontal as shown below.

Salient Features:
- It shall have single valve operation for Back Wash, recirculation, Rinse, Filter Waste close to eliminate leakage from individual valves.
- Give visual indication as to the present operation of the filter.
- It shall have Multi port valve with quick connect threaded barrel unions.
- It shall have Hydraulically balanced laterals to maximize water flow and automatic air bleed.
- Tank of the pressure sand filter shall be made of Fibre Glass.

Disadvantages

Pressure filters suffer from the following disadvantages:

a) In case of direct supply from pressure filters, it is not possible to provide adequate contact time for chlorine.

b) Because the water is under pressure at the delivery end, on occasions when the pressure on the discharge main is released suddenly, the entire sand bed might be disturbed violently with disastrous results to the filter effluent.

They may be used for Single Village schemes where population is less as traditional canal based scheme may be very expensive for small communities.
CHAPTER 15
COMPLETION PLAN AND REPORTS

When a project is commissioned and handed over, the history of the project has to be maintained. The advantages are, firstly it will be helpful while carrying out O & M functions, secondly it will act as a guide for future projects and thirdly it will examine the mistakes committed, why happened and how to avoid in future projects. This chapter explains how completion reports are to be prepared fulfilling the above requirements.

15.1 As Built Drawings/ Completion Drawings:

On execution of scheme components as per approved working/ construction drawings, it is necessary to prepare completion plans. The as built drawings may have to be prepared based on the construction drawings with modifications made while execution or variations to suite site conditions. The completion drawing in other words are as built drawings and it shall indicate all changes made during execution. These drawings and other project data shall be prepared in electronic format in relevant software like Auto Cad MS Excel etc to ensure easy storage and retrieval of the data. This data shall be stored in central computer and can be accessible through internet to the authorized user.

Note down the modifications, variations, changes made while carrying out works on the construction drawings with all site particulars for preparing as built drawing.

- Site plan or location plan with distance, angles with respect to other permanent objects for easy identification.
- All plan dimensions as built at site, cross sections strata details in case of bore well/open well.
- Alignment and location of pipe sizes indicating size, material of construction, classification, depth at which it is laid, location of valves, types, sizes, material of construction.
- If no changes are made, the construction drawing shall be certified that work is executed strictly as per the drawing and signed by Engineer-in-charge with seal having date, name and designation.

If there is any change during execution then as built drawing is to be prepared to reflect the change made and certified that work is executed as per this drawing.

15.2 Completion Report:

(a) The completion Report shall contain all the text information of the project that may be required in future for reference. This will be useful for carrying out O&M activities and while upgrading the scheme. The completion report shall have the following information.

Name of work

- Estimated cost
- Name of the Implementing Office
- Name of Agency/Contractor
- Work order No. and date
- Time stipulated for completion
- Date of commencement of work
- Date of completion of work
- Date of Handling over to GPWSC
- Cost as per final Bill of contract
b) Cost over runs:
List of all sub works of scheme to be furnished with costs in the following format to indicate abstract of scheme.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Sub work</th>
<th>Cost as per Estimate</th>
<th>Variation (-) savings (+) Excess</th>
<th>Reasons for Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tube well</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Pump Chamber</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Pumpset</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Piping inside PC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Disinfections Arrangement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>OHSR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Rising Main</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Distribution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Development of W/W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Topographical Survey</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Electric Connection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Environment Provision</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>General Adv. &amp; others</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c) Time over runs

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Sub work</th>
<th>Period of execution as per (In weeks)</th>
<th>Variation</th>
<th>Reasons for Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Plan</td>
<td>Execution</td>
<td></td>
</tr>
</tbody>
</table>

d) Comparative statement showing quantity, rates as per estimates and actual and reasons thereof or variations.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description</th>
<th>As per Estimate/ work order</th>
<th>As per Execution</th>
<th>Qty. of item which varied by 25%</th>
<th>Item which varied the amount by 25%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Qty</td>
<td>Rate</td>
<td>Amt</td>
<td>Qty Executed</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Plan, Design and Implementation Issues:

Planning of various components of the projects are carried out based on the certain ground and technical inputs. Engineering drawings are prepared following the plans. During execution of the project, certain anomalies may have been experienced. If so, these issues should be examined and possible cause for happening should be ascertained. The results of these exercise should be used for planning, designing and implementing the future projects.

During project cycle, there may be instances of problems/ delays faced by the implementing authorities from contractors, community, other Government offices, etc. These impediments should be analyzed and remedial actions be suggested for future projects.

For record purpose, following information be furnished.

f) Performance by Key Agencies

Track record of the key implementing agencies should be maintained in respect to project execution. This will help in assessing the managerial and technical capabilities of the agencies for subsequent reference. The suggested method is as below.

1. Contractors
   (a) Adherence to Quality
   (b) Adherence to Time schedule.

2. Support Agency
   (a) Preparation of Estimate and its efficacy in execution.
   (b) Quality Control measures adopted and results.

3. Gram Panchayat and GPWSC
   a) Maintenance of accounts
   b) Timely Payment to Contractors
   c) Involvement of Community during Planning and Implementation
   d) Capability in handling O & M activities.

15.3 Exit strategy for Multi Village Schemes:

In- village facilities

1) Joint verification by Department and GPWSC of assets created within village as per estimate
2) Joint assessment of the performance of the system. Service delivery – Quantity, Quality, Reliability at household level.
3) Proforma of handing over the in village facilities
   i. List of assets
   ii. Completion plans (soft copies)
   iii. Check list for O & M and format for registers.
4) Complaint Redressal (Help line) to be provided to GPWSC
   i. Contact particulars of the Construction/O&M contractors
   ii. Contact particulars of the Department Engineers
5) Financial details - O&M budget, consider payment for bulk water and fix tariff  
6) Social Audit.

**Common facilities:**

1) Form SLCs with representation from both existing and new villages,  
2) Joint verification by Department and SLC of common facilities as per estimate  
3) Joint assessment of the performance of the system delivery at each Village ESR of designed quantity, Quality and Reliability.  
4) Provide to SLC  
   a. List of common facilities  
   b. Completion plans (soft copies)  
   c. Check list for O & M and format for registers.  
5) Complaint Redressal (Help line) to be provided to SLC  
6) Contact particulars of the Construction/O&M contractors  
7) Contact particulars of the Department Engineers.  
8) Financial details - O&M budget, consider payment to be made to Department for bulk water and fix tariff for collecting from GPWSC  
9) Social Audit.

Accordingly Project/scheme completion report of sewerage schemes should be prepared as per main components taken in DSR.
CHAPTER-16
RAIN WATER HARVESTING

In the urban and rural areas part of the rain water collected from the surface can be harvested. The available rain water is collected in the water bodies such as dams, lakes and ponds but major part flows as surface run-off and in many places it stagnates on the roads and shallow depressions. The rain water can be diverted to the existing water bodies or else a pond may be constructed at suitable places to collect such water. This method serves both to avoid water stagnation on the roads as well as from water works area (WTP) and to use the rain water for recharge of ground water. The recharge from such water bodies depends on the availability of permeable formations at the bottom of the pond. If the pond has permeable formations then the water can percolate at a rate that depends upon the porosity of the formations. If the bottom of the pond is made up of impermeable formations, then a provision has to be made to reach the underlying permeable formations by means of constructing a shaft or bore well. If the permeable formation is at a shallow depth, then a shaft or open well may be constructed at the bottom of the pond to lead the rain water into the permeable formation for effective recharge. If the depth of the permeable formation is more, then the only option is to construct a bore well that penetrate the deeper permeable formations. For Rain Water Harvesting Guidelines of Central Ground Water Board Govt. of India for Roof Water harvesting may be referred.

Benefits of rainwater harvesting
Although some benefits of recharge of rainwater have already been mentioned above, there are some more benefits as under:

- Harvested rainwater may become an additional and ready source of water supply.
- It saves treated drinking water that may account for 30 – 50% in a typical household.
- By decreasing the use of treated water, it lowers the water bills.
- Being non-chlorinated, it proves better for watering the lawn and plants.
- It improves the quality of groundwater.
- It raises the water level in wells and bore wells.
- It counters drought and its effects.
- It reduces soil erosion by maintaining the green cover.

Collection and Use of Rainwater
Water is likely to become scarcer in years to come. Rainwater harvesting is an excellent option of conserving water for domestic uses (Non potable) for free, since the system is almost maintenance-free.

In rural water supply schemes Rain water harvesting is feasible only in the water works site. An area of 4.5 m x 2.5 m has been earmarked within the site as shown in Fig Nos. 14A, 14B, 14C and 14D, 14E & 14F (of drawings)

Rainwater Harvesting Systems for groundwater recharge will essentially comprise of the following

16.1 DESIGN CONSIDERATIONS
The important aspects to be looked into for designing a rainwater harvesting system to augment ground water resources are:

- Hydrogeology of the area including nature and extent of aquifer, soil cover, topography, depth to water level and chemical quality of ground water.
- The availability of source water.
- Area contributing run off like area available, land use pattern, industrial, residential, green belt, paved areas, roof top area etc.
- Rainfall duration, general pattern and intensity of rainfall.

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POTENTIAL AREAS

- Where ground water levels are declining on regular basis.
- Where substantial amount of aquifer has been de-saturated.
- Where availability of ground water is inadequate in lean months.
- Where due to rapid urbanization, infiltration of rain water into subsoil has decreased drastically and recharging of ground water has diminished.

DESIGN CRITERIA OF RECHARGE STRUCTURES

Recharge structures should be designed based on the availability of space, availability of runoff, depth of water table & lithology of the area.

ASSESSMENT OF RUNOFF

The runoff should be assessed accurately for designing the recharge structures and may be assessed by following formulae

Runoff = Catchment area x Runoff Coefficient x Rainfall

RUNOFF COEFFICIENTS

Runoff coefficients depend upon the catchment characteristics. It is the factor that accounts for the fact that not all the rainfall falling on a catchment can be collected as some of the rainfall will be lost by evaporation and retention on the surface itself. Values of runoff coefficients for various types of catchments are listed as:

<table>
<thead>
<tr>
<th>Type of Catchment</th>
<th>Runoff Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof Catchments</td>
<td></td>
</tr>
<tr>
<td>Tiles</td>
<td>0.8 - 0.9</td>
</tr>
<tr>
<td>Corrugated Metal Sheets</td>
<td>0.7 - 0.9</td>
</tr>
</tbody>
</table>

| Ground surface coverings          |                    |
| Concrete                          | 0.6 – 0.8          |
| Brick Pavement                    | 0.5 – 0.6          |

| Untreated ground catchments       |                    |
| Soil on slopes less than 10 percent | 0.0 – 0.3       |
| Rocky natural catchments          | 0.2 – 0.5          |
| Green area                        | 0.05 – 0.10        |

16.1.1 Interception & Collection

Area for water works site in a Tubewell based rural water supply scheme, will be of the order of 300 m².

Surface run-off from such a site can be calculated by formula.

\[ Q = 10 \times C \times i \times A \]

Where

- \( Q \) - Runoff in m³/hr
- \( C \) - Run-off coefficient – for such an area can be adopted as 0.6
- \( i \) - Intensity of rainfall – can be taken as 50 mm/hr
- \( A \) - Area in Ha as adopted 300 m² i.e 0.03 ha

\[ Q = 10 \times 0.6 \times 50 \times 0.03 = 9 \text{ m}^3/\text{hr} \]

Storm runoff has to be discharged into groundwater at above rate for a tubewell based rural water supply scheme.

A canal based rural water supply scheme for its water works, will require larger land area of about 1 Ha, 60% of which is occupied by Storage & Sedimentation tanks which do not generate any storm runoff. Average area of a water works complex is 0.4 A

Rate of run-off is estimated as:-

\[ Q = 10 \times 0.6 \times 50 \times 0.4 \times 0.6 = 72 \text{ m}^3/\text{hr} \]
Storm run-off from water works site of a canal based rural water supply scheme has to be disposed off at a rate of 72 m³/hr or 33.33 l/sec. Collection and conveyance of storm runoff is desirably achieved by drainage channels. In a rural water supply scheme, construction of drains will become expensive. In a tubewell based scheme, the collection of Run-off for rainwater harvesting is recommended to be achieved by surface-flow from site as shown in Fig No. 14G (of drawings).

Such arrangement of collection in case of a canal based scheme may not be feasible with a single recharge point on following considerations:-
- The area being large, maintaining slope to a single point, is not feasible
- The sub-surface aquifers may not be able to accept the high rate of recharge at single point.
- The location generally is close to a major canal and is likely to be recharged with subsurface water, which will interfere with the recharge system.

A multi recharge point system has to be adopted for a canal based scheme and will become expensive. A single arrangement is recommended.

16.1.2 Groundwater Recharge System

Rate of groundwater recharge is directly related to the aquifer characteristics. Selection of aquifer is therefore a key element in designing any groundwater recharge system. Adequate investigative steps should be carried out to access location, thickness and permeability of the intended aquifer.

Groundwater recharge can be through:-
- Existing Tubewell
- Existing Dugwell
- New Borewell

Situations to utilise existing tubewell or an abandoned dugwell in the vicinity is likely to be encountered rarely in rural water supply schemes. In case of Existing Tubewells or Dugwells, the recharge capacity can be ascertained by studying the lithologs available or by actual observations. Such arrangements will require a Filtration System to be introduced upstream, before water is lead for recharge into the well.

RAIN WATER HARVESTING THROUGH DUGWELL

Rain water harvesting through dugwell can also be used in the village itself; as there may be number of abandoned wells available. A schematic diagram is given as Fig No 14J (of drawings).

It can be done as:
- Existing and abandoned dug wells may be utilized as recharge structure after cleaning and desilting the same.
- The recharge water is guided through a pipe from desilting chamber to the bottom of well or below the water level to avoid scouring of bottom and entrapment of air bubbles in the aquifer.
- Recharge water should be silt free and for removing the silt contents, the runoff water should pass either through a desilting chamber or filter chamber.
- Periodic cleaning of top layer is required if silt water is poured into the dug well.
- Periodic chlorination should be done for controlling the bacteriological contaminations.
- It is very cost effective as huge quantity of water can be recharged.

In case of a New Borewell Recharge System, a 75 mm (3”) test borehole is to be drilled, at least upto the groundwater table. The litho logs will provide appropriate information on the
hydrogeology of the site. Strata charts from nearest borehole existing may also be studied to arrive at suitable conclusion.

Groundwater recharge system is comprised of:-

- A Recharge Pit/Filter Pit to allow water for recharge, free from debris, floating materials and suspended particles, which otherwise may cause serious hindrances in recharge process by causing reduction in permeability of the aquifer. Malfunctioning recharge systems may lead to stagnation of water and consequent hazards.
- A recharge well for discharging water into an aquifer (Refer to Fig No. 14H & 14I) (of drawings).

RAIN WATER HARVESTING THROUGH TUBEWELL (ABONDONED/NEW)

There are lots of abandoned tubewells available at existing water works of DWSS. Rain water harvesting through abandoned tubewells can be done by using these tubewells. Where such tubewells are not available, new tubewells can be installed with either M.S. Pipes & Stainless Steel/Galvanized Cage type V- wire Screen.

- Rainwater collected from rooftop of the building is diverted through drainpipes to settlement or filtration tank.
- In case of runoff from water works area, the slopes at the water works are made towards the tubewell.
- Rain Water is made to settle in the settling tank.
- Optimum capacity of settlement tank/filtration tank can be designed on the basis of area of catchment, intensity of rainfall and recharge rate.
- While recharging, entry of floating matter and silt should be restricted because it may clog the recharge structure. "First one or two shower should be flushed out through rain separator to avoid contamination. This is very important, and all care should be taken to ensure that this has been done." Recharge water should be silt free and for removing the silt contents, the runoff water should pass either through a desilting chamber or filter chamber before entering into tubewell.
- After settlement filtered water is diverted to bore wells to recharge deep aquifers. A schematic diagram is given as Fig No. 14I (of drawings).

16.1.3 Recharge Pit

In case of Existing Tubewell/Dugwell System

The Recharge Pit is provided with layers of filtration media constituted of:-

- Top layer of coarse sand 1.5 to 2.0 mm – 1 m thick
- A 1m thick layer of gravel 5-10 mm below the sand layer
- The bottom layer of gravel 5-20 mm, 1 m thick

In addition, a storage equivalent to :-

- 1 hr holding time for runoff is considered adequate to take care of the differential between rate of runoff and the rate of recharge through aquifer.
- A circular pit is preferred as can withstand larger earth pressure
- In a tubewell based rural water supply scheme, the dia of the pit, considering 2m water depth should be

\[ D = \sqrt{\frac{9\times 2 \times 4}{\pi}} = 2.4 \]
Total depth of the Pit should be around 6 m to accommodate the filter media, the stored water and a free board of 1 m.

- In case of canal based scheme,
- The water depth considered is 2.5 m and
- Number of Pit 5 nos
- In case of canal based schemes with total runoff of 120 m3/hr, 5 nos of recharge pits are considered with water depth 2.5 m. The dimensions are worked out as below:-

\[
D = \sqrt{\frac{120 \div 2.5 \times 4}{5 \times \pi}} = 3.5 \text{ m}
\]

Depth of Pit works out to 8 m to accommodate stored water, the filter media and a free–board.

- In case of Rainwater recharge through New Tubewells, the Recharge Pit is required to hold the storage water only, while the filtration is effected by installation of a screen on the recharge pipe. A water depth of 2.0 m is considered adequate for Tubewell based scheme whereas for a canal based scheme, the water depth should be 2.5 m. Diameters should be 2.5 m and 3.5 m respectively.

16.1.4 Recharge Well

Recharge Wells are intended to transfer surface water to the subsurface aquifers for recharging of the aquifer. The wells may be bore wells existing or new and Dug Wells existing. Existing Wells are to be cleaned properly to remove chokage in the aquifer and other floating/deposited materials. Only filtered rainwater as mentioned earlier, are to be charged into the wells. A new Borewell will be developed following criteria and procedure similar to that for a water supply well.

For Rainwater Harvesting 100 mm to 300 mm dia borewells are considered suitable. However, for a groundwater based scheme the dia may be adopted as 200 mm, whereas for canal based scheme the same should be 300 mm.

