

Natural Resources Conservation and Development

Level-II

**Based on March 2022, Version I Occupational
Standard**



**Module Title: - Operating and Maintaining Irrigation
Works and Drainage Systems**

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Introduction to the Module

This module covers the knowledge, skills, and attitude required to operate and maintain micro-irrigation and drainage systems. It requires the ability to organize equipment for installation work, set out and prepare site, and communicate with work team members.

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LG #14	LO #1- Prepare Tools and Materials for Installation Work
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Instruction sheet 1

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Identifying and selecting materials, tools, equipment, and machinery
- Checking the water supply
- Checking parts and equipment delivered to the site
- Adjusting power requirement for suction and delivery head
- Carryout the irrigation system after pumping

This guide will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Identify and selecting materials, tools, equipment, and machinery
- Check the water supply
- Check parts and equipment delivered to the site
- Adjust power requirement for suction and delivery head
- Carryout the irrigation system after pumping

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet 1

1.1 Identifying and Selecting Materials, Tools, Equipment, and Machinery

Tools are particularly important in construction work. They are primarily used to put things together (e.g., hammers and nail guns) or to take them apart (e.g., jackhammers and saws). Tools are often classified as hand tools and power tools.

Hand tools include all non-powered tools, such as hammers and pliers. Power tools are divided into classes, depending on the power source: electrical tools (powered by electricity), pneumatic tools (powered by compressed air), liquid-fuel tools (usually powered by gasoline), powder-actuated tools (usually powered by an explosive and operated like a gun) and hydraulic tools (powered by pressure from a liquid). Each type presents some unique safety problems.

Materials, tools, equipment and machinery needed to install micro-irrigation systems may include:-

- Surveying and levelling equipment such as ;
 - ✓ automatic level,
 - ✓ laser level,
 - ✓ dumpy level,
 - ✓ staff, boning rods,
 - ✓ pegs,
 - ✓ notebook,
 - ✓ pencil and
 - ✓ calculator;
- Hand tools such as
 - ✓ rakes,
 - ✓ shovels,
 - ✓ spades,
 - ✓ rollers,
 - ✓ wheelbarrows,
 - ✓ hoses and
 - ✓ hose fittings;
- Machinery such as;
 - ✓ ditch witches,
 - ✓ backhoes,
 - ✓ front-end loaders,
 - ✓ graders,
 - ✓ mechanical rollers,
 - ✓ trucks,
 - ✓ hydraulic trailers,
 - ✓ and tractors and
 - ✓ 3-point linkage equipment;

- Pumps and pump fittings; and
- Fitting and welding tools appropriate to the irrigation system.

Installing an irrigation system yourself will require specific irrigation tools to do the job right.

Here is a list of the most common irrigation tools you'll need to install an irrigation system, and how to use them.

- **Trenching Shovel:** A trenching shovel will be needed to dig holes and clean-out machine-dug trenches for the irrigation pipes and valves. Its narrow blade makes this the ideal tool for this tedious job.
- **Mattock:** A mattock is used to dig short trenches, and the pick end works great for breaking and removing rocks



Figure 1.1: mattock

- **Tamper:** A tamper bar is used to compact the soil after it is replaced over the piping
- **PVC Pipe Cutter:** The PVC pipe cutter is used to cut the PVC pipe leaving clean edges.



Figure 1.2: PVC pipe cutter

- **Hack Saw:** A hack saw can be used to cut PVC pipe, as well as metal pipe.
- **Wire Cutter/stripper:** A combination wire cutter and stripper is used for cutting and stripping wires
- **Screw Drivers:** You will need a flat screwdriver and a Phillips head screwdriver to connect the wires to the controller.



Figure 1.3: screwdriver

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1.2. Checking the Water Supply

1.2.1 Water Supply

Compliance with state laws in obtaining water rights and in wing irrigation water is the responsibility of the land user. However, there should be advice to the farmer about any water laws that may affect the plan or installation, and encourage the fanner to see a lawyer for interpretation of a law or for advice on a legal problem. The quantity of water available for irrigation, the rate at which it can be delivered to the farm or fields, and the reliability of the supply must be determined. The rate at which the water can be delivered to the farm usually expressed in cubic meters per second, in miner's inches at the head gate or diversion, or in liters per second if from a pump.

When irrigation water is transpired by plants, most of the salts that were in the water remain in the root zone unless there is enough rainfall or excess water provided in the next irrigation to leach. A Variety of methods and structures available provides great flexibility in selecting those best suited to your farm and your needs. Readyng a farm to use irrigation water involves development of a complete irrigation plan. This plan should show the land to be cleared, land leveling to be done, irrigation methods to be used, and the location of the farm irrigation structures. A good farm irrigation system should efficiently perform the following functions:

- Deliver water to all parts of the farm when needed,
- Deliver water in amounts needed to meet crop demands during peak use periods,
- Provide complete control of water,
- Measure the amount of water at entry into farm irrigation system,
- Divide water in required amounts for use in different fields,
- Dispose of waste water,
- Provide for reuse of water on the farm,
- Allow free, easy movement of farm machinery, and
- Distribute water evenly into the soil of each field.

In performing these functions, conservation of the water and land resources is a basic consideration. Irrigation and cropping methods that best fit the particular soil, slope, crop, and

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water supply should be used. This is conservation irrigation and it makes possible irrigation without soil erosion damage, saline or alkaline accumulation, water logging, or undue water loss, the salts downward. In areas where the water quality is not known, tests should be made and evaluated by soil scientists or other specialists. The total concentration of soluble salts, the relative proportion of sodium to other cations, the presence of toxic amounts of boron or other elements, and the relative concentration of bicarbonates to calcium and magnesium should be determined.

1.2.2 Measurement of Irrigation Water quantity

Measuring water in surface irrigation systems is critical for efficient irrigation water management. Without knowing the amount of water being applied, it is difficult to make decisions on when to stop irrigating or when to irrigate next. A good irrigation manager should know the flow rate of the irrigation water, the total time of the irrigation event and the area irrigated. Irrigation management decisions should be made based on the amount of water applied and how this relates to the consumptive use demands of the plants and the soil water holding capacity. The amount of water applied to a field can be estimated using the following equation:

$$Q * t = d * A$$

Q is the flow rate, in cubic meter per second (m³/s); t is the set time or total time of irrigation (hours); d is the depth of water applied (mm) and A is the area irrigated (ha).

Methods/Types of flow measurement

Irrigation water management begins with knowing how much water is available for irrigation. In this module, methods of measuring irrigation flow rate can be grouped into two basic categories:

- direct measurement methods,
- velocity-area methods,

Choice of method to use will be determined by the volume of water to be measured, the degree of accuracy desired and the financial investment required.

A. Direct Measurement Methods

Measuring the period of time required to fill a container of a known volume can be used to measure small rates of flow such as from individual siphon tubes, sprinkler nozzles, or from individual outlets in gated pipe.

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Example;the water supplied by a pump fills a container of 200 liters in 20 seconds. What is the flow rate of this pump? The formula used is

$$Q = \frac{V}{t} = \text{volume of water/time } 200/20 = \mathbf{10\text{ l/s}}$$

B. Velocity-area methods

The most practical method of measuring stream discharge is through the velocity-area method. Discharge is determined as the product of the cross-sectional area of the water times velocity. Discharge, or the volume of water flowing in a stream over a set interval of time, can be determined with the equation:

$$Q = V * A$$

Where; Q is discharge (volume/unit time (m^3/second), A is the cross-sectional area of the stream (m^2), and V is the average velocity (m/s). This method comprises measuring the mean velocity V and the flow area 'A' and computing the discharge Q from the continuity equation. The site which satisfies the requirements such as straightness, stability, uniformity of cross-section is chosen for discharge measurement. The discharge measurement site is then marked by aligning the observation cross-section normal to the flow direction.

The cross section is demarcated by means of masonry or concrete pillars on both the banks, two on each side 30 m apart.

Procedures of Water Measurement in an Open Channel;

Step 1; Measuring of width or average width of an open channel

In order to measure the width of a channel the following procedures are used:

- Select straight canal view and stretch a string from one side of the channel to the other side;
- Put marks on the string to indicate the exact water surface on both sides of the channel;
- Measure the distance between the two marks and this is the width of the channel. If the field channel does not have equal width along the straight line selected it is better to take measurements at more places and take the average width of the channel.

Step 2; measuring the average depth of water

In order to measure the average depth of water it is possible to use bamboo or a piece of wood circular at the base. The wooden piece should have a thickness of 3- 8 cm in order to resist the pressure of the water and delineated on it in meter and centimeter. The height preferably is more

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than one meter. On the measuring stick numeration should be written starting from 0 following bottom to up approach and zero should be marked at the flat bottom of the stick. The measuring can be done on the same area where the width is measured and measurements are taken at 30 cm interval. The average depth can be determined by dividing the sum of all the measured depths by the number of measurements taken.

Table 1.1; Sample data for measuring depth

No of tests	1	2	3	4	5	6	7	average
Depth, m	0.30	0.40	0.51	0.52	0.51	0.50	0.35	$3.09/7=$ 0.44

Number of trials for measuring depth are 7 and an average depth of an open channel is therefore, equal to 0.44 m (Total depths measured divided by the number of trials; $3.09/7 = 0.44$ m).

Step 3; measuring the cross- sectional area

The cross- sectional area is calculated by multiplying the width by the average depth of the canal. To do this first it is recommended summing up of all the partitions subdivided to measure the depths at certain intervals and then multiply the result with the average depth.

$$\text{cross – sectional area m}^2 = \text{average depth , m} * \text{average width, m}$$

$$2.3 * 0.44 = 1.012 \text{m}^2$$

Step 4; Measuring of the water velocity in an open channel

For the float method: measure out some convenient distance along the stream bank (try at least 30 meters). Station one person at the upstream end of your selected reach and one at the downstream end. The person at the upstream end has the stop-watch and the oranges. The person at the top releases an orange and starts the clock when the orange floats over the top boundary of your reach. When the orange passes the bottom boundary of your reach, the person at the bottom signals to the top person to stop the clock. Someone records the time and notes the distance traveled. Do this at least three times. Calculations:

$$\text{Surface velocity} = \text{distance/time}$$

$$\text{Average Surface velocity} = \text{sum of surface} \frac{\text{velocity}}{\text{no}} \text{ of trial}$$

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Finally, knowing the cross- sectional area of the channel and the average velocity of the water in the channel, the discharge of the water in the open channel could be calculated by multiplying the cross- sectional area by the velocity of the water.