A few guidelines regarding development of a Groundwater recharge bore well are as below:-

a) Artificial Recharge should be taken up in only those areas where water level is more than 10 m below ground surface.
b) The aquifer to be recharged should be moderately thick and extensive.
c) In case of recharging of confined aquifer, the aquifers to be recharged should be identified on the basis of strata chart of nearest borehole drilled
d) The slotted pipes should not be wrapped with nylon net which is in practice in case of pumping wells. It reduces the effective open area, thus the intake capacity of the recharge well decreases considerably.
e) The Stainless Steel/Galvanized ‘V’ wire screen is more effective as compared to conventional slotted pipes because 40% open area is available
f) The boreholes for construction of deep recharge wells should be drilled with reverse circulation rotary method. However in case of shallow recharge well drilling can be carried out with mechanized hand boring.
g) The slot openings of the slotted pipes or ‘V’ wire screen used for construction of recharging wells should be 1.5mm or 2mm as percentage of open area is more as compared to pipes having finer slot openings.
h) The gravel used for filling the annular space around the well should be 3mm – 6mm.
i) The finer gravel reduces the intake capacity of the well and there are more chances of getting it choked with silt.
j) The recharge well should be pumped now and then but preferably during the nonrecharge times to maintain the efficiency of the well.

k) In case recharge well is not pumped the clay particles choke the screen of the recharge well and surrounding formation material

l) First one or two showers should be flushed out through rain separator to avoid contamination. This is very important, and all care should be taken to ensure that this has been done.

Various arrangements of Groundwater Recharge System are presented in Fig No. 14H, 14I, 14J and 14K (of drawings).

16.2: Operation and Maintenance:

1) Always keep the catchment area clean and hygienic.
2) Remove algae from the roof tiles before the monsoon.
3) Change the filter media every rainy season.
4) Water should not be allowed to stagnate in the collection pit.
5) Put mesh on inlet to prevent solid debris from getting into the system.
6) Repair cracks in structures regularly.
### Annexure A (Refer Clause 2.5.1 A )

#### Calculation of Quantity of Bleaching Powder/ Sodium Hypochlorite/ Chlorine Dioxide requirement

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Type of chemical (CDD 5000)</th>
<th>Chlorine strength in percent</th>
<th>Chlorine dosage required in mg/lt</th>
<th>Qty of Water to be chlorinated in litre</th>
<th>Qty of chemical reqd in gram</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bleaching Powder</td>
<td>20</td>
<td>0.5</td>
<td>5000</td>
<td>12.5</td>
<td>Say 13Gm</td>
</tr>
<tr>
<td>2</td>
<td>Bleaching Powder</td>
<td>20</td>
<td>0.6</td>
<td>5000</td>
<td>15</td>
<td>Say 15Gm</td>
</tr>
<tr>
<td>3</td>
<td>Bleaching Powder</td>
<td>20</td>
<td>0.7</td>
<td>5000</td>
<td>17.5</td>
<td>Say 18Gm</td>
</tr>
<tr>
<td>4</td>
<td>Bleaching Powder</td>
<td>20</td>
<td>0.8</td>
<td>5000</td>
<td>20</td>
<td>Say 20Gm</td>
</tr>
<tr>
<td>5</td>
<td>Sodium Hypochlorite</td>
<td>9</td>
<td>0.5</td>
<td>5000</td>
<td>27.77778</td>
<td>Say 28ML</td>
</tr>
<tr>
<td>6</td>
<td>Sodium Hypochlorite</td>
<td>9</td>
<td>0.6</td>
<td>5000</td>
<td>33.33333</td>
<td>Say 33ML</td>
</tr>
<tr>
<td>7</td>
<td>Sodium Hypochlorite</td>
<td>9</td>
<td>0.7</td>
<td>5000</td>
<td>38.88889</td>
<td>Say 39ML</td>
</tr>
<tr>
<td>8</td>
<td>Sodium Hypochlorite</td>
<td>9</td>
<td>0.8</td>
<td>5000</td>
<td>44.44444</td>
<td>Say 44ML</td>
</tr>
<tr>
<td>9</td>
<td>Chlorine Dioxide</td>
<td>0.22</td>
<td>5000</td>
<td>1.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Above table can be used to calculate quantity of chemical required for different quantities of water to chlorinated. Alternatively following formula shall be used to determine quantity of bleaching powder / Sodium Hypochlorite

\[
\text{Qty of bleaching powder / Sodium Hypochlorite} = \frac{Q \times D \times 100}{P \times 1000}
\]

Where:
- \(Q\) = Qty of water to be chlorinated in liters
- \(D\) = Chlorine dosage required at water works in mg/lt
- \(P\) = Chlorine strength in percent
## Annexure B (Refer Clause 2.1)

### Design Standards for Rural Water Supply Schemes

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Item</th>
<th>Existing Practice in W/s Department</th>
<th>PRWSS Project under world Bank</th>
<th>Proposed Norm in Technical Manual under PRWSSS Improvement Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Per Capita Water supply Rate</td>
<td>ARP: 40 LPCD MNP: 70 LPCD</td>
<td>PRWSS Project: 70 LPCD</td>
<td>Proposed: 70 LPCD (40 ltrs for domestic use and 30 ltr. for cattle use) for all types of villages. However, if any habitation/village wants to design water supply scheme at higher per capita water supply rate they shall be allowed to do so with the condition that it bear all the incremental cost required in addition to 10% share.</td>
</tr>
<tr>
<td>2</td>
<td>Design Life for Tube Well and machinery</td>
<td>ARP: 15 years MNP: 15 years NABARD PROJECT: 15 years</td>
<td>15 years</td>
<td>15 years</td>
</tr>
<tr>
<td>3</td>
<td>Design Life for Head Works Structure</td>
<td>Do</td>
<td>Do</td>
<td>15 years</td>
</tr>
<tr>
<td>4</td>
<td>Design life Distribution systems and Rising Main</td>
<td>ARP: 15 years MNP: 30 years NABARD PROJECT: 30 years</td>
<td>30 years</td>
<td>30 years</td>
</tr>
<tr>
<td>5</td>
<td>Increase in Population per Annum</td>
<td>ARP: 1.2285% as per census 2001 MNP: 1.2285% as per census 2001 NABARD PROJECT: 1.2285% as per census 2001</td>
<td>Final population forecast. Population forecast shall be done considering the following factors: Population growth in the previous decade (from 1991-2001 Census Figure or the latest census), Possibilities of village growth due to factors such as industrial projects and other projects which influence the growth of population, Any special factors causing sudden influx or migration of population like proximity to a city/town.</td>
<td>Final population forecast. Population forecast shall be done considering the following factors: Population growth in the previous decade (from 2001-2011 Census Figure or the latest census) i.e. 0.798% per annum, Possibilities of village growth due to factors such as industrial projects and other projects which influence the growth of population, Any special factors causing sudden influx or migration of population like proximity to a city/town.</td>
</tr>
<tr>
<td>6</td>
<td>Pumping Hours</td>
<td>ARP: 8 hours for design population MNP: 8 hours for design population NABARD PROJECT: 6 hours</td>
<td>6 hours</td>
<td>8 hours in General but availability of electricity should also be kept in mind at the time of fixing the pumping hours</td>
</tr>
</tbody>
</table>

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<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pump Chamber size</td>
<td></td>
<td></td>
<td>Pump Chamber cum Staff Quarter</td>
</tr>
<tr>
<td>7</td>
<td>14X16 ft</td>
<td>14x16 ft</td>
<td>3.7mx4.3 mt</td>
<td>3.7x4.3 mt</td>
</tr>
<tr>
<td>8</td>
<td>Over Head service Reservoir capacity</td>
<td>Capacity of OHSR shall be calculated by Mass curve method keeping in view the realistic availability of Electricity and water supply hours. Normally in Rural areas of Punjab Electricity is available in shifts on rotation basis. PSEB supplies electricity in Morning shift, Evening shift and Night Shift. Pumping hours will vary as per availability of electricity. Hence before fixing the capacity of OHSR mass curve should be plotted for all the three shifts pumping of water and supply hours. OHSR capacity should be worked out for worst case scenario. It should be 30% of daily demand.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Pumping Set</td>
<td>VT / submersible Pump set</td>
<td>VT / submersible Pump set</td>
<td>Submersible Pump set</td>
</tr>
<tr>
<td>10</td>
<td>Peak demand Factor</td>
<td>2 times of average daily demand</td>
<td>3 times of average daily demand</td>
<td>Submersible Pump set</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Star rating Submersible Pump set</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Usually water supply is made twice/thrice a day to the village community at the rate of 3 hrs each time which is equal to 6 hrs and Alternatively due to non-availability of power in the day time, the distribution hours may be restricted to 4 hrs a day... It may be further kept in mind that demand of water is more in the morning shift which may be 1.5 – 2 times of the average daily demand. Hence peak factor for designing the distribution system shall be worked out as below: Calculation of peak flow rate for designing the peak flow rate Based on above following peak factors are recommended</td>
</tr>
</tbody>
</table>

Pumping time = 16 hours for design population > 15000
Pumping time = 16 hours for design population > 15000
<table>
<thead>
<tr>
<th></th>
<th>Sn</th>
<th>Water Supply Hours</th>
<th>Peak Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Minimum Terminal Head</th>
<th>5 mt</th>
<th>8 mt</th>
<th>12 mt</th>
<th>12 mt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unaccounted losses in tees bends and sluice valves</td>
<td>3 mt</td>
<td>3 mt</td>
<td>3 mt</td>
<td>3 mt</td>
</tr>
<tr>
<td>1</td>
<td>Stand Post</td>
<td>1 for 250 persons of 15 years prospective population</td>
<td>1 for 250 persons of 30 years prospective population</td>
<td>Nil</td>
<td>1 for 150 persons of 15 years prospective population</td>
</tr>
<tr>
<td>1</td>
<td>Provision of zoning in distribution network</td>
<td>Nil</td>
<td>Nil</td>
<td>N/a</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>Minimum size of the distribution pipe</td>
<td>Nil</td>
<td>Nil</td>
<td>90 mm</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>Distribution system design method</td>
<td>Manual calculation using Hazen Willima formula</td>
<td>Manual calculation using Hazen Willima formula</td>
<td>Manual calculation using Hazen Willima formula</td>
<td>Used standard computer software</td>
</tr>
<tr>
<td>1</td>
<td>Depth and Width of Trench required to lay the pipe</td>
<td>Width min=75 cm or D+30 cm which ever is higher Depth = One meter cover minimum</td>
<td>Width min=75 cm or D+30 cm which ever is higher Depth = One meter cover minimum</td>
<td>Width min=75 cm or D+30 cm which ever is higher Depth = One meter cover minimum</td>
<td>The pipes shall be laid with a minimum cushion of 1.0 m. How ever in narrow streets 3-5 feet wide where no vehicular traffic is expected and digging deep may cause danger to the stability of foundations of adjoining structures it may be reduced to 60 cm. The width of trench required to lay PVC pipes shall be outer diameter+30 cm and wider trench shall only be excavated near the coupler joint. Practice of measuring the uniform width of trench shall be discouraged as for laying PVC pipe a wider trench is only required at joints.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Pipe material</td>
<td>AC/PVC</td>
<td>AC/PVC</td>
<td>AC/PVC</td>
<td>PVC 6 Kg/cm²</td>
</tr>
<tr>
<td></td>
<td>Water Quality test for Pesticides for Toxicity and Pesticides</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Water quality to be checked for pesticides and toxic elements</td>
</tr>
<tr>
<td>20</td>
<td>Disinfection system</td>
<td>Chlorination using Bleaching powder</td>
<td>Chlorination using Bleaching powder</td>
<td>Chlorination using Bleaching powder/ sodium hypochlorite</td>
<td>Chlorination / Silver ionization</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Tube well development</td>
<td>Once at the time of installation</td>
<td>Once at the time of installation</td>
<td>Once at the time of installation and after that every three years</td>
<td>Once at the time of installation and after that every three years</td>
</tr>
<tr>
<td>22</td>
<td>Safe yield</td>
<td>60% of developed discharge</td>
<td>60% of developed discharge</td>
<td>60% of developed discharge and reduce it by 30% to account for decline in discharge with the passage of time</td>
<td>60% of developed discharge and reduce it by 30% to account for decline in discharge with the passage of time</td>
</tr>
<tr>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Use Full Life of Various Components:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Masonry and RCC structures</td>
<td>50 years</td>
<td>50 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Filter Beds</td>
<td>30 years</td>
<td>30 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percolation wells</td>
<td>15 years</td>
<td>15 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tube Wells and Their Pump Chambers</td>
<td>15 years</td>
<td>15 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electrical Machinery and Pumps</td>
<td>15 years</td>
<td>15 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Design Standards specifically for Canal Based Schemes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Storage and Sedimentation Tank</td>
<td>Storage capacity- 15 days with evaporation and percolation losses assumed as 25% . The optimum depth of the tank should be 15 ft (4.5 mt)</td>
<td>Storage capacity- 15 days with evaporation and percolation losses assumed as 25% . The optimum depth of the tank should be 15 ft (4.5 mt)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inlet Channel</td>
<td>Sufficient to fill S&amp;S Tank in 7 days . Its normal capacity shall be = peak factor x Daily demand</td>
<td>Sufficient to fill S&amp;S Tank in 7 days . Its normal capacity shall be = peak factor x Daily demand</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suction and Scour well</td>
<td>Normally of circular shape of 1.5 mt diameter for population less than 15000 And for population more than 15000 its diameter = 2.5 meter</td>
<td>Normally of circular shape of 1.5 mt diameter for population less than 15000 And for population more than 15000 its diameter = 2.5 meter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>High level</td>
<td>The storage capacity of</td>
<td>The storage capacity of</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>tank</td>
<td>High level tank shall kept in relation to filtration hours</td>
<td>High level tank shall kept in relation to filtration hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>------</td>
<td>----------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Slow sand filter Bed</td>
<td>Rate of filtration = 2.5 kl per sq meter + 25% filter area as stand bye. Filter shall consist of 750mm-900 m Sand layer supported on 225mm-300 mm gravel. The sand shall have effective size of 0.3 mm and Coefficient of Uniformity $Cu = 2.0$</td>
<td>Continuous sand filter.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Clear Water Reservoir</td>
<td>50% of daily requirement</td>
<td>50% of daily requirement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Annexure C -(Refer Clause 12.10 )

**WATER TARIFF STRUCTURE**

PUNJAB GOVERNMENT GAZATTE
(EXTRAORDINARY) Notification dt. 04.10.2002

Department of Public Health (B&R 2 branch)

No. 11/220/2002-6 B&R II/5773- Public Health Department is providing safe drinking water in the rural area of the State. Water Supply is often interrupted by the people which creates shortage of drinking water causing inconvenience to the general public and problems to the Department for maintenance. To overcome these difficulties and to ensure uninterrupted water supply in the rural areas, a system has been evolved under which fine will be imposed on the offenders according to the nature of offence committed by them. Accordingly, the Governor of Punjab is pleased to order the levy of fine of different offences as under:-

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Nature of offence</th>
<th>Fine to be levied</th>
<th>Authority to impose fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cleaning of utensil at public post</td>
<td>Rs. 10 per offence</td>
<td>Agency responsible for Operation &amp; Maintenance</td>
</tr>
<tr>
<td>2.</td>
<td>Washing of cloths</td>
<td>Rs. 20 per offence</td>
<td>Ditto</td>
</tr>
<tr>
<td>3.</td>
<td>Bathing of animals</td>
<td>Rs. 50 per offence</td>
<td>Ditto</td>
</tr>
</tbody>
</table>

PUNJAB GOVT. GAZ (EXTRA) OCT, 4, 2002 (ASVN 12, 1924 SAKA)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Nature of offence</th>
<th>Fine to be levied</th>
<th>Authority to impose fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.</td>
<td>Creating hindrance by ante-social elements for the collection of water</td>
<td>Rs. 50 per offence</td>
<td>Agency responsible for Operation &amp; Maintenance</td>
</tr>
<tr>
<td>5.</td>
<td>Installation of tullu pumps</td>
<td>Rs. 500 per offence &amp; confiscation of tullu pump</td>
<td>Ditto</td>
</tr>
<tr>
<td>6.</td>
<td>Tempering of water supply line</td>
<td>Rs. 500 per offence</td>
<td>Ditto</td>
</tr>
<tr>
<td>7.</td>
<td>Illegal water connections</td>
<td>Rs. 1000 per offence &amp; confiscation of pipe/material</td>
<td>Ditto</td>
</tr>
</tbody>
</table>

2. The tullu pumps pipe material so confiscated will be disposed of through open auction after the expiry of the period of three months and the revenue collected will be deposited in the receipt head of the department.

Chandigarh
The 3rd October, 2002

Principal Secretary/ to Government of Punjab
Department of Public Health
Memo No. 7/19/2001-6B&R-II/
Dated Chandigarh, the 23 December, 2002

Subject: Revision of user charges for repair and maintenance of Water Supply Schemes.

Reference on the subject noted above.

2. The Governor of Punjab is pleased to revise the Water Tariff structure for Private Water Connection for households, drawing water from Public Stand Post and for commercial establishment over a period of five years as under:-

a) Tariff for Rural Water Supply Schemes and Households drawing water from Public Stand Post.

<table>
<thead>
<tr>
<th>Sr. NO.</th>
<th>Year</th>
<th>Monthly tariffs for private water connections</th>
<th>Monthly tariff for households drawing water from stand posts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>For normal schemes designed @ 40 lpd</td>
<td>For NABARD schemes designed @ 70 lpd</td>
</tr>
<tr>
<td>1</td>
<td>2002-03</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>2003-04</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>2004-05</td>
<td>55</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>2005-06</td>
<td>55</td>
<td>70</td>
</tr>
<tr>
<td>5</td>
<td>2006-07</td>
<td>60</td>
<td>75</td>
</tr>
</tbody>
</table>

b) Commercial Establishment

i) The flat rate of Rs. 200/- per month per water connection from a commercial establishment/shop situated either inside the village or on the link roads.

ii) The flat rate of Rs. 500/- per month per water connection from a commercial establishment/shop situated on the National / State Highway.

3. This order will come into force from 1st January of every year.

Endst No. 7/19/2001-6B&R-II/    Dt. Chandigarh, the December 2002

A copy is forwarded to the following for information and necessary action:-
1) The Accountant General, Punjab, Chandigarh.
2) The Deputy Secretary, Finance (FE-IV Branch).