Table1.2 Estimated average velocity from different data set

No of test	Time in sec	Distance in m	Velocity of water m/s
1	20	10	0.5
2	21	10	0.48
3	22	10	0.45
Average	21	10	0.48

At the end of the test the results should be added and divided by the total number of tests. Therefore, an average velocity is $10/20.6 = 0.48$ m/s.

$$Q(l/s) = A * V = 1.012m^2 * 0.48m/s$$

$$= 0.49m^3/s$$

1.3.Checking Parts and Equipment Delivered to the Site

Parts and equipment delivered to site are checked according to system drawings and specifications.

You should make the following inspection:

- Each item should be inspected with care upon its arrival
- Total quantity of pipes, couplings, rubber rings, fittings, lubricant, etc... should be carefully checked against the delivery notes
- Any damaged or missing item must be pointed out to the dispatcher or driver and noted on the delivery note

Materials that have been damaged during transportation should be isolated and stored separately on site, until the material is checked by our site representative and repaired or replaced.

Unloading at the job site must be carried out carefully under the control and responsibility. Care should be taken to avoid impact with any solid object (i.e. other pipes, ground stones, truck side etc.).

Note: Damaged material must not be used before it is repaired.

1.4 Adjusting power requirement for suction and delivery head

All micro-irrigation systems require energy to carry water through the pipe distribution network and discharge it through the sprinklers and drippers. In some instances this energy is provided by gravity as water flows downhill through delivery system. In most irrigation systems, energy is imparted to the water by a pump that in turn receives its energy from either an electric motor or an internal combustion engine. The combination of pump and prime mover (electric motor or engine) is central to the performance of most irrigation systems. Therefore, it is important that both the pump and the prime mover be well-suited and matched to operate the irrigation system. Wide ranges of pumps are commercially available for irrigation purposes. Some applications have special pump requirements, but there are many common considerations in the selection of an appropriate pump. Some of these are listed below:

- Requirement of pressure (or head) and discharge
- Conditions at suction and pump
- Source of power available
- Cost per unit of power consumption
- Capital cost, depreciation and interest charges
- Frequency of operation
- Reliability
- Physical constraints (for example, pump must fit in a limited space such as in borehole)
- Housing of electrical motor and pump further to keep care of water proofing.

1.4.1 Types of Pumps

Pumps are classified in two main categories, based on how energy is given to lift water. The two types are:

- Rotor dynamic pumps (centrifugal pumps, mixed flow pumps and axial pumps)
- Positive displacement pumps (piston pumps, and helical-rotor pumps).

The principal requirement for pumping equipment used in commercial micro-irrigation is high efficiency against comparatively high pressures. This requirement usually limits pumps used for spray systems to rotor dynamic pumps. Centrifugal pumps are widely used in agriculture and are a good example of the rotor dynamic pump group. However, for small systems requiring pump discharge less than 2 liter/second positive displacement pumps can be used under certain

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conditions. These are normally used in fertilizer injection equipment. In irrigation terms, a pumping rate of 2 l/s is a very low flow and would be applicable to nurseries with misting jets, vegetable growers using drip irrigation, and domestic irrigation situations.

I. Rotor dynamic Pumps

Rotor dynamic pumps have a rotating impeller which gives energy to the water. The speed and size of the impeller determine the pressure and the rate of water flow out of the pump. The two main types of rotor dynamic pumps are the volute pump and the turbine pump.

A. Volute Type Centrifugal Pump

Volute pumps are widely used in irrigation. They are of simple in construction, the only moving parts being the impeller and shaft. The impeller is housed in a casing (volute). The volute pump most often used for irrigation purposes is the (radial-flow) centrifugal pump. It can be installed with the pump shaft in the vertical or horizontal position. Its size is specified by the internal diameter at the discharge outlet.

The advantages of the centrifugal pump include the following:

- It can be installed above the water surface.
- It can be mounted on skids for rapid removal of water to avoid floods.
- Not being submerged, it is less liable to corrosion, although most can operate submerged for short periods without damage.
- It can be installed as a portable unit and used at more than one pumping site.
- Where its use is applicable, it is easy and simple to install.
- It is cheap to maintain.

Where large quantities of water have to be pumped against low heads, mixed-flow volute (MFV) pumps are used. At low heads, it is possible to get higher efficiencies with MFV pumps than with radial flow centrifugal pumps. Another advantage is that the power requirements (for a given speed) are approximately constant through the range of head and discharge.

B. Turbine Pump

Turbine pumps are mixed-flow and radial-flow (centrifugal) pumps which direct water to the discharge outlet with diffusion vanes. Axial-flow pumps, in which the impeller resembles a ship's screw, are generally classed with the turbines. Since turbine pumps are most often used for pumping from bores, there is a limit on impeller diameter and the pressure which can be

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developed at a given speed. Volute pumps do not have this physical limitation. When high pressures are required from turbine pumps, extra impellers (stages) are added to the pump. Turbine pumps are driven by either a line-shaft or a submersible electric motor mounted below and close coupled to the pump.

C. Jet Pumps

Jet pumps are single-stage centrifugal pumps fitted with a special assembly called an ejector. The ejector allows the pump to draw water from depths not possible with a conventional centrifugal pump. The disadvantage of jet pumps is their very poor efficiency and discharge when used in high pressure applications.