Deputy Secretary, Public Health
Annexure D : (Refer clause 7.5)

**Guidelines for Selection, Installation and Maintenance of Domestic Water Meters**

1. **Scope**

1.1 This code covers the selection, installation and maintenance of inferential and semi-positive water meters conforming to IS: 779-1968*.

2. **Selection**

2.1 Water meters shall be selected according to flow to be measured and not necessarily to suit a certain size of main. The following points shall govern the selection of meters:

a). The maximum flow shall not exceed the nominal capacity of the meter specified in IS 779-1968*.

b). The continuous flow shall be not greater than the continuous running capacity rating specified in IS: 779-1968*.

c). The minimum flow to be measured shall be within minimum starting flows specified in IS: 779-1968*.

Inferential water meter has the same accuracy as the semi-positive type at higher flows: it passes unfiltered water better than a semi-positive meter and is lower in cost.

Special care is necessary in selecting the most suitable meter where large rates of flow may exist for short periods. The normal working flow shall be well within the continuous running capacity specified in IS: 779-1968*, as high rates of flow over short period may cause excessive wear if the meter chosen is too small for the duty.

Owing to the fine clearances in the working parts of meters, they are not suitable for measuring water containing sand or similar foreign matter, and in such cases a filter or dirt box of adequate effective area shall be fitted on the upstream side of the meter. It should be noted that the normal strainer fitted inside a meter is not a filter and does not prevent the entry of small particles, such as sand.

3. **Installation**

3.1 A meter shall not be run with free discharge to atmosphere, if the static pressure on the main exceeds 10 m head of water, otherwise the meter is liable to be overloaded and damaged. For hose connections and similar applications, there shall always be some resistance on the downstream side of the meter.

A Meter shall be located where it is not liable to get severe shock of water hammer, which might break the piston or damage the rotor, and the position shall be such that it is always full of water; a recommended method of making connection to achieve the purpose is shown in Fig. I. If the meter body or adjacent pipes become partially drained of water, the accumulated air, when passed through the meter, is registered as water, and may cause inaccuracies and perhaps damage. The inaccuracies may be more pronounced in the case of inferential meters. In such situations suitable devices like air-release valve may be fitted on the upstream side of
the meter. In the case of intermittent water supply system, where there are frequent changes of air locks, the piston of the semi-positive meter often breaks. In such a case, it is advisable to ensure that the top of the meter is below the level of the communication pipe.

Semi-positive meters may be fixed in any position, with the dials facing upwards or sideways, and they may be installed in horizontal or vertical pipe runs without affecting wearing properties of accuracy at normal service flows. Where backward flows are anticipated, reflux valves are recommended to be provided. A stop valve should be provided on the upstream side as shown in Fig. 1 to isolate the meter whenever necessary.

Inferential meters shall be installed in position for which they are designed; in the case of meters conforming to IS: 779-1968*, they shall be placed horizontally with dial facing upwards. However, where meters are to be installed in vertical pipelines, details shall be as agreed to between the manufacturer and the purchaser.

Turbulent flow of water affects the accuracy of the meter. There shall, therefore, be straight lengths of pipes upstream and downstream of meter for an equivalent length of ten times the nominal diameter of the pipe.

Meters liable to damage by frost shall be suitably protected. It is possible to incorporate frost protection devices in certain types of meters, if ordered. Several devices are adopted, the most common among them being a collapsible metal ring which, under frost pressure, allows the top plate carrying the mechanism to lift and thus safeguard the body, or a metal disc in the body which gives way under pressure. These devices have the following disadvantages.

a) The damaged ring or plate requires immediate replacement in order to stop wastage and restore water supply to consumer;

b) Water runs to waste till the meter is attended to, which means loss of revenue; and

c) Damage is discovered only after thawing has started.

3.6.1 A more satisfactory arrangement consists of a method whereby the proportionate increase in bulk of ice, which is approximately 14 percent, is accommodated by the provision of pads of special quality expanded natural rubber.

No arrangement, however, is regarded completely satisfactory, and for this reason, the general practice is to install meters well out of the way of frost. Meters should be fixed below ground level if they are located outside the building or, if in exposed portion inside the building, the bodies of the meters should be protected with some form of lagging; in the case of meters installed below ground, depth at which the meter should be fixed to afford frost protection will depend on the nature of the soil.

3.7 Before installing a meter, the section of line to be metered shall be thoroughly flushed to remove all foreign matter and, when starting up, control valves shall be opened slowly until the line is full, as a sudden discharge may damage the meter.

3.8 Water meters may be installed underground, either in the carriage way outside the premises or at a convenient place within the premises. In order to enable the meters to be accessible for periodical reading, inspection, testing and repairs, they shall be housed in water
meter boxes conforming to IS: 2104-1962*. Top of the meter box shall be placed at a slightly higher level than the surrounding ground level so as to prevent ground water entering in and flooding the chamber during rains.

3.8.1 If it is required to be located in a private passage leading to the premises, proper precautions shall be taken consistent with safety.

3.9 The meters and connecting pipes shall be strongly supported for protection of the meters and to avoid noisy vibration.

4. MAINTENANCE

4.1 Periodic Testing of Water Meters
4.1.1 The period over which water meters retain their overall accuracy depends largely on the quality of water being measured and to a certain extent on. Other factors which cause excessive wear or inaccurate registration. The only way to determine whether any specific meter is operating efficiently is to test it and the meter maintenance programme should aim at establishing the frequency for testing every meter in service. From an individual customer's viewpoint, meters should be tested to protect him against meter inaccuracy that could result in over charges, while from the point of view of the water undertaking; it should be to protect the undertaking against the revenue loss from under registration by meters. No definite recommendations could be given in this regard as the results depend on such factors as the rates charged for water, the effect of water of different quality on meters, local conditions under whole they operate and the cost of removal, testing, repairing and re-installation proper economic balance should be attained.

   Irrespective of these considerations, the meters should be tested at least once in two years.

4.1.2 In case of inferential water meters, water is passed even if the meter stops registering, whereas, in the case of semi-positive meters, the water supply would be shut off when the meter stops registering. From the waters supply would be shut off when the meter and having regard to the seasonal fluctuations in the demand for water supply of a consumer, it is possible to determine whether the meter requires to be removed for test, being suspected of running slow.

4.2 When a meter is removed from the line for whatever reason, opportunity should be taken to see that it is clean and functioning properly before it is re-installed. It should also be tested for accuracy and reset to zero before installation.
0.1 This Indian Standard (Third Revision) was adopted by the Indian Standards Institution on 27 February 1981, after the draft finalized by the Sanitary Appliances and Water Fitting Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 This standard was first published in 1963 and the first and second revisions were issued in 1968 and 1973 respectively. A third revision of the standard has been taken up to review the standard and incorporate changes found necessary in the light of comments received from manufacturers and user during the course of implementation of the standard.

0.2.1 In this revision, minimum thickness of the liner for enclosed type water meter has been incorporated to ensure life of the body of water meters.

0.3 This standard contains clauses 4.6.1, 4.6.2, 4.12 and 6.2, which permit the purchaser to use his option for selection to suit his requirements. This standard also contains clause 8.2.2, which requires agreement between the purchaser and the manufacturer.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS: 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. Scope

1.1 This standard covers bulk type water meters of the following types:

a). Vane-wheel (impeller) type water meters form 50 to 300 mm

b). Helical type water meters from 50 to 500 mm.

2. Terminology

2.0 For the purpose of this standard, the following definitions shall happy.

2.1 Meter Casing - The outer casing in which the entire meter mechanism is housed.
2.2 **Body** – The part of the meter, which the runner and the transmission gear train of the water meter. Some parts of the body may be integral with the casing.

2.3 **Registration Box** – The part of the meter casing which houses the registration device.

2.4 **Cap** – The part of the meter casing body to which is fitted the dial cover and the lid.

2.5 **Lid** – The top cover, which is hinged to the cap with a view to protecting the transparent dial cover.

2.6 **Registration Device** – The unit, which comprises the recording gear train and the indicating device consisting of a cyclometer type counter or pointer on a dial or a combination of both. It registers in suitable volumetric units the quantity of water, which has passed through the meter.

2.7 **Vane Wheel Type Meter** – Meter whose runner or impeller is mounted on a vertical spindle, which has several vanes symmetrically spaced round its axis. The water impinges on the runner over a part or the whole of its circumference.

2.8 **Helical Type Meter** – Axial flowmeter whose runner is provided with a number of vanes forming a multi-threaded helix.

2.9 **Water Meter, Dry Deal Type** - Meter in which the counter mechanism is isolated from water flowing through the meter.

2.10 **Water Meter, Wet Dial Type** – Meter in which the complete counter unit is in contact with water flowing through the meter.

### Nominal Size

3.1 The water meters shall be of the following nominal sizes:

<table>
<thead>
<tr>
<th>MM</th>
<th>MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>250</td>
</tr>
<tr>
<td>80</td>
<td>300</td>
</tr>
<tr>
<td>100</td>
<td>350</td>
</tr>
<tr>
<td>150</td>
<td>400</td>
</tr>
<tr>
<td>200</td>
<td>500</td>
</tr>
</tbody>
</table>

3.1.1 The nominal size of water meters shall be denoted by the bore of their inlet.

4. **Materials and manufacture**
4.1 **General** - Water meters and their parts, especially parts coming in continuous contact with water, shall be made of materials resistant to corrosion and shall be non-toxic and non-tainting; where cast iron is used, it shall be protected suitably against corrosion. Use of dissimilar metals in contact under water shall be avoided, as far as possible, to minimize electrolytic corrosion. Information required to be supplied by the purchaser with the enquiry and order is given in Appendix A.

4.2.1 **Casing** – The casing of the meter shall be made from cast iron conforming to grade FG 200 of IS: 210-1978* or bronze conforming to grade 2 of IS: 318-1962* or brass conforming to Grade 3 of IS: 292-1961* grade cuzn 40 of IS: 1264-1965.

4.2.2 **Body** – The body of the water meter shall be made of bronze conforming to grade 2 of IS: 318-1962* or brass conforming to grade 3 of 292-1961* or Grade CuZn 40 of IS : 1264-1958. in the case of enclosed type water meters as the liner shall be made of minimum 1.5 mm thick brass sheet conforming to IS : 410-1977.

4.2.2.1 The body shall be free from all manufacturing and processing defects, such as blow holes and spongy structures and shall not be repaired by plugging, welding or by the addition of material. The integral shape of the body shall ensure smooth flow of water and easy dismantling.

4.3 **Connections** – The water meter shall be provided with flanges at both the ends, the internal diameter of which shall be equal to the nominal size of the meter. The flanges shall be machined flat, that is, without a raised joint face. The dimensions and drilling of the flanges shall be in accordance with IS : 1538 (Part IV) –1976 and IS : 1538 (Part VI) –1976**. Tolerances on dimensions and drillings shall be in accordance with IS : 1538 (Part I) –1’976 **. For meters of 50 mm size the dimensions and drilling of flanges and tolerances shall be in accordance.

4.4 **Screws, Studs, and Nuts** – Screws, Studs and Nuts shall be of mild steel, brass or some other corrosion resistant material. Where fasteners are likely to be in contact with water, they shall be made of brass conforming to IS: 318-1962* or of stainless steel conforming to designation 07 or 18 Ni 9 of IS

4.5 **Registration Box** – The registration box shall be made of the same material as specified for body in 4.2.2.
4.6 **Cap** - The cap shall be made of the same material as specified for body in 4.2.2. The cap shall be so designed and fixed to the registration box as to avoid entry of water and dirt. The transparent window, which covers the dial, shall be inserted from the inside into the cap. The protective lid shall be secured by a robust hinge or other suitable methods of robust construction.

4.6.1 Where required by the purchaser, provision shall be made to lock the lid to the registration box. The provision shall be such that the lock may be conveniently operated from the top. Where the provision is designed for use in conjunction with padlocks, the hole provided for padlock shall be of diameter not less than 4 mm.

4.6.2 Where so required, for dry type water meter, the transparent window covering the dial shall be provided with a wiper on the inner side for wiping off condensed water.

4.7 **Strainer** - Strainers shall be made of a material which is not susceptible to electrolytic corrosion. They shall be of plastic or other corrosion resistant materials. They shall be rigid, easy to remove and clean and shall be fitted on the inlet side of the water meter. The strainer shall have total area of holes not less than twice the area of the nominal inlet bore of the pipe to which the meter is connected. Where strainer is installed outside the meter, it shall be at such a distance that it does not affect the accurate functioning of the meter.

4.8 **Runners (Impellers)**

4.8.1 The runner shall be of tensile brass conforming to IS: 320-1962*, stainless steel conforming to designation 07 Cr 18 Ni 9 of IS: 1570 (Part V )-1972t or nickel alloys conforming in IS: 4131-1967*.

4.8.2 Runner of the meter shall be of ebonite, vulcanite, or suitable plastic, bronze conforming to Grade 2 of IS :318-1962§, stainless steel conforming to designation 07 Cr 18 Ni 9 or IS: 1570 (Part V )-1972t or nickel alloy conforming to IS: 4131-1967.; It. shall be accurately balanced. Runner shall be durable and shall work with as low frictional resistance as possible.

4.9 **Runner Chamber** - In the case of vane-wheel type meters, the runner chamber shall be of brass conforming to Grade 3 of IS : 292-1961*. Bronze conforming to Grade 2 of IS: 318-1 962t. Stainless steel conforming to designation 07 Or 18 Ni 9 of IS: 1570 (Part V)-1972: or nickel alloy Conforming to IS: 4131-1967§. The runner chamber shall be rigid and
shall not change its form as a result of internal stresses or with use.

4.10 **Gears** - Gears shall be 10 constructed as to fully and smoothly mesh with each other, and shall be firmly fitted on their shaft. Gears coming in contact with water shall be of stainless Steel conforming to designation 07 Or 18 Ni 9 of IS: 1570 (Part. V)-1972: Or nickel alloy conforming to IS: 4131-1967§. In the helical type meters, the worm gears may be fined on a shaft and the worm wheel shall be enclosed and protected against the incursion of solid particles.

4.11 **Bearings** - Impeller bearings shall be of agate, sapphire, graphite filled nylon or graphite filled ebonite suitable ground and polished. The shape of the impeller bearing shall be such as to prevent the penetration of particles of sand and to preclude the deposit of anything in solution or suspension in water and to facilitate the washing away of such deposits by water flow. The shafts of the gears shall revolve freely in their bearings. The length of the bearing shall ensure their effective operation.

4.12 **Counting Mechanism** - The pointer shall be made of sheet brass conforming to' 410-197711 or suitable plastic. The counter shall be of circular multi-pointer pattern with all pointers preferably reading clockwise. The indicating device may also be of the straight reading cyclometer type counter or a combination of pointer and the counter. The rollers of the cyclometer counter shall be made of nickel or nickel-plated brass or plastic specially suitable for the purpose and shall be self lubricating. The external numbering shall be such that it will not fade away under continued use.

4.12.1 The range of registration shall be as given in Table 2.

4.13 **Dial** - The dial shall be of vitreous enamel, copper or suitable plastic, ensuring indestructible marking and good legibility. The unit of measurement namely, 'litre' or 'kilolitre" shall be marked on the dial 81 'LITRES' or 'KILOLITRES' in boldface; the unit, cubic metre (m³) may also be used in place of kilolitre.

4.14 **Sealing** - Sealing holes shall be provided and the meter shall be sealed in such a manner as to render it inaccessible to the 'measuring unit, including registration box and cap without breaking the seal. The sealing wire shall be rust proof such as tinned copper.

4.15 **Regulator** - Every meter shall be provided with either an external or an internal regulator. The external regulator shall be accessible from outside to be operated by a suitable key without dismantling the meter and protected by a sealed
4.16 **Location of Serial Number** - The serial number of the meter shall be clearly indicated in any suitable place except the lid.

**Performance Requirements**

**5.1 Temperature** – The meter shall be suitable for use with water up to 45°C.

**5.1.1 Temperature Suitability Test** – The water meter shall be immersed in a water-bath maintained at 45± 1°C for 10 h. afterwards it should be checked for flow and accuracy tests.

**5.2 Hydrostatic Test** – Meters shall satisfactorily withstand a pressure of 1.6 MPa (16 KGF/CM²).

5.3 Capacity Ratings for Water meters

5.3.1 Nominal Capacity or short period rating – Vane wheel water meters shall be capable of giving discharges not less than as given in without the headless exceeding 10 m within the meter. The helical meters shall be capable of giving discharges not less than as given in without the headless exceeding 3 m within the meter.

5.3.2 Recommend Capacities for Intermediate Flows – Vane-wheel water meters shall be capable of giving discharges not less than as given in Table 4 without the head loss exceeding 3 m within the meter; helical meters shall be capable of giving discharges not less than as given in Table 4 without the headloss exceeding 1 m within the meter.

5.3.3 The headloss within meters shall be measured in accordance with the method given in Appendix B.

5.4 Minimum Starting Flow - The minimum flow at which the meters start registering shall be as given in Table 5.

5.5 Metering Accuracy - The accuracy at lower limit of flow shall be calculated at one-thirtieth of the nominal capacities of water meters given in Table 3; at the lower limit of flow, the metering accuracy shall be ± 2 percent for both types of water meters. The same accuracy shall be complied with at least up to intermediate flows.
specified in Table 4.

6. FROST PROTECTION DEVICES

6.1 Meters liable to be damaged by frost shall be protected with suitable frost protection devices. Several devices are adopted and the following, which have been found to give satisfactory performance, are given as typical examples:

a) Provision of pads of special quality rubber which accommodate the increase in bulk of water when it freezes; and

b) Provision of collapsible metal ring which under frost pressure allows the top plate carrying the mechanism to lift and so safeguard the body, or a metal disc in the body which gives way under pressure. It should be noted that the damaged ring or plate requires immediate replacement to restore water supply to user or to stop waste.

6.2 The purchaser shall specify with his order whether he requires frost protection device.

7. MARKING

7.1 Each water meter shall be marked with the following information: a) Manufacturer's name or trade-mark,

b) Nominal size of the meter, and
c) Direction of flow of water on both sides of the meter.

7.1.1 Each water meter (with or without strainer) may also be marked with the ISI Certification Mark.

NOTE - The use of the 151 Certification Mark is governed by the provision of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI mark on products covered by an Indian standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control, which is devised and supervised by ISI and operated by the producer. 151 marked products are also continuously checked by 151 for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the 151...
Certification Mark may be granted to manufacturers or processors, may be, obtained from the Indian Standards Institution.