II. Positive Displacement Pumps

The positive displacement (or reciprocating pump) consists of a piston (displacer) moving in a cylinder from which liquid enters or leaves through a valve arrangement. The positive displacement pump is a low volume, high head pump, and so is not used extensively in irrigation systems. These pumps are used, where constant flow is needed such as in drip, fertigation, spray or mist irrigation.

a) Piston Pump

Piston pumps have a horizontal cylinder sealed from both ends with a piston inside. As the piston moves backwards and forwards, water is drawn in during the suction stroke and discharged during the compression stroke. The discharge pulsates because of this need to be smoothed out using an air chamber in the delivery line.

b) Helical Rotor Pump

Helical rotor pumps are single screw pumps consisting of a rigid screw-like rotor rolling with a slight eccentric motion in a resilient internal rubber lining (stator). The rotor and stator engage so that a constant seal between the two is maintained. The diameter, pitch and eccentricity of the rotor control the pump's performance.

The characteristic curve for helical rotor pumps is very steep: small changes in flow result in large changes in pressure. All positive displacement pumps require a pressure relief valve at downstream of the pump to protect the mainline.

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1.4.2 Size of Pumping Unit

i. Pump Performance Parameters

Capacity, head, power, efficiency, required net positive suction head, and specific speed are parameters that describe a pump's performance.

ii. Capacity

The capacity of a pump is the amount of water pumped per unit time. Capacity is also frequently called discharge or flow rate (Q). In metric units it is expressed as liters per minute (Lmin-1) or cubic meters per second (m3s-1).

iii. Head

Head is the net work done on a unit weight of water by the pump impeller. It is the amount of energy added to the water between the suction and delivery sides of the pump. Pumping head is measured as pressure difference between the discharge and suction sides of the pump.

Pressure in water can be thought of as being caused by a column of the water due to its weight, exerts a certain pressure on a surface. This column of water is called the head and is usually expressed in meters (m) of the liquid. Pressure and head are two different ways of expressing the same value. Usually, when the term "pressure" is used it refers to units in kilopascals (kPa), whereas "head" refers to meter's (m).

iv. Power Requirements

The power imparted to the water by the pump is called water horsepower or water power. To calculate water power, the flow rate and the pump head must be known. Water power can be calculated using the following equation:

$$W_P = \frac{Q \times H}{360}$$

Where

WP = water power, kilowatts

Q = flow rate (pump capacity), m3h-1

H = pump head, m

In any physical process there are always losses that must be accounted for. As a result, a certain amount of power is imparted to the water a larger amount of power is imparted to the pump

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shaft. This power is called brake horse power. The efficiency of the pump determines how much more power is required at the shaft.

$$BP = \frac{WP}{E}$$

Where, E is the efficiency of the pump expressed as a fraction, BP and WP are brake power and waterpower, respectively.

v. Efficiency

Pump efficiency is the percent of power input to the pump shaft (the brake power) that is transferred to the water. Since there are losses in the pump, the efficiency of the pump is less than 100% and the amount of energy required to run the pump is greater than the actual energy transferred to the water. The efficiency of the pump can be calculated from the water horse power (WP) and brake horse power (BP) and is given by

$$E(\%) = \left(\frac{WP}{BP} \right) \times 100$$

1.4.3 Power Requirement and Pump Selection

A. Determination of operating conditions

Before a pump is selected it is necessary to determine the head (H) and discharge (Q) required for the irrigation system (sprinkler/ drip). The system head versus discharge relationship is developed for the entire range of operating conditions. Most pumps operate for specific range of head-discharge condition. The selection of pump becomes difficult for satisfying all operation conditions when these exist in wide range of system head discharge variation. Since most pumps are not very efficient over wide range in operating heads, the most prevalent conditions should be determined and a pump that operates efficiently over this set of conditions, and can operate under all other possible conditions, should be selected.

B. Total dynamic head required by the system

For a given irrigation system a pump must provide the required flow rate at the required head (or pressure). The total dynamic head (TDH) curve of the system (Figure 9.1) illustrates the head is required to deliver desired flow through the system Fig. 9.1).

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The pressure required for operating a given sprinkler nozzle or emitter represents only a portion of the total dynamic system head. Additional pressure must be produced by the pump to lift water from the well or other water source, to overcome friction losses in the pipe and other components of the system, and to provide velocity for the water to flow through the pipe. As a result, the total dynamic head for the system is the sum of static head (distance the water must be lifted), well drawdown, operating pressure (pressure required at the emitter or sprinkler head), friction head (energy losses) and velocity head (energy required for water to flow). Figure 9.1 illustrates these components of the system TDH. It can be expressed as:

$$H_t = H_n + H_m + H_f + H_s$$

Where,

H_t = total design head against which pump is working, m

H_n = maximum head required at the main to operate the sprinklers/ drip on the lateral at the required average pressure, m

H_m = maximum friction loss in the main and in suction line, m

H_f = elevation difference between the pump and the junction of the lateral and the main, m

H_s = elevation difference between the pump and junction of the lateral and the main, m

Horsepower requirement of pump

The horsepower requirement of pumping unit is computed by using following equation (Michael, 2010).

$$\text{Horse power (hp)} = \frac{Q \times H}{75 \times \eta_p \times \eta_m}$$

Where,

H = total head loss, m

Q = Capacity of drip/ sprinkler irrigation system Ls-1

η_p = Efficiency of pump, fraction

η_m = Efficiency of motor, fraction

C. System head variations

The total system head will vary with time due to variations in well drawdown, head loss due to friction, operating conditions, and static water level. The static water level changes due to seasons. The friction losses will increase with the life of pumping system components. This is

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due to corrosion or deposits in the pipe and other components. The static lift component of the total dynamic head may vary due to fluctuating water levels throughout the season, or from year to year. In some systems there is a periodic change in the operating head of the system. It may not be possible to select a pump that is efficient under a wide range of system heads. In some cases an additional (booster) pump, in series with a main pump, may provide the additional head, when necessary.