8. TESTS

8.1 Classification of Tests - Tests shall be classified into three groups, namely (a) production routine tests, (b) type tests, and (c) acceptance tests.

8.1.1 Production Routine Tests - These tests are carried out on each and every meter to check the requirements, which are likely to vary during production.

8.1.2 Type Tests - These tests are carried out to prove conformity to the requirements of the relevant specification. These are intended to check the general quality and design of a given type of meter (see 8.4). Once a meter has undergone type tests, any major or essential alterations, which the manufacturer intends to make, shall be reported to the testing authority and further type tests shall be carried out in accordance with the procedure laid down in this standard.

8.1.3 Acceptance Tests - Tests carried out on samples selected from a lot for the purposes of acceptance of the lot.

8.2 Samples for Tests

8.2.1 Type Tests - Two meters in the case of 50 mm size and one meter in the case of 80 mm size and above shall be sent along with 4 copies of the manufacturer's detailed specification together with figures for the loss of head and accuracy curves to the recognized testing authority for the purpose of type test. The samples shall be picked up at random from stock or routine factory production.

8.2.2 Acceptance Tests - The number of samples shall be agreed to between the manufacturer and the purchaser.

8.3 Production Routine Test - Production routine tests shall consist of:

a) Hydrostatic test (set 5.2), and

b) Tests conducted requirements to determine the following performance requirements
   1) Recommended capacity for intermediate flows (set 5.3.2 and Non: given below),
   2) Minimum starting flows (see 5.4), and
   3) Metering accuracy (see 5.5).
8.4 Type Tests - Besides all the production routine tests outlined in 8.3, the type tests shall comprise those given in 8.4.1 and 8.4.2.

8.4.1 Construction - The meter shall be dismantled completely to its component parts and checked for conformity with regard to dimensions and tolerances with this standard; in the case of meters of 50 mm size, only one meter need be dismantled. A study of the details of assembly shall be made on matters, such as case of assembly, absence of riveted or turned over parts, forced fitting and liability of, parts to break during dismantling and assembly.

8.4.2 Flow Test - The meter (both the meters in the case of 50 mm) shall then be subjected to the flow test to measure the following:

a) Loss of head at nominal capacity and recommended capacity at intermediate flows,

b) Minimum starting flows, and

c) Metering accuracy.

NOTE 1 - Before the meter is subjected to the flow test it shall be run and brought to normal condition by passing through them water at intermediate flow value for a period of two hours.

NOTE 2 - Type test certificate may be made available in lieu or' flow test at manufacturer's premises.

8.4.2.1 Results of the type tests shall be reported in the form given in Appendix C.
APPENDIX A
Clause 4.1)

INFORMATION TO BE SUPPLIED BY THE PURCHASER
WITH THE ENQUIRY AND ORDER

A-I. The following information shall be supplied by the purchaser with the enquiry and orders:

a) Nominal size of meter required;
b) Type of meter required, namely, vane-wheel or helical;
c) Provision for locking, whether required or not;
d) Type of counter required, namely:
   1) Circular multipointer pattern,
   2) Straight reading cyclometer type, or
   3) Combination of pointer and counter;
e) Frost protection device required or not;
f) Strainer required or not;
g) Wiper required or not; and
h) Wet or dry dial required.
APPENDIX 8
(Clause 5.3.3)

METHOD FOR DETERMINATION OF HEADLOSS IN WATER METERS

B-1. DETAILS

B-1.1 Pressure gauges or manometer shall be fixed upstream and downstream of the water meter under test. The inlet and outlet of the water meter shall each be provided with a straight pipe of internal diameter equal to the nominal size of the meter and having a length equal to at least 10 times its diameter on the upstream or inlet side and a straight length of at least times its diameter on the downstream or outlet side, free from tees, bends, valves, etc, and the meter in no case shall freely discharge into the atmosphere. When discharging water at the specified rates the pressure drop shall be noted which shall be the headloss at the corresponding flows. A typical arrangement for measurement of headloss is shown.

TYPICAL ARRANGEMENT FOR MEASUREMENT OF HEADLOSS OF WATER METERS

B-1.2 The regulating valve shall be situated at a distance not less than 40 times the diameter of the pipe from the inlet end of the water meter. When the feed of the water is through a pump instead of through an overhead tank; the pump shall be situated and where required suitable damping devices, such as air vessels or automatic pressure Switches, shall he so provided that the pulsation in the flow water through the meter is reduced to the minimum
APPENDIX C (Clause 8.4.2.1)

**TYPE TEST ON WATER METERS**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th>-</th>
<th>---------------------------------</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of the manufacturer</td>
<td></td>
<td>________________________________</td>
</tr>
<tr>
<td>Type designation</td>
<td></td>
<td>________________________________</td>
</tr>
<tr>
<td>Nominal size</td>
<td></td>
<td>________________________________</td>
</tr>
</tbody>
</table>
Annexure F *(Refer clause 8.5.2)*

**Difference Between Dosatron Non electricity based water powered liquid dispenser dosing pumps and conventional pumps**

<table>
<thead>
<tr>
<th>Dosatron</th>
<th>Electric pumps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precise: Dosing proportional to the water flow passing through the Dosatron.</td>
<td>Non proportional, no dosing, only injecting. Needs flow meter and servo control to obtain proportional injection.</td>
</tr>
<tr>
<td>Unlike other systems, proportional dosing provides uniform distribution of the products over the entire sector(s).</td>
<td>Over or under dosing risk when not servo-controlled.</td>
</tr>
<tr>
<td>Non electric runs on water power and flow dependent system.</td>
<td>Non autonomous: Needs Electricity</td>
</tr>
<tr>
<td>Easy maintenance as moving parts do not have metal parts. No high installation cost. Simple piping required.</td>
<td>Higher cost, especially with servo-control installation.</td>
</tr>
<tr>
<td>Saving in electricity. About Rs. 800/- per month and Rs.9600/- per Annum. In ten years about 1.00 lac saving.</td>
<td>No saving of electricity it is must for running.</td>
</tr>
<tr>
<td>Longer life of about 10 years or more subject to quality of water only periodically AMC is required.</td>
<td>Average life 1to 2 years it means department has to buy in 10 years 9 times. Units of about Rs. 315000/-.</td>
</tr>
</tbody>
</table>
ANNEXURE G (Refer Chapter 12)

OPERATION AND MAINTEINANCE

DETAILS REQUIRING ATTENTION TO PREVENT OPERATIONAL PROBLEMS IN PUMPING

Guide Lines for Maintenance Centrifugal Pumps:

FOUNDATION

The concrete foundation must have thoroughly dried and set before erection of the pump to ensure that loads due to weights of pumpsets, twisting moments and inertia forces due to the machine as well as the weight of, and thrust set up by the pipeline can be borne without any movement or settling of the foundation. Concrete foundations for reciprocating pumps should be still heavier, and if necessary they should be isolated from the adjacent ground by a layer of material such as sand, cork, felt padding, timber etc. capable of damping out vibrations.

Rotary machines are invariably dynamically balanced so that no unbalanced inertia forces of any appreciable magnitude can occur.

Vibrations of the foundations can be avoided provided the machines are correctly aligned under stilled supervision. This is necessary even for smaller pump units usually mounted on a common base plate and lined up before despatch to take care of the possible distortions occurring during transport or set up on site by irregularities in the surface of the foundation.

B. SUCTION PIPES

The internal dia selected for the suction lines should in no case be less than that of the suction branch of the pump. The suction pipe must be kept as short as possible and total suction from all causes should not exceed the limiting value specified by the manufacturer. Normally, it should not exceed more than 4.5 m for general purpose pumps.

Pipeline should be supported and fixed in such a manner that the pump is not subjected to any stress from piping. To avoid the formation of air pockets, suction lines must be arranged with a continuous rise towards the pump. Isolating valves of the gate type on the suction side should be fitted with the valve spindle horizontal and their glands sealed by means of water from the discharge side of the pump.

When water containing dissolved air or other gas is pumped, it is desirable to provide an air separation vessel and a divide such a vacuum pump for removing the air.

If at all possible, each pump should have a separate suction line in order to prevent air leaking in, from a pump that is shut down. However, if the use of a common suction line cannot be avoided, the non return valves of the
discharge side of the pumps should be omitted, and instead such valves should be fitted immediately upstream of the suction branches.

When a number of pumps are installed adjacent to one another, with their suction pipe in the same pump, care should be taken to see that a minimum of 3 dia distance is kept generally between two suction pipes to prevent aeration problem resulting in the loss of output because of entrance of air into the pump or even ceasing of some pumps altogether.

In the absence of a suction strainer fitted with a foot valve, the inlet to the suction pipe should be bell mouthed, situated at an adequate height above the bottom of the well, and also always submerged below the lowest water level. The bell mouth diameter should be at least 1.5 times that of the suction pipe and it should be at a height of at least half the dia of suction pipe, from the bottom of the sump. Vortex effects with vertical axial-flow and propeller type pumps can be minimized by locating their bell-mouth inlets as close as possible to the rear wall of the suction chamber.

In the case of suction strainers fitted with foot valves, it should be located at an adequate height above the bottom of suction chamber and also submerged below the lowest surface level of the water. They should be arranged to ensure uniform intake of water from all sides. The total area of the holes in the strainers should be equal to or more than the cross sectional area of the suction pipe. The flow velocity in the suction branch of the pump should not exceed 2 mps.

C. DELIVERY PIPE

Non-return valves must always be fitted when the discharge head exceeds 10m, so that in case of sudden stoppage of pump the surge pressure due to the returning column of liquid is not imposed on the casing. The non-return valve should be provided with a bypass so that all the surge pressure is not imposed on the seating of the valves, but it is bypassed and the water goes to the sump. A relief valve should also be provided on the delivery side.

PIPE FITTINGS

If it is found necessary to fit a bend immediately upstream of the suction branch of a pump, the radius of the bend should be equal to or greater than 2 D+100mm.
Branch fitting of Y type are to be preferred to T pieces.

The length of tapered reducing pieces, when the divergence, should be about five times the difference between outlet and inlet diameters.

If used as reduces, tapered fittings may be very much shorter; the most suitable form is that of a nozzle type.
E. COMMISSIONING

Priming is essential and is done by using a foot valve. In the case of large pumping units, priming is generally done by using a vacuum pump which exhausts the air from the pump casing and sucks in the liquid from the sump. In the case of pumps having a positive head on the suction line, priming is done by opening the valve on suction pipe.

Prior to starting, the direction of rotation of the drive should be checked. All lubrication system should also be checked. The stuffing boxes should be packed properly and care is taken to see that the lantern ring is located exactly underneath the water seal piping. After making all the above checks, the coupling pins are fitted and the rotating elements are rotated by hand or with the help of spanners in case of large units. This makes sure that the pump will accelerate and attain full speed smoothly. Over packing of stuffing box may damage the sleeves.

The pump should be started with the delivery valve closed. On starting, check that the pump is generating the head. This will be indicated by the delivery pressure gauge. Immediately after the pumps run to full speed, check should be made on bearings, stuffing boxes and vibrations and residual air should be vented out by the air-cock provided on the top of the casing.

Stuffing boxes and glands should be checked for over heating and gland leakage. The gland packing, when it is new, does tend to get slightly heated but it comes to normal after running for sometime. A few drops of liquid should trickle out in the gland bowl. If the gland leakage is excessive the gland should be tightened or additional gland packing should be introduced.

The centrifugal pump should not be run on closed valve for long periods. After making all checks the delivery valve should gradually be opened and the pump may be put on its rated load. The ammeter should be checked to see that the meter is not overloaded.

Attention should be given to the temperature of the bearing after running the pump on its rated load. Periodic check on temperature of the bearing should be made.

In case the pump fails to generate pressure, it should be stopped immediately and checked for air leakage from all joints in suction pipes and the stuffing boxes.

It is most important that in no case should the pump be started without liquid, as this may result in seizure of the internals of the pump.
<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Name of section or part to be attended</th>
<th>Maintenance to be carried out</th>
<th>Frequency time internal at which inspection &amp; maintenance to be done</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Bearings</td>
<td>Checking of temperature with thermometer</td>
<td>Two months</td>
<td>Hot ball or roller bearing point to too much oil or grease; hot sleeve bearings need more oil or heavier lubricant does not correct, dissemble and inspect the bearing alignment of pump and driver.</td>
</tr>
<tr>
<td>2.</td>
<td>Glands</td>
<td>Changing of land packing</td>
<td>Two months</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Bearings</td>
<td>Lubrication (greasing)</td>
<td>Two months</td>
<td>Check for saponification resulting in whitish colour wash out with kerosene.</td>
</tr>
<tr>
<td>4.</td>
<td>Gauges</td>
<td>Checking of pressure &amp; vacuum gauges</td>
<td>Three months</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Valves</td>
<td>Changing of gland packing in delivery sluice valve, suction valves, bye pass valve, reflex valve.</td>
<td>Six months</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Exhaust pump &amp; its auxiliaries</td>
<td>Checking of gland packing &amp; six months its auxiliaries etc.</td>
<td>Six months</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Impeller</td>
<td>Checking of impeller blades Year sleeves, efficiency Rings, bearings, neck ring impeller nut etc.</td>
<td>Year</td>
<td></td>
</tr>
</tbody>
</table>
### SCHEDULE OF PREVENTIVE MAINTENANCE

#### “Electrical Motors”

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Name of section or part to be attended</th>
<th>Maintenance to be carried out</th>
<th>Frequency time internal at which inspection &amp; maintenance to be done</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Induction Motor stator &amp; Rotor</td>
<td>Opening of end covers dust blowing &amp; checking of air gap.</td>
<td>One month</td>
<td>Depending on the working conditions and maintenance staff available</td>
</tr>
<tr>
<td>2.</td>
<td>Slip Ring Device</td>
<td>Cleaning of slip rings &amp; adjustment of carbon brushes, shortcircuiting jaws, oiling of clutch etc.</td>
<td>One month</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Bearings</td>
<td>Proper lubrication</td>
<td>Two months</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Windings</td>
<td>Checking of motor after taking out its Rotor, dust blowing, checking of end connections of stator &amp; Rotor &amp; taking insulation test, no load test before putting the motor on load.</td>
<td>Two years</td>
<td></td>
</tr>
</tbody>
</table>

#### SCHEDULE OF PREVENTIVE MAINTENANCE

#### “Power Transformers”

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Name to be Carried out</th>
<th>Frequency time internal at which inspection &amp; maintenance to be done</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Checking of silicagel, topping of transformer oil, temperature gauge, vent pipe, voltage tap changing switch.</td>
<td>Six months</td>
<td>Checked &amp; if required silicagel must be changed before the outbreak of monsoon.</td>
</tr>
<tr>
<td>2</td>
<td>Filtration of oil, checking of dielectric strength, checking of viscosity of oil, terminal boxes (H.T. &amp; L.T. both), insulators, Neutral Earthing, tightening of nuts bolts, cable rockets, stopping of leakages if any through joints.</td>
<td>Year</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Checking of its functioning</td>
<td>Year</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Checking of condition of core of the transformer and its windings insulation condition</td>
<td>5 years</td>
<td></td>
</tr>
</tbody>
</table>
### SCHEDULE OF PREVENTIVE MAINTENANCE

**Clariflocculators & Their Drive**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Name of section or part to be attended</th>
<th>Maintenance to be carried out</th>
<th>Frequency time internal at which inspection &amp; maintenance to be done</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Trolley wheels</td>
<td>Lubrication (greasing)</td>
<td>One month</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Reduction Gear Box</td>
<td>Checking and topping of oil level</td>
<td>Three months</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Turn Table mechanism</td>
<td>Checking and topping of oil level</td>
<td>Three months</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Vertical slip Ring Motor</td>
<td>Dust blowing, checking of carbon brushes, bearing etc.</td>
<td>Four months</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Rail/Track</td>
<td>Adjustment of gap between two rails &amp; its aligning etc.</td>
<td>Four months</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Reduction gear box</td>
<td>Checking of helical or spur gears condition</td>
<td>Six months</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Rubber type wheels iron wheels</td>
<td>Checking of wear &amp; tear alignment &amp; its positioning</td>
<td>Six months</td>
<td>More frequently in the old installments</td>
</tr>
<tr>
<td>8.</td>
<td>M/S Sorapers</td>
<td>Tightening of nuts &amp; bolts, replacement of broken parts.</td>
<td>Year</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Turn table mechanism</td>
<td>Checking of its sprockets chains, steel balls, gear boxes etc.</td>
<td>Two years</td>
<td></td>
</tr>
</tbody>
</table>
### SCHEDULE OF PREVENTIVE MAINTENANCE

**Switchgears (Air or Oil Circuit Breakers)**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Name of section or part to be attended</th>
<th>Maintenance to be carried out</th>
<th>Frequency time internal at which inspection &amp; maintenance to be done</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Oil circuit breaker or Air circuit breaker</td>
<td>Checking, cleaning and tightening of nuts, bolts of fixed auxiliary contacts, moving auxiliary contacts, main fixed contacts, main moving contacts. No volt coil, overload coil, interlock system, condition of transformer oil, knife switches &amp; insulators, etc.</td>
<td>Six months</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Oil tank</td>
<td>Cleaning &amp; topping of oil &amp; checking dielectric strength of transformer oil.</td>
<td>Six months</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Contacts</td>
<td>Changing of old &amp; sluggish transformer oil of oil circuit breaker. Changing of old &amp; wearing out contacts (fixed moving auxiliaries)</td>
<td>Three years</td>
<td>Depending on the source of power supply &amp; its tripping etc.</td>
</tr>
</tbody>
</table>

### SCHEDULE OF LUBRICATION

<table>
<thead>
<tr>
<th>S. No</th>
<th>Name of machines to be lubricated</th>
<th>Grade of lubricants</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Bearing of motors, pumps</td>
<td>Mobilux grease No. 3</td>
<td>The manufacture recommendation also be carefully studied. In case of difference discussion may be held and proper lubricant decided upon.</td>
</tr>
<tr>
<td>2.</td>
<td>Oil bearings of motors, pump, Air compressors, lathes, Drilling machines, shaper, Milling machine</td>
<td>D.T.E. heavy medium oil</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Gear Boxes</td>
<td>Cylinder oil or as per manufacturers recommendation</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Turn table mechanizing</td>
<td>Tress oil 65</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Sluice valve, by pass valves pen stock etc.</td>
<td>Ordinary yellow grease or BRB-I</td>
<td>In no case too many grades of lubricating oils and grease by used Experience has provided that the chances of mixing up, increase and more damage is caused than good to the machines.</td>
</tr>
</tbody>
</table>
# APPENDIX-17