1.4.4 Pump Selection

Pump selection is the last step in the irrigation system design process. An irrigation designer estimates field sizes, pipe size and layout, the number of valves, type of filters and the different types of fittings to be used. All of these information helps to determine the pressure and flow rate required by the pump, and thus finally the pump selection is done.

1. Head - Discharge Curve

Characteristic curves

A set of four curves known as the pump's characteristic curve is used to describe the operating properties of a centrifugal pump. These four curves relate head, efficiency, power, and net positive suction head required to pump capacity (Figure 9.2). Pump manufacturers normally publish a set of characteristic curves for each pump model they make. Data for these curves are developed by testing several pumps of a specific model. The operating properties of a pump depend on the geometry and dimensions of the pump's impeller and casing.

I. Head Vs. Pump Capacity

This curve relates head produced by a pump to the volume of water pumped per unit time. Generally, the head produced decreases as the amount of water pumped increases. The shape of the curve varies with pump's specific speed and impeller design. Usually, the highest head is produced at zero discharge and it is called the shut-off head.

II. Efficiency Vs Pump Capacity

The efficiency of a pump steadily increases to a peak, and then declines as Q increases further. Efficiency varies between types of pumps, manufacturers and models.

III. Brake power Vs pump capacity

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The shape of the brake power versus discharge curve is a function of the head versus discharge and efficiency versus discharge curves. In some cases the highest power demand is at the lowest discharge rate and it continues to decline as the discharge increases. It is important to notice that even at zero discharge, when the pump is operating against the shut-off head; an input of energy is needed.

IV. Net Positive Suction Head Required Vs Pump Capacity

One of the curves typically published by manufacturers is the net positive suction head required (NPSHr) versus capacity (Q). For a typical centrifugal pump the NPSHr steadily increases as Q increases. To assure that the required energy is available, an analysis must be made to determine the net positive suction head available NPSHa which is a function of the pumping system design. All pumps come with a head discharge curve graph that shows their operating efficiency at different flow rates and pressures. Most head discharge curve graphs work in meters head for pressure, and cubic meters per hour or liters per minute for flow. It is very important to work in the correct appropriate units.

Table 1.1 conversion of one unit to other required units.

Pressure Conversions			Flow Conversions		
Convert from	To	Multiply by	Convert from	To	Multiply by
kPa	Meters head	0.102	L h ⁻¹	L s ⁻¹	0.017
Meters head	kPa	9.8	L s ⁻¹	L h ⁻¹	3600
kPa	psi	0.145	m ³ h ⁻¹	L h ⁻¹	1000
psi	kPa	6.9	L h ⁻¹	m ³ h ⁻¹	0.001

Example 9.1: A field has 20 rows of tree with 30 trees per row. One 50 Lh-1 microsprinkler is located between each tree, plus one either end of the row. Select the required pumping unit for the system by assuming required data.

The total number of micro sprinklers = 20 (rows) x 31 (micro sprinklers per row)
= 620 micro sprinklers

The required flow rate is calculated by multiplying the number of emitters by the Output of one sprinkler: 620 x 50 Lh-1 = 31,000 Lh-1.

This is the same as $31\text{m}^3/\text{hr}$, $516\text{ lit}/\text{min}$ or $8.6\text{ lit}/\text{sec}$

Consider 200 kPa is emitter operating pressure (from manufacturer's specifications)

& 265 kPa is system pressure losses (calculated by a designer), then

Required Pressure = 200 kPa (emitters) + 265 kPa (system losses) = 465 kPa .

Therefore, we need a pump that can deliver discharge of $31,000\text{ Lh}^{-1}$ at a pressure of 465 kPa .

Using this information we can now select the pump to best suit this irrigation system. The pressure requirement is 465 kPa which is equal to 47.4 m head. The flow rate requirement is $31,000\text{ Lh}^{-1}$ which is equal to 8.6 L s^{-1} . Using these figures and the head-discharge curve graph one can check whether this pump will run the irrigation system efficiently? Normally the pump efficiency should be greater than 60% . Using the head-discharge curve graph locate 47.4 m total head on the vertical axis and draw a horizontal line across the graph. On the horizontal axis locate 8.6 L s^{-1} discharge and draw a vertical line up. The point at which these two lines intersect shows the efficiency at which the pump will operate under these flow rate and pressure conditions. The pump selected would be the pump with the 264 mm diameter impeller operating at 2900 rpm . This particular pump is expected to be approximately 69% power efficient. This means that 69% of the energy supplied to the pump from the motor is converted to the required pressure and flow.

There is a large range of pumps available in the market with their own set of head-discharge curve graphs. By knowing the pressure and flow rate required to operate the irrigation system effectively, one can compare one pump against another and select the most efficient pump for a given set of condition.

1.4.5 Pumping System Maintenance /Checking Of Pumping System

I. Before Operation

- Check fuel, oil and water levels in diesel engines.
- Check fertilizer tanks for correct type of fertilizer and adequate quantity.
- Check fertilizer pump(s) for proper functioning
- Check valves for proper functioning.
- Make sure all filters are clean.
- Check chlorination equipment

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II. During Startup

- Verify that the pumps are functioning properly.
- Watch for unusual noises, vibrations and overheating that may develop in the pump drive due to pump malfunction

III. After Startup

- Check pressure and flow rate at pump outlets.
- Check fertilizer and/or chlorine injection; check dosage.
- Check downstream filter pressure and make sure that pressure loss is within the acceptable limits.
- Check the system visually for bursts.
- Select critical points in the irrigation system and measure the pressure at those points

The maintenance of pumps and drive units includes their proper lubrication, in accordance with the manufacturer's recommendations. Maintenance also includes: periodic adjustment of the impeller clearance in turbine pumps, tightening of packing glands in centrifugal pumps, periodic adjustment of the engines for improving their efficiency, and frequent inspection of the proper pump operation

1.5. Carryout the Irrigation System after Pumping

The irrigation system consists of a (main) intake structure or (main) pumping station, a conveyance system, a distribution system, a field application system, and a drainage system.

The (main) intake structure, or (main) pumping station, directs water from the source of supply, such as a reservoir or a river, into the irrigation system.

The conveyance system assures the transport of water from the main intake structure or main pumping station up to the field ditches.

The distribution system assures the transport of water through field ditches to the irrigated fields.

The field application system assures the transport of water within the fields. The drainage system removes the excess water (caused by rainfall and/or irrigation) from the fields.

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1.5.1 Main intake structure and pumping station

Main intake structure

The intake structure is built at the entry to the irrigation system. Its purpose is to direct water from the original source of supply (lake, river, reservoir etc.) into the irrigation system.

Pumping station

In some cases, the irrigation water source lies below the level of the irrigated fields. Then a pump must be used to supply water to the irrigation system.

1.5.2 Conveyance and distribution system

The conveyance and distribution systems consist of canals transporting the water through the whole irrigation system. Canal structures are required for the control and measurement of the water flow.

I. Open canals

An open canal, channel, or ditch, is an open waterway whose purpose is to carry water from one place to another. Channels and canals refer to main waterways supplying water to one or more farms. Field ditches have smaller dimensions and convey water from the farm entrance to the irrigated fields.

A. Canal characteristics

According to the shape of their cross-section, canals are called rectangular, triangular, trapezoidal, circular, parabolic, and irregular or natural.

The most commonly used canal cross-section in irrigation and drainage is the trapezoidal cross-section.

B. Earthen Canals

Earthen canals are simply dug in the ground and the bank is made up from the removed earth.

The disadvantages of earthen canals are the risk of the side slopes collapsing and the water loss due to seepage. They also require continuous maintenance in order to control weed growth and to repair damage done by livestock and rodents.

C. Lined Canals

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Earthen canals can be lined with impermeable materials to prevent excessive seepage and growth of weeds.

Lining canals is also an effective way to control canal bottom and bank erosion. The materials mostly used for canal lining are concrete (in precast slabs or cast in place), brick or rock masonry and asphaltic concrete (a mixture of sand, gravel and asphalt).

The construction cost is much higher than for earthen canals. Maintenance is reduced for lined canals, but skilled labor is required.

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Self-check 1	Written test
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Name..... ID..... Date.....

Directions: Answer all the questions listed below.

Test I: Choose the best answer (3point)

- The irrigation system consists of :
 - Intake structure or pumping station,
 - Conveyance system,
 - Distribution system,
 - Field application system,
 - Drainage system.
 - Cross- Drainage Structure
- _____are types of canal simply dug in the ground and the bank is made up from the removed earth.
 - Earthen canals
 - lined canals
 - rectangular canal
 - concrete canal
- _____ is the percent of power input to the pump shaft (the brake power) that is transferred to the water.
 - Capacity
 - Efficiency
 - Head
 - Waterpower

Test II: Short Answer & workout Questions (12 point)

- What are the characteristics of a good irrigation farm system in terms of water supply?
- What things will be check on the delivered equipment?
- What are the two most factors to select a pump?
- List down materials needed to install micro-irrigation system.
- The water supplied by a pump fills a container of 1000 liters in 1hr and 30min. What is the flow rate of this pump in l/s?

Note: Satisfactory rating - 15 points Unsatisfactory - below 15points
You can ask you teacher for the copy of the correct answers.

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Operation Sheet -1

3.1 Prepare materials tools and equipment used for installation work

A. Tools and equipment's

- ✓ automatic level,
- ✓ laser level,
- ✓ dumpy level,
- ✓ staff, boning rods,
- ✓ pegs,
- ✓ notebook,
- ✓ pencil and
- ✓ calculator;
- ✓ rakes,
- ✓ shovels,
- ✓ spades,
- ✓ rollers,
- ✓ wheelbarrows,
- ✓ hoses and
- ✓ hose fittings;
- ✓ ditch witches,
- ✓ backhoes,
- ✓ front-end loaders,
- ✓ graders,
- ✓ mechanical rollers,
- ✓ trucks,
- ✓ hydraulic trailers,
- ✓ and tractors and
- ✓ 3-point linkage equipment;
- ✓ Pumps and pump fittings;
- ✓ Fitting and welding tools
- ✓ Trenching Shovel
- ✓ Mattock
- ✓ Tamper:
- ✓ PVC Pipe Cutter
- ✓ Hack Saw:
- ✓ Wire Cutter/stripper:
- ✓ Screw Drive

B. Procedures to prepare materials tools and equipment's used for installation work

1. Wear suitable personal protective equipment.
2. Identify materials tools and equipment's for specific purpose
3. Check materials tools and equipment's
4. Select materials tools and equipment's in your store.
5. Return materials tools and equipment's to store.