## CHECK CHART FOR CENTRIFUGAL – PUMP TROUBLES

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Possible causes</th>
<th>Key</th>
</tr>
</thead>
</table>
| Pump does not deliver liquid    | 1,2,3,4,6,11,14,16,17,22,23                                                    | 1. Pump not printed.  
2. Pump or suction pipe not completely filled with liquid. |
| Insufficient capacity delivered | 2,3,4,5,6,7,8,9,10,11,14,17,20,22,23,29,30,31                                | 3. Suction lift too high.  
4. Insufficient margin between suction pressure and vapour pressure. |
| Insufficient pressure developed | 5,14,16,17,20,22,29,30,31                                                      | 5. Excessive amount of air or gas in liquid.                         |
| Pump loses prime after starting | 2,3,5,6,7,8,11,12,13                                                           | 6. Air pocket in suction line.  
7. Air leaks into suction line.                                      |
| Pump requires excessive power   | 15,16,17,18,19,20,23,24,26,27,29,33,34                                      | 8. Air leaks into pump through stuffing boxes.  
| Stuffing box leaks excessively  | 13,24,26,32,33,34,35,36,38,39,40                                               | 10. Foot valve partially clogged.  
11. Intel of suction pipe insufficiently submerged.                     |
| Packing has short life          | 12,13,24,26,28,32,33,34,35,36,37,38,39,40                                     | 12. Water-seal pipe plugged.  
13. Seal cage improperly located in stuffing box, preventing sealing fluid from entering space to form the seal. |
| Pump vibrates or is noisy       | 2,3,4,9,10,11,21,23,24,25,26,27,28,30,35,36,41,42,43,44,45,46,47            | 14. Speed too low  
15. Speed too high  
16. Wrong direction of rotation.  
17. Total head of system higher than design head pump.  
18. Total head of system lower than pump design head.  
19. Specific gravity of liquid different from design.  
20. Viscosity of liquid differs from that for which designed.  
21. Operation at very low capacity.  
22. Parallel operations of pumps unsuitable for such operation. |
| Bearings have short life        | 24,25,26,27,28,35,36,41,42,43,44,45,46,47                                     |                                                                      |
| Bearings have short life        | 24,26,27,28,35,36,41,42,43,44,45,46,47                                     |                                                                      |
| Pump overheats and seizes       | 1,4,21,22,24,27,28,35,36,41                                                    | 14. Speed too low  
15. Speed too high  
16. Wrong direction of rotation.  
17. Total head of system higher than design head pump.  
18. Total head of system lower than pump design head.  
19. Specific gravity of liquid different from design.  
20. Viscosity of liquid differs from that for which designed.  
21. Operation at very low capacity.  
22. Parallel operations of pumps unsuitable for such operation. |
<table>
<thead>
<tr>
<th></th>
<th>Mechanical Troubles</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>Foreign matter in impeller.</td>
</tr>
<tr>
<td>24</td>
<td>Misalignment.</td>
</tr>
<tr>
<td>25</td>
<td>Foundation not rigid.</td>
</tr>
<tr>
<td>26</td>
<td>Shaft bent.</td>
</tr>
<tr>
<td>27</td>
<td>Rotating part rubbing on stationary part.</td>
</tr>
<tr>
<td>28</td>
<td>Bearing worn.</td>
</tr>
<tr>
<td>29</td>
<td>Wearing rings worn.</td>
</tr>
<tr>
<td>30</td>
<td>Impeller damaged.</td>
</tr>
<tr>
<td>31</td>
<td>Casing gasket defective, permitting internal leakage.</td>
</tr>
<tr>
<td>32</td>
<td>Shaft or shaft sleeves worn or scored at the packing.</td>
</tr>
<tr>
<td>33</td>
<td>Packing improperly installed.</td>
</tr>
<tr>
<td>34</td>
<td>Incorrect type of packing for operating conditions.</td>
</tr>
<tr>
<td>35</td>
<td>Shaft running off-centre because of worn bearings or misalignment.</td>
</tr>
<tr>
<td>36</td>
<td>Rotor out of balance, resulting in vibration.</td>
</tr>
<tr>
<td>37</td>
<td>Gland too tight, resulting in no flow of liquid to lubricate packing.</td>
</tr>
<tr>
<td>38</td>
<td>Failure to provide cooling liquid to water-cooled stuffing boxes.</td>
</tr>
<tr>
<td>39</td>
<td>Excessive clearance at bottom of stuffing box between shaft and casing, causing packing to be forced into pump interior.</td>
</tr>
<tr>
<td>40</td>
<td>Dirt or grit in sealing liquid leading to scoring of shaft or shaft interior.</td>
</tr>
<tr>
<td>41</td>
<td>Excessive thrust caused by a mechanical failure inside the pump or by the failure of the hydraulic balancing device, if any.</td>
</tr>
<tr>
<td>42</td>
<td>Excessive grease or oil in antifriction bearing housing or lack of cooling, causing excessive bearing temperature.</td>
</tr>
<tr>
<td>43</td>
<td>Lack of lubrication.</td>
</tr>
<tr>
<td>44</td>
<td>Improper installation of antifriction bearings (damage during assembly, incorrect assembly of stacked bearings, use of unmatched bearings as a pair, etc.).</td>
</tr>
<tr>
<td>45</td>
<td>Dirt getting into bearings.</td>
</tr>
<tr>
<td>46</td>
<td>Rusting of bearings due to water getting into housing.</td>
</tr>
<tr>
<td>47</td>
<td>Excessive cooling of water-cooled bearing, resulting in consideration in the bearing housing of moisture from the atmosphere.</td>
</tr>
</tbody>
</table>
CHECK CHART FOR ROTARY PUMPS: CAUSES OF TROUBLES AND SUGGESTED REMEDIES

I. Pumps falls to discharge:

A. Not Properly Primed:
   Reprime from discharge side. Keep air vents open until liquid begins to discharge.

B. Wrong Direction of Rotation:
   Reverse wiring at motor.

C. Speed Too Low, hence Displacement is less than Slip through Clearances:
   Check driver to see than it is upto rated speed. Change drive to increase speed, if necessary.

D. Valves closed or an Obstruction in Suction or Discharge Pipe:
   Open all valves. See that flange gaskets have the centre cut out and that there if no obstruction across end of suction pipe.

E. Strainer Clogged:
   Remove basket, clean and be sure it has ample area.

F. Suction-pipe End not submerged in Liquid:
   Increase length of suction pipe or raise liquid level in supply tank.

G. Foot Valve Stuck:
   Check to see that suction pipe has not been screwed into foot valve far enough to hold it closed.

H. Suction Lift Too High:
   Check with vacuum gauge. Suction lift should not be within 0.15 kg/cm² of vapour pressure of liquid at its pumping temperature.

J. By-Pass Open:
   Examine all by pass return lines for open valves. Close them, if open. A relief valve stuck open may by pass the entire pump capacity.

K. Air Leaks in Suction:
   Paint and tighten all suction-pipe gaskets and threaded joints. Tighten stuffing-box packing.
L. Check Valve in Discharge Backed up by Hydraulic Pressure:

Install an air-release valve between check valve and pump.

M. Pump Badly Worn:

Replace parts, so clearance will not cause slip equal to pump displacement.

II. Pumps is Noisy:

A. Insufficient Liquid Supply:

Increase suction-pipe size and reduce its length. Lower position of pump to prevent liquid from vaporizing and producing cavitation noises within pump.

B. Air Leaks in Suction:

Paint all pipe joints, replace faulty flange gaskets, repack stuffing box to stop cracking noise due to air bubbles in pump.

C. Pump Out of Alignment:

Align drive with pump. Release pipe flanges to determine if they strain pump casing enough to cause metallic contact between rotating elements and casing.

D. High Spots on Rotating Elements:

File or scrap high spots that cause rotating elements to bind and produce a noise synchronized with each revolution.

E. Bent Drive Shaft:

Replace shaft, as it causes rotating element to operate unevenly, with consequent noise.

F. Excessive Pressure:

Check Pressure. Install a relief valve.

G. Coupling Out of Balance or Alignment:

Align driver and pump. If coupling has floating sleeve or cover, misalignment often results in slapping sound.

III. Pump Wears Rapidly:

A. Grit or Dirt in Liquid:

Install fine-mesh strainer or filter in suction.

B. Pipe Strain strainer or filter in suction.
Release piping and align it in independent support before connecting to pump.

C. **Pump Operating against Excessive Pressures:**

Install relief valve to protect pump, or use a heavier duty pump.

D. **Corrosion Roughens Rubbing Surface:**

Order a pump made of metals that resist corrosive action.

E. **Pump Runs Dry:**

Provide ample supply of liquid at all times. Do not allow pump to operate under conditions where liquid supply may fail.

**IV  Pump Not up to Capacity:**

A. **Suction Lift Too High. Bubbles form Reducing Pump Capacity:**

Check with vacuum gauge. Suction lift should not be within 0.15kg/cm² of vapour pressure of liquid at its pumping temperature.

B. **Suction Strainer Partly Clogged or of Insufficient Area:**

Clean the screen. If all danger of foreign material has passed and screen has insufficient area, remove Pump.

C. **Suction Pipe End Insufficient Submerged, so that liquid Eddied and Allows Air to be Drawn into Pump:**

Increase suction-pipe length to obtain greater submergence.

D. **Suction Pipe Too Small, Too Long, or has Many Fittings to Increase Pipe Friction Abnormally and Cause Liquid to Vaporise:**

Simplify suction line to reduce pipe friction and increase its size.

E. **Stuffing Box Improperly Packed, so that Air is Drawn In:**

Repack box, tighten gland. Caution: Don’t tighten enough to cause excessive packing wear and heating.

D. **Air Leaks in Suction Piping:**

Paint all pipe joints. Replace gaskets where necessary.

G. **Speed Too Low:**

Check driver for speed and overload. Change drive speed ratio.

H. **Hand By-pass or Return Line Partly Open:**
Close all by-pass valves and see that they are sealed properly.

J. *Relief Valve Improperly Seated or Incorrectly set:*

Regrind valve on its seat. Be sure that valve does not open until desired pressure is reached.

K. *Pump Parts Worn:*

Replace parts and adjust clearness to eliminate excessive slip.

V. *Pumps Starts, then Loses its Suction:*

A. *Suction-line End Not Immersed Deeply Enough:*

Increase suction –pipe length so that liquid is not drawn down to near the end of pipe.

B. *Liquid Vaporizes in Suction Line:*

Reduce suction lift.

C. *Air or Gas Pockets in System:*

Reduce size of pockets in suction system, or provide a partly open by-pass to maintain pump prime.

D. *Air Leaks in Suction Lind:*

Check for air leakage into the pump suction.

VI. *Pump Takes Too Much Power:*

A. *Speed Too High, or Liquid Heavier or More Viscous than specified for Pump.*

Reduce speed or heat liquid to reduce its viscosity.

B. *Obstruction in Discharge Line Causes Pump to Operate above Rated Pressure:*

If new installation, recalculate what the head should be. Don’t forget to include head due to friction losses in pipe and fittings. Check this head against rated pump head. With pressure gauge, check head developed by pump. An obstruction or partly closed valve in discharge line may increase head above normal. If head cannot be reduced to give safe load on motor, reduce pump speed or install larger motor.

C. *Stuffing-box Packing Too Tight:*

Check packing. If too tight, make necessary adjustments or replace packing with correct type, properly installed.
D. **Shaft Bent or Out of Alignment:**

Check shaft, pump and motor alignment. If shaft is bent, straighten it or install new one. Properly align pump and motor.

E. **Rotating Element Binds and Wears Excessively:**

Pipe connection out of line distorts pump casing. Disconnect suction and discharge piping from pump to see if they are in alignment. Flange faces should be parallel and align axially without being forced. Support pipe separate from pump. Check fit of rotating parts to make sure they do not bind or have not worked endwise on shaft to rub casing.
ANNEXURE- H (Refer clause 6.4.3)
SPECIFICATION OF SUBMERSIBLE PUMPING SET

The submersible pumping set should conform to I.S. 8034-1989 with latest amendment. The pump should be fitted dynamically balance enclosed type impeller. Each impeller shall be balanced dynamically to grade of G 6.3 (6.3mm/s). The pump shaft shall be guided by bearing provided in each stage bowl & in the suction land discharge casing. The surface finish of shaft or of the protecting sleeves should be 0.75 micron Ra Max. The inlet passage of the suction casing shall be streamlined to avoid eddies. The suction case shall be fitted with a strainer of corrosion resistant material. Suitable sand guard shall be provided just above the suction case bearing to prevent the entry of foreign material into suction case. The pump should be provided with the non return valve above the pump discharge case with standard flanged connection. The individual casting part or pump as a whole in assembled condition should be able to withstand a hydrostatic pressure of 1.5 time maximum discharge pressure. The gaskets & seals used shall conform to I.S. 5120-1968 or latest. The cable clamp of adequate size be supplied for fixing submersible cables to the rising main pipes.

The pump shall be directly coupled to a submersible motor. The submersible motor shall be squirrel cage induction motor conforming to I.S. 9283-1979 or latest capable of operating on 415± 6% volts, 3 phase 50 cycles, A.C. supply. Both pump and motor shall run at 2900 R.P.M. The water lubricated thrust bearing should be of adequate size to withstand the weight of all rotating parts as well as the imposed hydraulic thrust. The motor shall be protected by means of cable glands, rubber seals etc. from ingress of bore well water, sand and other foreign material. The motor shall be provided with breathing attachment like bellows, diaphragm etc. to compensate the volumetric variation due to change in the temperature. The motor shall be made of corrosion resisting material or suitable materials to resist corrosion under normal conditions. The rotor shall be provided with shaft protecting sleeves having a surface finish of 0.75 micron Ra Max. The starter shall be star delta. The class of insulation shall be F. The submersible cable of L&T & finolex make for submersible motor shall conform to I.S. 694 (Part-III)-1964 or latest. The flanged column pipe shall conform Table 2 I.S. 1239 ( Part-I) - 1979 or latest (Medium Class) Table-2.

The efficiency of submersible pump shall be guaranteed to specified point of rating only & shall not be guaranteed to cover the performance of the pump under condition varying there form nor for a sustained performance for any period of time. The pump discharge may be guaranteed for the range of head between – 25% & + 10% of the specified head when the later is 30 meters of above. Below 30 meters the limits shall be from – 25% to 25% or + 3 meters whichever is less. The H.P. of motor shall be such that is shall be 15% in the excess of maximum H.P. required under all heads of working. Performance guarantees shall be based on laboratory tests corrected for field performance.
### MATERIAL OF COMPOSITION OF DIFFERENT COMPONENTS OF PUMP:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Component</th>
<th>Material</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Bearing Sleeve (As per IS: 8034-1989)</td>
<td>Stainless Steel or Bronze</td>
<td>12% Chromium Steel Grade 04 Cr 13, 12 Cr or 20 Cr 13 of ISI 1570 (Part-5) 1985 or latest or Bronze Grade LTB3, 4 or 5 of I.S. 318-1981 or latest.</td>
</tr>
<tr>
<td>2.</td>
<td>Casing wear ring</td>
<td>Bronze</td>
<td>LTB 3, or 4 of I.S. 5 318-1981 or latest.</td>
</tr>
<tr>
<td>5.</td>
<td>Discharge casing</td>
<td>Cast iron</td>
<td>Grade FG200 of IS 210 of IS 1978 or latest.</td>
</tr>
<tr>
<td>6.</td>
<td>Pump bowl/diffuser</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>7.</td>
<td>Suction casing</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>8.</td>
<td>Pump shaft</td>
<td>Stainless steel</td>
<td>04 Cr 13, 12 Cr 13 or 20 Cr 13 or IS 1570 (Part-5) 1985 or latest</td>
</tr>
</tbody>
</table>

### Pumps should be of following make or equivalent:

1. CALAMA or equivalent
2. KSB or equivalent
3. SU or equivalent
4. WPIL or equivalent
5. SEEREX or equivalent

Note: Glass filled Polyphenylene Oxide (Modified PPO)
INFORMATION TO BE FURNISHED WITH THE TENDER (As per IS: 8034-1989)

DETAIL OF PUMP

CODE DESIGNATION PUMP

1. METHOD OF LUBRICATION:
2. MINIMUM BORE WELL DIAMETER IN MM:
3. NUMBER OF STAGES
4. OUTSIDE DIAMETER OF BOWL

(The max. diameter pump fitted non return valve & max. overall diameter of the pump set including the cable guard)

5. DISCHARGE IN LPM
6. TOTAL HEAD MTR
7. SPEED IN RPM
8. PUMP INPUT AT DUTY POINT IN K.W.
9. OVER ALL EFFICIENCY IN %
10. MINIMUM SUBMERGENCE REQUIRED

DETAILS OF MOTOR

1. RATING IN K.W.
2. TYPE
   (in accordance with I.S. 9283-1979)

3. DETAILS OF POWER SUPPLY
4. RATED SPEED

ADDITIONAL INFORMATION

INSTRUCTIONS FOR INSTALLATION & MAINTENANCE WEIGHT OF PUMP, MOTOR & CABLE & RISING MAIN PIPE FOR A SPECIFIC SETTING
SPECIFICATION OF CONTROL PANEL FOR SUBMERSIBLE PUMPING SET

Panel board having size 900mm x 250 mm made of not less than 2 mm prestressed cold rolled sheet & auto claved painted. The board should comprise of rigid welded structural frames made of structural steel sections of not less than 3 mm thickness. The board should be smoothly finished & free from flaws. The panel board should have the following flush mounted instruments. It should have space for providing power meter & light meter.

6. M.C. B:- Standard, MDS, Havell, GE. or equivalent (upto 10 H.P.)

7. M.C.C.B:- L&T, Crompton, G.E. Havell or equivalent (Above 10 H.P.)

8. E.L.C.B.: L&T Havell, MDS, G.E or equivalent

9. Switch Fuse Unit:- L&T Simens, G.E or equivalent

10. Contractors, Relays & Timers : L&T Simens, G.E or equivalent

11. Single Phase Preventor : L&T Minillec or equivalent

12. Ammeter & Voltmeter : AE, Meco, L&T or equivalent

13. CT for ammeter; AE, EE, GE or equivalent

14. Selector switch for ammeter & Voltmeter : L&T Kaycee or equivalent

15. Capacitor : ISI marked or approved by P.S.E.B.

16. Indicating Lamps (22.5 mm dia):- Led Type

17. H.R.C. Fuses: Havell, L&T Siemens, G.E. Havell or equivalent

Fuse Bases:- -do-
18. Wires:- Plaza, Kent, Finolex or equivalent

19. THIMBLES: DOWELL, JAINSONS, Urmiltron or equivalent

**TESTS:** The following tests should be performed on the panel board during the inspection at the manufacturer place.

1. General Visual Test.
2. High voltage test upto 2 KV
3. No load operational test by energizing the panel.

**NOTE:**

1. Upto 7.5 H.P. D.O.L. Starter will be installed. Above 7.5 H.P. Star Delta Starter will be installed.
2. THE FOLLOWING FAMILY CURVE ALONGWITH THE CHARACTERISTICS CURVES SIGNED BY THE MANUFACTURER (not below the rank of REGIONAL MANAGER OF REGIONAL INCHARGE) be attached with the tender. Photo copy of the same will not be accepted.

D. HEAD V/S DISCHARGE CURVE.
E. DISCHARGE V/S POWER INPUT CURVE.
F. DISCHARGE V/S OVERALL EFFICIENCY CURVE.

3. PERFORMA NO. 1 PRICE FOR THE SUBMERSIBLE PUMPING SET, CONTROL PANEL, COLUMN PIPE & CABLE SHOULD BE QUOTED SEPERATELY
4. PERFORMA NO. 2 ONLY THE PRICE OF SUBMERSIBLE PUMPING SET WITHOUT CONTROL PANEL IS TO BE QUOTED.
5. The inspection of the pump will be carried out at the manufacturers premises by the two representative of the Department.
6. The firm should supply the following information for all the pumping set.

<table>
<thead>
<tr>
<th>DISCRITION</th>
<th>1. NET EFFECTIVE HEAD</th>
<th>2. GROSS EFFECTIVE HEAD INCLUDING LOSSES IN PUMPING SET</th>
<th>3. DISCHARGE 4. EFF. OF PUMP</th>
<th>5. COMBINED EFF. OF PUMP &amp; MOTOR</th>
<th>6. BHP REQUIRED</th>
<th>7. BHP COL. 6+15</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUTY POINT</td>
<td>25% OF D.P.</td>
<td>+ 10% OF D.P</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ANNEXURE-I (Refer clause 2.5.1.1 & 2.2.6)
WATER SAMPLE QUALITY TESTING AND SAMPLE COLLECTION PERFORMA

PARTICULARS TO BE SUPPLIED WITH THE WATER SAMPLES

A
1. Name and address of person requesting the examination.
2. Date and time of collection and dispatch.
3. Purpose of examination.
4. Source of water and its location (well, tubewell, stream, river, etc.).
5. Exact place and depth below surface, from which sample was taken.
6. Weather at the time of collection and particulars of recent rainfall, if any.
7. Does the water become affected in taste or odour after rainfall or under any particular circumstances.
8. Are there any complaints from the consumers. If so, the nature of the complaint.
9. Character of surroundings and proximity to drains, cess pools, cattle sheds, manure heaps, grave yard, bathing ghats and other sources of pollution.
10. Methods of purification and disinfection if any, details, dose of chemicals and points of application.

B
11. If from a dug well or a bore well.
   (a) Whether an old source or newly constructed.
   (b) Whether open or covered: nature and material of cover.
   (c) Nature of steining or casing and depth to which constructed and whether it is in good condition.
   (d) Height and condition of parapet and apron.
   (e) Method of pumping or other means of raising water.
   (f) Depth of well and of water surface from ground level.
   (g) Whether the water is clear as it flows out of tube well and remains clear if exposed to air (4-6 hours) or becomes discoloured and turbid.
12. If from a river or stream.
   (a) Nature of flow and whether floods are common or rate.
   (b) Whether level of water is above or below normal.
   (c) Is there any bathing ghat, boat jetty, burial ground and sewer outfall? If upstream, give distance from sampling point.
13. If from lakes, impounded reservoirs and tanks.
   (a) How supplied (channel, stream, rain).
(b) Nature of catchment, whether conserved or not.

(c) Nature and extent of weed growth.

14. Size and number of service reservoirs.
   (a) Whether open or covered.
   (b) How often cleaned and method of cleaning.
   (c) Date of last cleaning.

15. Number of hydrants and sewers on the distribution system.

1. Hours of pumping and supply.

17. Population served.

18. Any other particulars.

**Station**

**Date**

Signature and name in block letters of the person collecting and forwarding the samples.
SPECIMEN FORM FOR SHORT PHYSICAL AND CHEMICAL EXAMINATION

Name and Address of the Laboratory:
Name and Address of Sender  Sender’s No.  Date of Collection………………

Date & time of receipt at Lab……
Lab. Ref. No.  Date & time of commencing of examination

1. Raw water
2. Coagulated water
3. Filtered water
4. Water after specific treatment
5. Distribution system

-------------------------------------------------------------------------------------------------------------

1. 2. 3. 4. 5.

Time of Collections

**PHYSICAL**  **Expressed as**

1. Temperature  °C
2. Turbidity  JTU
3. Colour  Units of Pt.Co. scale
4. Taste and Odour  Qualitative

**Chemical**
5. pH
6. Conductivity  micromhos/cm
7. Free CO₂  (mg/1) CO₂
8. Alkalinity  (mg/1) CaCO₃
9. Chlorides  (mg/1) C₁
10. Nitrites  (Qualitative)
11. Dissolved oxygen  (mg/1)O
12. Hardness  (mg/1) CaCO₃
   (a) Carbonate
   (b) Non-carbonate
   (c) Total
13. Iron  (mg/1)Fe
14. Fluorides  (mg/1)F
15. Residual Chlorine  (mg/1) C₁
16. Alumina in Alum  (% A₁₂O₃
17. Available chlorine  (% C₁
   in Bleaching Powder
18. Coagulant Dose Jar Test  (mg/1)
19. Chlorine Demand  (mg/1) C₁

Remarks :

Date

Officer-in charge
SPECIMAN FOR COMPLETE PHYSICAL, CHEMICAL AND BILOGICAL EXAMINATION

Name and address of the Laboratory:  
Name and Address of Sender:  
Sender’s No.:  
Date of Collection:  
Lab. Ref. No.:  
Date & time of commencing of examination:  
Date & time of receipt at Lab:  

<table>
<thead>
<tr>
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<td></td>
</tr>
</tbody>
</table>

Time of Collections

**PHYSICAL**

1. Temperature  
   Expressed as: °C
2. Turbidity  
   Expressed as: JTU
3. Colour  
   Expressed as: Units of Pt.Co. scale
4. Taste and Odour  
   Expressed as: Qualitative

**Chemical**

5. pH
6. Conductivity  
   Expressed as: micromhos/cm
7. Free CO₂  
   Expressed as: (mg/1) CO₂
8. Alkalinity  
   (a) Pheno-phthalen  
   (b) Total
   Expressed as: (mg/1) CaCO₃
9. Chlorides  
   Expressed as: (mg/1) Cl
10. Ammonia  
    (a) Free and Saline  
    (b) Albuminoid
    Expressed as: (mg/1) N
11. Nitrites  
    Expressed as: (mg/1) N
12. Nitrites  
    Expressed as: (mg/1) N
13. Dissolved oxygen  
    Expressed as: (mg/1) O
14. Oxygen absorbed at 27 °C  
    Expressed as: (mg/1) O
    (a) 3 minutes  
    (b) 4 hours
    B.O.D.  
    Expressed as: (mg/1) O
    B.O.D.  
    Expressed as: (mg/1) O
    Hardness  
    (a) Carbonate  
    (b) Non-carbonate  
    (c) Total
15. Iron  
    Expressed as: (mg/1) Fe
16. Manganese  
    Expressed as: (mg/1) Mn
17. Fluorides  
    Expressed as: (mg/1) F
18. Calcium  
    Expressed as: (mg/1) Cl

206
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td>(mg/l) Mg</td>
</tr>
<tr>
<td>Residual Chlorine</td>
<td>(mg/l) Cl</td>
</tr>
<tr>
<td>Sulphates</td>
<td>(mg/l) SO₄</td>
</tr>
<tr>
<td>Total Solids</td>
<td></td>
</tr>
<tr>
<td>(a) Dissolved</td>
<td></td>
</tr>
<tr>
<td>(b) Suspended</td>
<td></td>
</tr>
<tr>
<td>(c) Volatile</td>
<td></td>
</tr>
<tr>
<td>Alumina in Alum</td>
<td>(%) Al₂O₃</td>
</tr>
<tr>
<td>Available chloride in Bleach Powder</td>
<td>(%) Cl</td>
</tr>
<tr>
<td>Coagulant Dose-Jar Test</td>
<td>(mg/l)</td>
</tr>
<tr>
<td>Langelier Index</td>
<td></td>
</tr>
<tr>
<td>Chlorine Demand</td>
<td>(mg/l) Cl</td>
</tr>
<tr>
<td>Total Silica</td>
<td>(mg/l) SiO₂</td>
</tr>
<tr>
<td>Penolic Compounds</td>
<td>(mg/l) Phenol</td>
</tr>
<tr>
<td>Synthetic Detergents</td>
<td>(mg/l)/MBAS</td>
</tr>
<tr>
<td>Sulphide</td>
<td>(mg/l) S</td>
</tr>
<tr>
<td>Arsenic</td>
<td>(mg/l) As</td>
</tr>
<tr>
<td>Cadmium</td>
<td>(mg/l) Cd</td>
</tr>
<tr>
<td>Hexavalent Chromium</td>
<td>(mg/l) Cr</td>
</tr>
<tr>
<td>Copper</td>
<td>(mg/l) Cu</td>
</tr>
<tr>
<td>Cyanide</td>
<td>(mg/l) CN</td>
</tr>
<tr>
<td>Lead</td>
<td>(mg/l) Pb</td>
</tr>
<tr>
<td>Selenium</td>
<td>(mg/l) Zn</td>
</tr>
<tr>
<td>Zinc</td>
<td>(mg/l) Zn</td>
</tr>
<tr>
<td>Mercury</td>
<td>(mg/l) Hg</td>
</tr>
<tr>
<td>Oil and grease</td>
<td>(mg/l)</td>
</tr>
<tr>
<td>Polynuclear Aromatic</td>
<td>(mg/l) PAH</td>
</tr>
<tr>
<td>Hydrocarbon</td>
<td></td>
</tr>
<tr>
<td>Radio activity</td>
<td>(pci/l)</td>
</tr>
<tr>
<td>(a) Grossalpha Activity</td>
<td></td>
</tr>
<tr>
<td>(b) Gross Beta Activity</td>
<td></td>
</tr>
</tbody>
</table>

**BIOLOGICAL**

<table>
<thead>
<tr>
<th>Parameter</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total count of Plankton</td>
<td></td>
</tr>
<tr>
<td>Total count of SAU Organisms/ml</td>
<td></td>
</tr>
</tbody>
</table>

**SPECIMAN FORM FOR SHORT BACKTERIOLOGICAL EXAMINATION OF WATER**

Name and address of Laboratory:

Name and Address of Sender: Sender’s No. Date of Collection………………

Date & time of receipt at Lab……..

Lab. Ref. No. Date & time of commencing of examination

1. Raw water
2. Filtered water

207
<table>
<thead>
<tr>
<th>Time of Collections</th>
<th>Expressed as</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plate count</td>
<td>Colonies/ml</td>
</tr>
<tr>
<td></td>
<td>(a) 20 °C</td>
</tr>
<tr>
<td></td>
<td>(b) 35 °C</td>
</tr>
<tr>
<td>2. Coliform Organisms</td>
<td>MPN/100 ml</td>
</tr>
</tbody>
</table>

Remarks: Office-in-charge
**SPECIMAN FORM FOR SHORT BACTERIOLOGICAL EXAMINATION OF WATER**

Name and address of Laboratory:

Name and Address of Sender  
Sender’s No.  
Date of Collection

Date & time of receipt at Lab.

Lab. Ref. No.  
Date & time of commencing of examination

1. Raw water
2. Filtered water
3. Chlorinated Water
4. Distribution system

<table>
<thead>
<tr>
<th>Time of Collections</th>
<th>Expressed as</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plate count</td>
<td>Colonies/ml</td>
</tr>
<tr>
<td>(a) 20 °C</td>
<td></td>
</tr>
<tr>
<td>(b) 35 °C</td>
<td></td>
</tr>
<tr>
<td>2. Coliform Organisms</td>
<td>MPN/100 ml</td>
</tr>
<tr>
<td>3. E. Coli</td>
<td>MPN/100 ml</td>
</tr>
<tr>
<td>4. Completed Test</td>
<td></td>
</tr>
<tr>
<td>5. Differential Test</td>
<td>(IMVic)</td>
</tr>
</tbody>
</table>

Date:  
Office-in-charge
**ANNEXURE J (Refer clause 2.5.1.1, and 2.1.2.1)**

**PHYSICAL AND CHEMICAL PARAMETERS (as per IS: 10500-2012 (Second Revision))**

*(These standards are subject to change or revisions by Bureau Of Indian Standards from Time to time)*

<table>
<thead>
<tr>
<th>Sr no</th>
<th>Characteristics</th>
<th>Acceptable</th>
<th><strong>Cause for Rejection</strong></th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Turbidity (NTU)</td>
<td>1</td>
<td>5</td>
<td>Consumer acceptance decreases</td>
</tr>
<tr>
<td>2.</td>
<td>Colour (Units on Platinum cobalt scale Hazen Unit)</td>
<td>5</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Taste and Odour</td>
<td>Un objectionable</td>
<td>Un objectionable</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>PH</td>
<td>6.5-8.5</td>
<td>6.5 -8.5</td>
<td>Water will affect the mucous membrane &amp;/water supply system</td>
</tr>
<tr>
<td>5.</td>
<td>Total dissolved solids (mg/lt)</td>
<td>500</td>
<td>2000</td>
<td>Consumer acceptance decreases. Laxative effect upon people who are not accustomed to it. May cause gastro-intestinal irritation.</td>
</tr>
<tr>
<td>6.</td>
<td>Total hardness (as CaCO3) (mg/lt)</td>
<td>200</td>
<td>600</td>
<td>Engrustation in water supply structure and adverse effects on domestic use/scale formation</td>
</tr>
<tr>
<td>7.</td>
<td>Chlorides (as Cl I) (mg / l)</td>
<td>250</td>
<td>1000</td>
<td>Taste, palatability and adverse effects on domestic use/are affected</td>
</tr>
<tr>
<td>8.</td>
<td>Sulphates (as SO4) (mg/lt)</td>
<td>200</td>
<td>400</td>
<td>Causes Gastro intestinal irritation</td>
</tr>
<tr>
<td>9.</td>
<td>Flourides (as F) (mg/lt)</td>
<td>1.0</td>
<td>1.5</td>
<td>Results in dental/skeletal fluorosis</td>
</tr>
<tr>
<td>10.</td>
<td>Nitrates (as NO3) (mg/lt)</td>
<td>45</td>
<td>45</td>
<td>May cause Methaemoglobineamia / blue baby disease</td>
</tr>
<tr>
<td>11.</td>
<td>Calcium (as Ca) (mg/lt)</td>
<td>75</td>
<td>200</td>
<td>Engrustation in water supply structure and adverse effects on domestic use</td>
</tr>
<tr>
<td>12.</td>
<td>Magnesium (as Mg) (mg/lt)</td>
<td>&lt;30*</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*If there are 250 mg/l of sulphates Mg content can be increased to a maximum of 125mg/l with the reduction of Sulphates @ 1 unit per every 2.5 units of Sulphates</td>
</tr>
<tr>
<td>13.</td>
<td>Iron (as Fe) mg/lt)</td>
<td>0.3</td>
<td>0.3</td>
<td>Taste &amp; appearance are affected and promotes iron bacteria &amp; adverse effect on domestic use and water strips.</td>
</tr>
<tr>
<td>14.</td>
<td>Alkalinity (mg/lt)</td>
<td>200</td>
<td>600</td>
<td>Water will affect the mucous membrane &amp;/water supply system, taste becomes unpleasant.</td>
</tr>
<tr>
<td>15.</td>
<td>Manganese as Mn mg/l</td>
<td>0.05</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>Copper as Cu mg/l</td>
<td>0.05</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>Zinc as Zn mg/l</td>
<td>5.0</td>
<td>15.0</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Phenolic Compounds as Phenol mg/l</td>
<td>0.001</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>Anionic detergents as MBAS mg/l</td>
<td>0.2</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>20.</td>
<td>Mineral Oil mg/l</td>
<td>0.01</td>
<td>0.3</td>
<td></td>
</tr>
</tbody>
</table>
## Toxic Materials

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>22.</td>
<td>Arsenic (as As) (mg/lt)</td>
<td>0.01</td>
</tr>
<tr>
<td>23.</td>
<td>Pesicides (total, mg/lt)</td>
<td>Absent</td>
</tr>
<tr>
<td>24.</td>
<td>Cadmium as Cd mg/l</td>
<td>0.003</td>
</tr>
<tr>
<td>25.</td>
<td>Chromium as Hexavalent Chrome Cr^6 mg/l</td>
<td>0.05</td>
</tr>
<tr>
<td>26.</td>
<td>Cyanide as CN mg/l</td>
<td>0.05</td>
</tr>
<tr>
<td>27.</td>
<td>Lead as Pb mg/l</td>
<td>0.01</td>
</tr>
<tr>
<td>28.</td>
<td>Selenium as Se mg/l</td>
<td>0.01</td>
</tr>
<tr>
<td>29.</td>
<td>Mercury total as Hg mg/l</td>
<td>0.001</td>
</tr>
<tr>
<td>30.</td>
<td>Polynuclear aromatic Hydrocarbons (PAH)</td>
<td>0.2 micro g/l</td>
</tr>
</tbody>
</table>

### RADIO ACTIVITY

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>32.</td>
<td>Gross Alpha Activity</td>
<td>3 pCi/l</td>
</tr>
<tr>
<td>33.</td>
<td>Gross Beta Activity</td>
<td>30 pCi/l</td>
</tr>
</tbody>
</table>

### Residual free chlorine (mg/lt)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>35.</td>
<td>0.2</td>
</tr>
</tbody>
</table>

To be applicable only when water is chlorinated. Tested at consumer end. When protection against viral infection is required, it should be min. 0.5 mg/lt

### Bacteria (MPN/100ml)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>36.</td>
<td>0</td>
</tr>
</tbody>
</table>

Results in diarrhoea, decently, typhoid etc

---

**Notes:**

* The figures indicated under the column “Acceptable” are the limits upto which water is generally acceptable to the consumers.