LAP Test 1	Performance Test
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Name.....

ID.....

Date.....

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 1hour. The project is expected from each student to do it.

Task 1: Prepare materials tools and equipment's used for installation work

LG #15

Lo #2- Set Out and Prepare the Site

Instruction sheet2

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Determining crop water requirement
- Soil moisture measurement
- Soil water retention testing techniques
- Carryout pre-operational and safety checks on tools, equipment, and machinery
- Undertaking measurement and marking out of irrigation lines
- Confirming equipment operation and work practices

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Determine crop water requirement
- Soil moisture measurement
- Soil water retention testing techniques
- Carryout pre-operational and safety checks on tools, equipment, and machinery
- Undertake measurement and marking out of irrigation lines
- Confirm equipment operation and work practices

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

Information Sheet 2

2.1. Determine Crop Water Requirement

2.1.1 What is Crop Water Requirement

Crop water requirement is the water required by the plants for its survival, growth, development and to produce economic parts. This requirement is applied either naturally by precipitation or artificially by irrigation. Hence the crop water requirement includes all losses like:

- Transpiration loss through leaves (T)
- Evaporation loss through soil surface in cropped area (E)
- Amount of water used by plants (WP) for its metabolism.

These three components cannot be separated so easily. Hence the ET loss is taken as crop water use or crop water consumptive use.

- Other application losses are conveyance loss, percolation loss, runoff loss, etc., (WL).
- The water required for special purposes (WSP) like peddling operation, plugging operation, land preparation, leaching, requirement, for the purpose of weeding, for dissolving fertilizer and chemical, etc. Hence the water requirement is symbolically represented as: $WR = T + E + WP + WL + WSP$ Or

$$WR = IR + ER + S \quad \text{or}$$

$$WR = CU + WL + WSP \quad CU = E + T + WP$$

Where

IR - Irrigation requirement;

ER - Effective rainfall and S - Contribution from ground water table.

The crop water requirement varies from place to place, from crop to crop and depends on agro-ecological variation and crop characters. The following features which mainly influence the crop water requirement are:

1) Crop factors;

- Variety
- Growth stages
- Duration
- Plant population
- Crop growing season

2) Soil factors;

- Structure
- Texture
- Depth
- Topography
- Soil chemical composition

3) Climatic factors;

- Temperature
- Sunshine hours
- Relative humidity
- Wind velocity
- Rainfall

4) Agronomic management factors;

- Irrigation methods used
- Frequency of irrigation and its efficiency
- Tillage and other cultural operations like weeding, mulching etc

Irrigation requirement: -The field irrigation requirement of crops refers to water requirement of crops exclusive of effective rainfall and contribution from soil profile.

It may be given as follows $IR = WR - (ER + S)$ IR - Irrigation requirement; WR - Water requirement; ER - Effective rainfall; S - Soil moisture contribution Irrigation requirement depends upon the

- a) Irrigation need of individual crop based on area of crop
- b) Losses in the farm water distribution system etc.

All the quantities are usually expressed in terms of water depth per

Net irrigation requirement; - It is the actual quantity of water required in terms of depth to bring the soil to field capacity level to meet the ET demand of the crop. $d =$ Net irrigation water to be applied (cm) $M_{fc} =$ FC in the layer (%) $M_{bi} =$ Moisture content before irrigation in the layer (%) $A_i =$ Bulk density (g/cc) $D_i =$ depth (cm) $n =$ number of soil layer

Gross irrigation requirement; -The total quantity of water used for irrigation is termed gross irrigation requirement. It includes net irrigation requirement and losses in water application and other losses. The gross irrigation requirement can be determined for a field, for a farm, for an outlet command area, and for an irrigation project, depending on the need by considering the approximate losses at various stages of crop.

Irrigation frequency: -Irrigation frequency is the interval between two consecutive irrigations during crop periods. It depends upon the rate of uptake of water by plants and soil moisture

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supply capacity to plant and soil moisture available in the root zone. Hence it is a function of crop, soil and climate. Normally, irrigation should be given at about 50 percent and not over 60 per cent depletion.

Irrigation period: -Irrigation period is the number of days that can be allowed for applying one irrigation to a given design area during peak consumptive use period of the crop.

The stage at which the water stress causes severe yield reduction .It is also known as moisture sensitive period. Moisture stress during the sensitive period reduces the yield. For most of the crops the least sensitive stages are ripening except for vegetables like Lettuce, Cabbage etc.

2.1.2 How to Estimate the Water Requirement of Crops?

The following points highlight the top five methods used for estimating the water requirement of crops. The methods are:

1. Lysimetric Technique
2. Water Balance Techniques
3. Soil Water Depletion Method
4. Field Experiment Plots Method
5. Estimation of ET from Climatological Data.

1. Lysimetric Technique:

Lysimeter was constructed by Philippe de La Hire (1640-1718). Lysimeter is a proven method to provide complete information on all the components of water balance. It can be used for measuring the amount of percolating water and precipitation as well as to quantify water balance in soil column.

A lysimeter is a large container through which water losses and gains can be measured in soil in which crops are grown. The container is fitted with suitable inlets for irrigation and outlets for drainage. The lysimeters are buried in the soil and are surrounded by the same crop as is grown inside. The size of lysimeter varies from small oil drums to large size and deep lysimeters. They can be either the non- weighing or weighing type.