** Figures in excess of those mentioned under ‘Acceptable’ render the water not acceptable, but still may be tolerated in the absence of an alternative and better source but upto the limits indicated under column “Cause for Rejection” above which the sources will have to be rejected.
**BACTERIOLOGICAL QUALITY OF DRINKING WATER**

<table>
<thead>
<tr>
<th>Organisms</th>
<th>Guideline Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All water intended for drinking</strong></td>
<td></td>
</tr>
<tr>
<td>E.coli or thermotolerant coliform bacteria</td>
<td>Must not be detectable in any 100-ml sample. A sample of the water entering the distribution system that does not conform to this standard calls for an immediate investigation in to both efficacy of the purification process and method of sampling</td>
</tr>
<tr>
<td>Total coliform bacteria</td>
<td></td>
</tr>
<tr>
<td><strong>Treated water entering the distribution system</strong></td>
<td></td>
</tr>
<tr>
<td>E.coli or thermotolerant coliform bacteria</td>
<td>Must not be detectable in any 100-ml sample. Must not be detectable in any 100-ml sample.</td>
</tr>
<tr>
<td>Total coliform bacteria</td>
<td>Must not be detectable in any 100-ml sample. Must not be detectable in any 100-ml sample.</td>
</tr>
<tr>
<td>Coliform Organism</td>
<td>Not more than 10 per 100 ml sample Coliform organism should not be detectable in 100 ml of any two consecutive samples or more than 5% of the samples collected for the year</td>
</tr>
<tr>
<td><strong>Treated water in the distribution system</strong></td>
<td></td>
</tr>
<tr>
<td>E.coli or thermotolerant coliform bacteria</td>
<td>Must not be detectable in any 100-ml sample Must not be detectable in any 100-ml sample.</td>
</tr>
<tr>
<td>Total coliform bacteria</td>
<td>Must not be detectable in any 100-ml sample. In case of large supplies, where sufficient samples are examined, must not be present in 95 % of samples taken throughout any 12 month period.</td>
</tr>
<tr>
<td><strong>Virological Aspects</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.5mg/l of free chlorine residual for one hour is sufficient to inactivate virus even in water that was original polluted. This free Chlorine residual is to be insisted in all disinfected supplies in areas suspected of endemicity of infestations hepatitis to take care of the safety from the bacteriological pint of view as well. For other areas 0.2mg/l of free residual for half an hour should be insisted</td>
</tr>
</tbody>
</table>

a. Immediate investigative action must be taken if either *E.coli* or total coliform bacteria are detected. The minimum action in the case of total coliform bacteria is repeat sampling; if these bacteria are detected in the repeat sample, the cause must be determined by immediate further investigation.

b. Although *E.Coli* is the more precise indicator of faccal pollution, the count of thermotolerant coliform bacteria is an acceptable alternative. If necessary, proper confirmatory test must be carried out. Total coliform
bacteria are not acceptable indicators of the sanitary quality of rural water supplies, particularly in tropical areas where many bacteria of no sanitary significance occur in almost all untreated supplies.
ANNEXURE-K (Refer Chapter 3.1)
POPULATION FORECAST EXAMPLE FOR CALCULATING

Data assumed

<table>
<thead>
<tr>
<th>Census Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>343</td>
</tr>
<tr>
<td>1971</td>
<td>589</td>
</tr>
<tr>
<td>1981</td>
<td>686</td>
</tr>
<tr>
<td>1991</td>
<td>1087</td>
</tr>
</tbody>
</table>

Using various methods the population for the design period is estimated and the realistic value of population is selected for the design of the scheme.

1. **INCREMENTAL INCREASE METHOD**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Year of Census</th>
<th>Population</th>
<th>Increase/ Decade</th>
<th>% Increase in population</th>
<th>Incremental Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1961</td>
<td>343</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>1971</td>
<td>589</td>
<td>246</td>
<td>71.72</td>
<td>149</td>
</tr>
<tr>
<td>3</td>
<td>1981</td>
<td>686</td>
<td>97</td>
<td>16.46</td>
<td>-149</td>
</tr>
<tr>
<td>4</td>
<td>1991</td>
<td>1087</td>
<td>401</td>
<td>58.45</td>
<td>+304</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>744</td>
<td>146.63</td>
<td>155</td>
</tr>
</tbody>
</table>

Average population increase/decade = \( X = \frac{\text{Total Increase}}{\text{No. of decades}} \) = \( \frac{744}{3} = 248 \)

Net Incremental Increase = \( Y = 155 \)

Average Incremental Increase = \( Z = \frac{Y}{2} = \frac{155}{2} = 77.5 \)

Population forecast for 2001 = \( P_{1991} + (X + Z) \times n \)

| Population in 2001 = 1087 + (248 + 77.5) \times 1 = 1412.5 |
| Population in 2011 = 1087 + (248 + 77.5) \times 2 = 1738.0 |
| Population in 2021 = 1087 + (248 + 77.5) \times 3 = 2063.5 |

II. **ARITHMETIC INCREASE METHOD:**

Average population increase/decade = \( X = \frac{\text{Total Increase}}{\text{No. of decades}} \) = \( \frac{744}{3} = 248 \)

Population forecast for 2001 = \( P_{1991} + (X) \times n \)

| Population in 2001 = 1087 + 248 \times 1 = 1335 |
| Population in 2011 = 1087 + 248 \times 2 = 1583 |
| Population in 2021 = 1087 + 248 \times 3 = 1831 |

III. **GEOMETRICAL INCREASE METHOD**

Total % increase in

Average percentage increase in population = \( M = \frac{\text{Population}}{\text{No. of decades}} \)

\( = (71.72 + 16.46 + 58.45) = 146.63/3 = 48.87 \)

Population forecast for 2001 = \( P_{1991} + (1+M/100) \times n \)
Where \( n \) = No. of decades

Population in 2001 \( = 1087 \times (1 + \frac{48.87}{100})^1 = 1616.36 \)

Population in 2011 \( = 1087 \times (1 + \frac{48.87}{100})^2 = 2403.54 \)

Population in 2021 \( = 1087 \times (1 + \frac{48.87}{100})^3 = 3574.06 \)

Population forecast can be calculated by using a software also. The results obtained from software is appended and is in agreement with hand calculation.

Final Prediction:

The geometric progression gives too a high a value hence cannot be considered in the present case. It gives a value more than 2% annual growth. Considering 2% average national growth per year; the population in 2021 will be 1880. Hence, arithmetical increase method gives the nearest value. However, as there is a drastic change in population from 1981 to 1991 by nearly 100% in this particular case. Rural population growth during the decade 2001-2011 is 0.798%.

The design of rural water supply and sanitation schemes shall be based on actual existing population with realistic projection for the project using the methods described above. However, the per year growth rate must be taken @ 0.798% per annum based on census 2011.
ANNEXURE-L (Clause 6.7.1 & 10.7)

Environmental Data Sheet for Water Supply and Sewerage Schemes for DSR Stage

| Format for Environmental Data Collection for Water Supply and Sewerage Schemes |
|---------------------------------|---------------------------------|

1. GENERAL

1.1. Name of Village/Habitation: 
1.2. Gram Panchayat: 
1.3. Block: 
1.4. District: 
1.5. Zone (North/Central/South): 

2. BASELINE ENVIRONMENT

2.1. Topography (Plain/Rolling/Hilly)

2.2. Type of Soil: 
- Alluvial
- Silt
- Silty Clay
- Sandy
- Sandy Clay
- other

2.3. Intensity of Rainfall: 
- Low
- Moderate
- High

2.4. Temperature: 
Min: °C  
Max: °C

2.5. Natural Slope of the Land

2.6. Predominant wind Direction

2.7. Water Table (Depth Below Ground Level): 
- Shallow (0-5m)
- Moderate (5-10m)
- Deep aquifer (10-20m)
- Very Deep (below 20m)

2.8. Existing water body within village: 
- River
- Canal
- Pond/Lake
- Other (Specify)

2.8.1. If pond, current use of it. (Please give the numbers of ponds): 
- Drinking
- Cattle washing
- Irrigation
- Sewage disposal
- Others

2.9. Water logging problem within village/villages: (Yes/No) 
if yes, 
- a. Name of area/areas: 
- b. Area under water logging: 
- c. Period of water logging (Annually): 
- d. Population affected by water logging: 
- e. Contamination of Drinking water sources from

2.10. Minimum and Maximum width of village roads (meters)

2.11. Existing Roads in the village are metallic/un-metallic/Brick Paved

2.12. Current Solid Waste Disposal System: 
- Combined Dust bin
- Door to door collection
- Drains
- In Streets

2.13. Local Vegetation: (Mention Species)
### Format for Environmental Data Collection for Water Supply and Sewerage Schemes

#### 3. SOCIAL ENVIRONMENT

<table>
<thead>
<tr>
<th>3.1. Population</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2. Number of households</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3. Land use pattern of village</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4. Historical/ Religious Importance</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3.5. Major Source of Income</td>
<td>Agriculture</td>
<td>Business</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>Others</td>
</tr>
<tr>
<td>3.6. Is the proposed project likely to affect any natural habitats/cultural properties?</td>
<td>Yes / No</td>
<td></td>
</tr>
<tr>
<td>3.6.1. If yes, whether appropriate safeguards are proposed? (Write note)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7. Is the proposed project likely to infringe on the rights of the local people, including traditional land water rights?</td>
<td>Yes / No</td>
<td></td>
</tr>
<tr>
<td>3.7.1. If yes, whether appropriate mitigation measures have been proposed? (Write Note)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 4. PUBLIC HEALTH ISSUES

| 4.1. Any incident of Waterborne epidemic/ disease in the recent past | Yes | No |
| 4.1.1. If Yes: Name of disease (Waterborne) | Diarrhea | Gastro entities |
|  | Typhoid | Others |
| 4.2. Is there any vector borne disease | Yes | No |
| 4.2.1. Name of Vector borne disease | Malaria | Dengue | Filaria |

#### 5. WATER SUPPLY SCHEME

<table>
<thead>
<tr>
<th>5.1. Type of Scheme</th>
<th>Existing/New Scheme</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.1. Whether the proposed water supply scheme is</td>
<td>Single Village Scheme</td>
<td>Multi Village Scheme</td>
</tr>
<tr>
<td>5.1.2. If new water Supply scheme is proposed, briefly give data on the current drinking water situation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.3. Source of drinking water supply:</td>
<td>River</td>
<td>Lake</td>
</tr>
<tr>
<td></td>
<td>Canal</td>
<td>Pond</td>
</tr>
<tr>
<td>5.1.4. Water availability in lpcd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1.5. Availability of Land for Intake/WTP site</td>
<td>Panchayati Land</td>
<td>Private land</td>
</tr>
<tr>
<td>5.1.6. Has the source of water quality been assessed, if yes attach a copy of the test report.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5.1.7. Mention the appropriate nature of the quality problem</td>
<td>Fluoride</td>
<td>Iron</td>
</tr>
<tr>
<td></td>
<td>Bacteriological</td>
<td>TDS</td>
</tr>
<tr>
<td></td>
<td>Nitrate</td>
<td>Others</td>
</tr>
<tr>
<td>5.1.8. Is there potential risk of contamination of source due to industrial contaminants, human waste discharge, solid waste dumping, use of agro chemicals (Fertilizers, pesticides etc?)</td>
<td>Yes / No</td>
<td></td>
</tr>
<tr>
<td>5.1.8.1. If yes, whether appropriate preventive/ corrective actions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Format for Environmental Data Collection for Water Supply and Sewerage Schemes

<table>
<thead>
<tr>
<th>Issue</th>
<th>Mitigation measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water availability</td>
<td></td>
</tr>
<tr>
<td>Water quality</td>
<td></td>
</tr>
<tr>
<td>Sanitation</td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td></td>
</tr>
<tr>
<td>Disposal of construction wastes</td>
<td></td>
</tr>
</tbody>
</table>

#### 5.1.9. Does the proposed project involve provision of any bore well within 1 km of international border between India and Pakistan?

Yes / No

5.1.9.1. If yes, the project cannot be sanctioned.

5.1.10. If Canal source, indicate the Treatment Technology proposed.

- □ Slow Sand Filter (SSF)
- □ Rapid Sand Filter (RSF)
- □ Package Treatment Plant
- □ Any other method

5.1.11. If groundwater, indicate the Treatment Technology proposed.

- □ RO Plant
- □ Iron removal Plant
- □ De-fluoridation Plant
- □ Any other method

5.1.12. Has disinfection system been provided

- □ Yes
- □ No

5.1.12.1. If yes, type of disinfection method (Silver Ionization or Chlorinator)

#### 5.2. Provision Required from Generic EMF in the water supply scheme village

5.2.1. Air, Noise and water quality testing & rain water harvesting

- □ Yes
- □ No

5.2.2. Lawns and Tree Plantation in Water Works

- □ Yes
- □ No

#### 5.3. Anticipated Environmental Issues and Mitigation Measures during implementation

<table>
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<tbody>
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<tr>
<td>Disposal of construction wastes</td>
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</table>

#### 6. SEWERAGE SCHEME

6.1. Whether Proposed Sewerage Scheme is

- □ Single Village Scheme
- □ Multi Village Scheme

6.2. Current Sanitation Practices *

- □ Septic Tank
- □ Septic Tank with Soak Pits
- □ Open Defecation
- □ Bore well/ soak pit type
- □ Others

6.3. Usage of toilets in terms of number and percentage

6.4. Percentage of households having septic tanks*

6.5. Availability of water supply in toilets

6.6. Current Drainage Pattern*

- □ Open Drains
- □ Partially covered with Open Drains
- □ No Drainage system

6.7. Does the wastewater from cattle sheds discharged into the open drains*

- □ Yes
- □ No

6.8. Does the grey water and black water mix*

- □ Yes
- □ No

6.9. Villagers feedback about current sanitation practice*

- □ Satisfied
- □ Unsatisfied

6.10. Approximate Wastewater Quantity in mld

6.11. Method of treatment to be Provided

6.11.1. Whether existing Ponds will be used as STP

- □ Yes
- □ No

6.11.2. Pond’s distance from the nearest settlement (m)
### Format for Environmental Data Collection for Water Supply and Sewerage Schemes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Issues</th>
<th>Mitigation measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.11.3. Whether distance from the nearest schools/primary health center/religious structure is more than 200 m.</td>
<td>□ Yes □ No</td>
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<td>6.11.4. Water Quality of Pond by visual inspection</td>
<td>□ Good □ Very bad</td>
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<td>6.11.5. Current use of Pond proposed for STP</td>
<td>□ Cattle Wash □ Irrigation □ Sewage Disposal □ Aquaculture □ Any other</td>
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<tr>
<td>6.11.6. Is there any requirement of expansion of pond to use as a STP</td>
<td>□ Yes □ No</td>
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<tr>
<td>6.12. Is there sufficient land available for expansion of the pond or new STP</td>
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<tr>
<td>6.12.1. If yes, current land use</td>
<td>□ Agriculture □ Barren land □ Forest</td>
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<td>6.13. Is there plantation around pond site/STP</td>
<td>□ Yes □ No</td>
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<tr>
<td>6.14. Environmental Features around the new STP site,</td>
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<tr>
<td>i. Approximate area of land in ha.</td>
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<tr>
<td>ii. Land use pattern</td>
<td></td>
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<tr>
<td>iii. Distance from the nearest water body</td>
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<tr>
<td>iv. Distance from the nearest settlement</td>
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<tr>
<td>v. Accessibility of area</td>
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<td>vi. Is there stagnation of water takes place (Yes/No)</td>
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<tr>
<td>6.15. Contamination of Drinking Water Source from the Pond/STP</td>
<td>□ Yes □ No</td>
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<td>6.16. Disposal of Treated Effluent</td>
<td>□ Inland water body □ On to land for irrigation</td>
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<td>6.17. Is there potential risk of contamination of source of water? If yes, what are the appropriate preventive/corrective actions taken? (write note)</td>
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<td>6.18. Provision Required from Generic EMF in the Sewerage Scheme Village</td>
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<tr>
<td>6.18.1. Provision of Lawns and Tree Plantation at the STP Site water works premises and STP site</td>
<td>□ Yes □ No</td>
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<td>6.18.2. Provision of Rainwater harvesting</td>
<td>□ Yes □ No</td>
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<td>6.18.3. Repair and Cleaning of Drains</td>
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<td>6.18.4. Air, noise and water quality testing</td>
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<td>6.18.5. Need of Public Awareness on health and hygiene</td>
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<td>6.19. Anticipated Environmental Issues and Mitigation Measures during implementation</td>
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<td>Parameter</td>
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<td>6.19.1. Site selection of STP</td>
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<td>6.19.3. Disposal of Treated effluent</td>
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<td>6.19.4. Disposal of Sludge</td>
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<td>6.19.5. Construction Phase impacts</td>
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<td>6.19.6. Disposal of Construction debris</td>
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<tr>
<td>7. Whether Cleaning of Pond is required</td>
<td>Yes □ No</td>
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219
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<th>Format for Environmental Data Collection for Water Supply and Sewerage Schemes</th>
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<tr>
<td>EE (Approval as per ES Recommendation)</td>
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Note: * In case of multi-village scheme, please attach the data for each village separately.
ANNEXURE-M (Refer clause 4.12.1)

EXAMPLE FOR CALCULATING THE YIELD OF TUBEWELL

Data: A 15 cm. well penetrates 30 m below static water level. After a long period of pumping a rate of 1800 lpm, the draw down in the observation wells at 12 m and 36 m from the pumped well are 1.2 m and 0.5 m respectively.

Factors to be Determined from the data:

i) The transmissibility of the aquifer

ii) The draw down in the pumped well assuming R = 300 m

iii) The specific capacity of the well.

Solution:

Assuming radial flow into the aquifer from Dupit’s equation

\[
\text{Dupit’s Eqn. } Q = K \left( h_2^2 - h_1^2 \right) \frac{2.303 \log_{10} r_2}{r_1}
\]

Where,

- \( T \) = Transmissibility of the water table aquifer
- \( H \) = Saturated thickness of the aquifer
- \( R \) = Radius of influence
- \( r_w \) = Radius of the well
- \( h_w \) = Depth of water in the well during pumping
- \( H-h_w \) = the resultant draw down in the pumped

\( h_1 = H - S_1 = 30 - 1.2 = 28.8 \text{ m}, \quad r_1 = 12 \text{ m} \)

\( h_2 = H - S_2 = 30 - 0.5 = 29.5 \text{ m}, \quad r_2 = 36 \text{ m} \)

\( Q = 1800 \text{ lpm} \quad K = \text{co-efficient of permeability} \)

Refer enclosed sketch for the above details.

\[
1.800 = K \left( 29.5^2 - 28.8^2 \right) \frac{2.303 \log_{10} 36}{12}
\]

\( K = 2.57 \times 10^{-4} \text{ m/sec} \text{ (or) } 22.21 \text{ m/day} \)

i) Transmissibility \( T = K \times H \)

\( = 2.57 \times 10^{-4} \times 30 = 77.1 \times 10^{-4} \text{ m}^2/\text{sec} \text{ (or) } 666.3 \text{ m}^2/\text{day} \)

ii) Draw down in pumped well

\[
Q = 2.72 T (H-h_w) = 2.72 \times (77.1 \times 10^{-4}) \times S_w
\]

\( = \frac{300}{0.10} \)

Draw down \( S_w = 5.15 \text{ m} \)

iii) The specific capacity of the well

\[
\frac{Q}{S_w} = \frac{1.8}{60 \times 51.5} = 5.82 \times 10^{-3} \text{ cu.m/sec/m}
\]

or 361.8 lpm/m
Pump set to be provided for pumping at the rate of 360 Ltrs. per minutes against total head involved to deliver water in the receiving tank.

**Precaution during yield test:**
The water pumped out should be led away from the well/ borewell so that the same will not reenter the aquifer. The influence of pumping in the neighboring bore well/ well on the test well has also to be observed especially if such wells / borewells are in the zone of influence.
Table I showing Discharge of tube well corresponding to water head discharge over 60 deg V-notch in LPH

<table>
<thead>
<tr>
<th>HEAD OVER V- NOTCH</th>
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Table –II
DISCHARGE OVER 90 deg. V- NOTCH
(Liters per hour)

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Table – 1A

**DISCHARGE OVER 60 V-NOTCH**  
(Gallons per hour)

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Table – II A

**DISCHARGE OVER 90 V-NOTCH**

(Gallons per hour)

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<tr>
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<tr>
<td>12</td>
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</tbody>
</table>
Annexure ‘O’

Design examples of following types of Technology Options:

1. Water Supply Scheme Single Village- Tubewell Based
2. Water Supply Scheme Multi Village- Tubewell Based
3. Water Supply Scheme Single Village- Canal Based
4. Water Supply Scheme Multi Village- Canal Based
5. OHSR capacity calculation using mass curve method
6. Economical size of Pumping Main.

Note: Designs as per Standard DSRs will be made part after finalization by Consultant being hired for preparation of DSRs.
DRAWINGS
### DEEPWELL HANDPUMP

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<td>Table 1</td>
<td>Mild Steel</td>
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<td>10</td>
<td>Pipe Socket — 32</td>
<td>Fig. 4.28</td>
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<td>Riser Pipe, 32NB</td>
<td>Table 2</td>
<td>Mild Steel</td>
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<td>Std 12</td>
<td>Steel</td>
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<tr>
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<td>Hex Nut — M12</td>
<td>Std 04</td>
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<td>Fig. 4.21</td>
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<td>Water Tank — Standard</td>
<td>Fig. 4.15</td>
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<td>Normal Stand — Standard</td>
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<td>Cylinder Assembly — SDWP</td>
<td>Fig. 3.5</td>
<td>Grade A of IS 2062</td>
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<tr>
<td>1</td>
<td>Head Assembly — Standard</td>
<td>Fig. 3.1</td>
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* Depending on the field conditions/pump settings.

**FIGURE 1**  
Ref. Clause 4.2.1

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Department of Water Supply & Sanitation, Punjab

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WATER SUPPLY & SANITATION DEPARTMENT

FIG. 2 (c)  Ref: Clause 6.4.1
### BUTTERFLY VALVES

![Diagram of Butterfly Valves]

<table>
<thead>
<tr>
<th>Part Ref</th>
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<th>See Fig.</th>
<th>Part Ref</th>
<th>Name of Part</th>
<th>See Fig.</th>
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<tr>
<td>1</td>
<td>Body</td>
<td>1, 2</td>
<td>26</td>
<td>Bolted Gland</td>
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<tr>
<td>2</td>
<td>Body end port</td>
<td>1, 2</td>
<td>27</td>
<td>One-piece gland</td>
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</tr>
<tr>
<td>3</td>
<td>Body end</td>
<td>1</td>
<td>28</td>
<td>Gland flange</td>
<td>2</td>
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<tr>
<td>4</td>
<td>Body seat port</td>
<td>1, 2</td>
<td>29</td>
<td>Gland bush</td>
<td>1</td>
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<tr>
<td>5</td>
<td>Body boss</td>
<td>1</td>
<td>30</td>
<td>Gland bolting</td>
<td>1, 2</td>
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<td>6</td>
<td>Body tapping</td>
<td>1</td>
<td>31</td>
<td>Gland packing</td>
<td>1, 2</td>
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<td>7</td>
<td>Shaft boss</td>
<td>1</td>
<td>32</td>
<td>Shaft seal retainer</td>
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<tr>
<td>8</td>
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<td>1</td>
<td>33</td>
<td>Shaft seal retainer gasket</td>
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<tr>
<td>9</td>
<td>Body foot</td>
<td>1</td>
<td>34</td>
<td>Disk</td>
<td>1, 2</td>
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<td>Body seat ring</td>
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<td>35</td>
<td>Disk hub</td>
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<td>11</td>
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<td>36</td>
<td>Disk face</td>
<td>1, 2</td>
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<tr>
<td>12</td>
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<td>1</td>
<td>37</td>
<td>Disk facing ring</td>
<td>1</td>
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<td>Body plug</td>
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<td>38</td>
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<td>41</td>
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<td>1, 2</td>
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<td>Indicator</td>
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<td>45</td>
<td>Thrust bearing</td>
<td>2</td>
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<td>1, 2</td>
<td>46</td>
<td>Thrust faces</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>Lantern ring</td>
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<td>47</td>
<td>Thrust washer</td>
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<td>23</td>
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<td>48</td>
<td>Disk centralizing device</td>
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<td>49</td>
<td>Disk locking device</td>
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**FIG. 3**  
Ref. Clause 6.6.2

**Department of Water Supply & Sanitation, Punjab**
Fig. No. 4  Pump Characteristic Curves
Ref. Clause 6.4.4.2

Department of Water Supply & Sanitation, Punjab
A TYPICAL SKETCH OF A SLUICE VALVE

1B TYPICAL SKETCH OF A SLUICE VALVE WITH DOUBLE FLANGED ENDS

NOTE: GLAND PACKING REQUIRES PERIODICAL REPLACEMENTS

FIG. NO. 5(a) DETAILS OF SLUICE VALVE
REF. CLAUSE G.G.1.

Department of Water Supply & Sanitation, Punjab
DESIGN OF SLUICE VALVE HAUDI 0.60 X 0.60

WATER SUPPLY AND SANITATION DEPARTMENT
PUNJAB
FIG. 6  TYPICAL SKETCH SHOWING LOCATION OF AIR VALVE & SCOUR VALVE IN A DISTRIBUTION SYSTEM

REF. CLAUSE 6.6.3

Department of Water Supply & Sanitation, Punjab
SCHEMATIC REPRESENTATION OF POSITION OF PIPE IN THRUST BLOCK FOR DIFFERENT SITUATIONS

Ref. Clause 6.6.5

Department of Water Supply & Sanitation, Punjab
SCHEMATIC ELEVATION

SCHEMATIC PLAN

FIG NO.-8

SCHEMATIC DIAGRAM OF BYPASS SYSTEM FOR OHT (REG. 71.5)

Department of Water Supply & Sanitation, Punjab
DESIGN OF PICKET TYPE BARBAD WIRE FENCING

SECTION ON A-B

FIG. 9 (a)

WATER SUPPLY AND SANITATION DEPARTMENT
PUNJAB
DESIGN OF CORNER PILLAR

SCALE: 1MM=16 MM

B.B. IN CEMENT SAND MORTER 1:5

GROUND

LEVEL

SECTION ON A.E.

950

270

230

120

120

300

1350

DETAIL OF CORNER PILLAR

FIG. 9 (b)

WATER SUPPLY AND SANITATION DEPARTMENT
PUNJAB
TYPE DESIGN OF STEEL GATE

PLAN

FIG 9 (c)

WATER SUPPLY AND SANITATION DEPARTMENT
PUNJAB
TYPE DESIGN OF WICKET GATE
SIZE = 0.75 MTR X 1.22 MTR.

GROUNDF
M.S. FLAT 50x6 MM
ON BOTH SIDES

50x5ox6 MM
M.S. FRAME
750 x 1220

12.5 MM THICK CEMENT PLASTER
1:5 WITH FALSE TILE LINING
225 X 50 MM
B.B. IN CEMENT
MORTER 1:5

62x4 MM
WHEEL TRICK

13.70
LEVEL

SLIDING BOLT
300 MM LONG

GROUND

ELEVATION

300 340 120
580 15

C.C. 1:18:16

G.L

SECTION "A"

C.C. CONC. 1:2:4 CLOCK
150X150X150 MM

"A"
910
910
750
340

WHEEL TRICK

340

460

LIME POINTING

PLAN

FIG. 9 (d)

WATER SUPPLY AND SANITATION DEPARTMENT
PUNJAB
DESIGN OF D. HOOK

FIG. 9 (e)

WATER SUPPLY AND SANITATION DEPARTMENT
PUNJAB
FIG. NO. 10a: TWIN PIT POUR FLUSH TYPE TOILETS
REF. CLAUSE 11-2

Department of Water Supply & Sanitation, Punjab
FIG. NO. 106 : TWIN PIT POUR FLUSH TYPE TOILETS

REF. CLAUSE 11.2

Department of Water Supply & Sanitation, Punjab
FIG. NO. 11. COMMUNITY TOILET BLOCK (GENERAL ARRANGEMENT)

NOTES:
1. INSPECTION CHAMBER (IC) 600x600x800 DEEP WITH AIRTIGHT WN COVER
2. SEPTIC TANK & SOAK PIT AS PER SITE CONDITIONS

FDN. TO DETAIL

Department of Water Supply & Sanitation, Punjab
TYPICAL DRAWING SHOWING THE PLAN OF ROAD, LONGITUDINAL SECTION (L.S.) AND CROSS SECTION (C/S) FOR LAYING THE PUMPING MAIN

DEPARTMENT OF WATER SUPPLY & SANITATION, PUNJAB

REF CLAUSE 6.1
FIG. NO. 13  TYPICAL HOUSEHOLD SERVICE CONNECTION  Ref. Clause 7.5

Department of Water Supply & Sanitation, Punjab
Notes:
1. All dimensions are in mm & all levels are in mtrs.
2. Bulk Water Meter as per IS : 2373 - 1981

Representative Drawn Of:
LAYOUT PLAN OF WATER WORKS SITE WITHOUT OHSR
(FOR TUBE WELL BASED WATER SUPPLY SCHEME)

Prepared By:
TECHNICAL SUPPORT CONSULTANT
TO DWSS, PUNJAB
CONSULTING ENGINEERING SERVICES (I) PVT LTD
57, MANJUSHA NEHRU PLACE, NEW DELHI-110019
Notes:
1. All dimensions are in mm & all levels are in mtrs.
2. Bulk Water Meter as per IS : 2373 - 1981
NOT TO SCALE
PUNJAB RURAL WATER SUPPLY & SANITATION PROJECT
(WORLD BANK ASSISTED)
STATE PROGRAM MANAGEMENT CELL, GOVT. OF PUNJAB

LAYOUT PLAN OF WATER WORKS SITE
WITHOUT GUARD ACCOMMODATION
(FOR TUBE WELL BASED WATER SUPPLY SCHEME)

Representative Drawing of

Prepared By-
TECHNICAL SUPPORT CONSULTANT
TO DWSS, PUNJAB
CONSULTING ENGINEERING SERVICES (I) PVT LTD
97, MANAVSHRI NEHRU PLACE, NEW DELHI-110019

Fig. 14C
Notes:
1. All dimensions are in mm & all levels are in mtrs.
2. Bulk Water Meter as per IS : 2373 - 1981

FIG. - 14D

LAYOUT PLAN OF WATER WORKS SITE
WITHOUT OHSR & GAURD ACCOMMODATION
(FOR TUBE WELL BASED WATER SUPPLY SCHEME)
Notes: -
1. All dimensions are in mm & all levels are in mtrs.

255
NOTES :-
1. All dimensions are in mm & all levels are in mtrs.

PUNJAB RURAL WATER SUPPLY & SANITATION PROJECT
(WORLD BANK ASSISTED)
STATE PROGRAM MANAGEMENT CELL, GOVT. OF PUNJAB

LAYOUT PLAN FOR WATER WORKS
- RAPID SAND FILTRATION
(CANAL BASED WTP)

PREPARED BY:
TECHNICAL SUPPORT CONSULTANT
TO DWS, PUNJAB
CONSULTING ENGINEERING SERVICES (P) LTD
AT, MANISHA MEHRU PLACE, NEW DELHI-110019

Fig. - 14F
FIG. - 14G

Collection of Run-off for RWH at Water Works (Tubewell Based Scheme)
FIG. - 14 I

Existing Well

Plan

0.23m THICK WALL

150mm DIA RCC PIPE

WATER CHAMBER

SECTION

STEPs

REMOVABLE SLAB

RCC SLAB

G.L.

G.L.

COARSE SAND 1.5-2.0mm

GRAVEL 5-10mm

BOULDERS 5-20mm

SLOTTED PIPE

100mm DIA M.S. / PVC PIPE 5.4mm THICK

250mm DIA BORE FILLED WITH GRAVEL 3-6mm SIZE

SLOTTED PIPE 1.58mm SLOT SIZE /
STAINLESS STEEL CAGE TYPE WIRE
WOUND SCREEN 1.50mm SLOT SIZE

BAIL PLUG

RAIN WATER HARVESTING THROUGH EXISTING WELL

Ref. Clause 16.1.2 & 16.1.3

PREPARED BY:
TECHNICAL SUPPORT CONSULTANT TO DWSS, PUNJAB
CONSULTING ENGINEERING SERVICES J J PVT LTD
57, MANJUSHA NEHRU PLACE, NEW DEHI-110019

NOT TO SCALE
PUNJAB RURAL WATER SUPPLY & SANITATION PROJECT
(WORLD BANK ASSISTED)
STATE PROGRAM MANAGEMENT CELL, GOVT. OF PUNJAB

REPRESENTATIVE DRAWING OF:
RAIN WATER HARVESTING THROUGH EXISTING WELL
RAIN WATER HARVESTING THROUGH DUG WELL

Ref. Clause 16.1.2 & 16.1.3

FIG. - 14 J
SECTION

INLET

CORSE SAND 1.5-2mm
GRAVEL 5-10mm
BOULDERS 10-20cm
BOULDERS 0.2m
REMOVABLE SLAB

102mm DIA M.S PIPE
GRAVEL
BAIL PLUGIN

OPENING 50X50mm
5mm DIA M.S BAR
MESH

12mm JHONSON V WIRE SCREEN (1mm SIZE)

SLOTTED PIPE 3mm SLOT SIZE

Ref. Clause 16.1.3
FIG. -14K

PUNJAB RURAL WATER SUPPLY & SANITATION PROJECT
(WORLD BANK ASSISTED)
STATE PROGRAM MANAGEMENT CELL, GOVT. OF PUNJAB

ROOF TOP RAIN WATER HARVESTING
THROUGH TRENCH WITH RECHARGE WELL

PREPARED BY:
TECHNICAL SUPPORT CONSULTANT
TO DWSS, PUNJAB
CONSULTING ENGINEERING SERVICES (I) PVT LTD
57, MANUJSHA NEHRU PLACE, NEW DELHI-110019

NOT TO SCALE
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<th>Abbreviation</th>
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<td>BF</td>
<td>Butterfly</td>
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<tr>
<td>BOD</td>
<td>Biochemical Oxygen Demand</td>
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<tr>
<td>BW/OW</td>
<td>Bore well / Open well</td>
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<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
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<tr>
<td>CPHEEO</td>
<td>Central Public Health Environmental Engineering Organisation</td>
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<td>Environment Data Sheet</td>
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<td>ELSR/ESR</td>
<td>Elevated Service Reservoir</td>
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<td>EMF</td>
<td>Environment Management Framework</td>
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<td>EMP</td>
<td>Environment Management Plan</td>
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<td>GI</td>
<td>Galvanized Iron</td>
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<td>HDPE</td>
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<td>Membrane Bio Reactor</td>
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<td>MOV</td>
<td>Valve Actuator Drive</td>
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<td>Over Head Service Reservoir</td>
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<td>Punjab State Electricity Board</td>
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<td>RCC</td>
<td>Reinforced Cement Concrete</td>
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<td>RSC</td>
<td>Residual Sodium Carbonate</td>
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<td>RTU</td>
<td>Remote Terminal Unit</td>
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<td>Sodium Adsorption Ratio</td>
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<td>Storage &amp; Sedimentation</td>
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<td>TDS</td>
<td>Total Dissolved Solids</td>
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<td>TPPFL</td>
<td>Twin Pit Pour Flush Latrine</td>
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<td>Tubewell</td>
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<tr>
<td>uPVC</td>
<td>Un-plasticized Poly Vinyl Chloride</td>
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References:

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3. IS 13095 : 1991 (Reaffirmed) – Butterfly Valves
4. IS 10500 : 2012 (Second Revision) – Drinking Water - Specification
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