For weighing lysimeters, actual evapotranspiration can easily be calculated using the following equation: $E_t = P - S \pm \Delta S$

Where, E_t , actual evapotranspiration (mm); P , the precipitation (mm); S , the amount of seepage water (mm); and, ΔS , change in the amount of stored water (mm).

For non-weighing lysimeters, changes in water balance are measured volumetrically weekly or biweekly. No accurate daily estimates can be obtained. Weighing lysimeters can provide precise information on soil moisture changes for daily or even hourly periods. The lysimeter is placed inside another tank which is in contact with the surrounding soil.

2. Water Balance Techniques:

Water balance models were developed in the 1940s by Thornthwaite (1948) and were later revised. It is also known as inflow-outflow method and has been mostly used to make quantitative estimates of water resources and the impact of man's activities on the hydrologic cycle suitable for large area over long period of time. On the basis of the water balance approach, it is possible to make a quantitative evaluation of water resources and its dynamic behaviour under the influence of man's activities.

The basic concept of water balance is: input to the system – outflow from the system = change in storage of the system (over a period of time).

The basic equation may be formulated as follows:

$$CU = P + I + \Delta GW - R$$

CU = yearly consumptive use of water over a large area (hectare meter)

P = yearly precipitation (area in hectare × precipitation in meter)

I = surface water inflow into the area (hectare meter)

ΔGW = change in the ground water storage (hectare meter)

R = yearly outflow (run off) from the area (hectare meter)

3. Soil Water Depletion Method:

In this method, soil moisture content is measured from various layers of soil before and after each irrigation cycle or whenever soil profile is recharged by effective rainfall. The total depletion of soil moisture after every irrigation cycle from the root zone of crop give Consumptive Use (CU) of crops.

Consumptive Use (CU) of crops can be estimated as follows:

$$CU = \frac{M_{ai} - M_{bi}}{100} \times B_{di} \times D_i$$

Where;

CU = consumptive use of water

M_{ai} = soil moisture (%) after irrigation in the layer

M_{bi} = soil moisture (%) before irrigation in the layer

B_{di} = bulk density of the layer of soil

D_i = depth of the layer of soil

4. Field Experiment Plots Method:

Field experiment with various levels of irrigation is carried out to estimate the consumptive use of crops. Water table should be at least 3 m deep for field crops. This is reliable and common method for determining water requirement of crops used throughout the country. In this method, measurement of water applied through irrigation and effective rainfall and change in soil water reserve is calculated.

In simple words, total quantity of water used to produce the most profitable yield is called consumptive use (CU) of crop.

The consumptive use of crop can be calculated from the following equation:

$$CU = ER + IR_n + \Delta SW$$

Where,

CU = seasonal consumptive use (cm)

ER = effective rainfall (cm)

IR_n = net irrigation applied to realize most profitable yield (cm)

ΔSW = soil water contribution

Effective rainfall is the portion of rainfall falling during the growing period of a crop, which meets crop water requirement or crop evapotranspiration requirement.

This method is, otherwise, effective but having some limitation to get correct estimation of crop water requirement, i.e. amount of actual soil water content before and after irrigation, deep percolation loss of water.

5. Estimation of ET_c from Climatological Data:

Evapotranspiration (ET) is the loss of water from a vegetative surface through the combined processes of plant transpiration and soil evaporation (ET is equivalent to and frequently referred to as consumptive use). Both environmental and biological factors affect ET. Evaporation and transpiration occur simultaneously and there is no easy way of distinguishing between the two processes. Apart from the water availability in the top soil, the evaporation from a cropped soil is mainly determined by the fraction of the solar radiation reaching the soil surface.

This fraction decreases over the growing period as the crop develops and the crop canopy shades more and more of the ground area. At sowing, nearly 100% of ET comes from evaporation, while at full crop cover; more than 90% of ET comes from transpiration. The evapotranspiration rate is normally expressed in mm per unit time.

Evapotranspiration Concepts:

1. Climatic factors (temperature + wind + humidity) + well watered grass = ET_o
2. $ET_o \times$ well watered crop (optimal agronomic condition) = ET_c
3. $ET_o \times$ water and environmental stress = ET_c adjusted

ET_o is a climatic parameter expressing the evaporation power of the atmosphere. ET_c refers to the evapotranspiration from excellently managed, large, well-watered fields that achieve full production under the given climatic conditions. Due to suboptimal crop management and environmental constraints that affect crop growth and limit evapotranspiration, ET_c under non-standard conditions generally requires a correction.

The ET_o is usually expressed in millimetres per unit of time, e.g. mm/day, mm/month, or mm/season. Grass has been taken as the reference crop. ET_o is the rate of evapotranspiration from a large area, covered by green grass, 8 to 15 cm tall, which grows actively, completely shades the ground and which is not short of water.

2.1.3 Factors Affecting Water Requirement of Crops

1. **Water Table:** If the water table is closer to the ground surface, the water requirement will be less. In case it is much beneath the ground surface, the water requirement of crops will be more.
2. **Climate:** In warm climate, the evaporation misfortunes more and henceforth the water requirement of crops will be more and the other way around.
3. **Ground Slope:** If the slope of the ground is steep, the water streams down rapidly and the soil gets brief period to retain imperative moisture bringing about water misfortune. In this way, the water requirement of crops will be all the more however in the event that the ground is level, the water streams gradually and the soil gets sufficient opportunity to retain the adequate moisture. Along these lines, the water requires is less.
4. **Intensity of Irrigation:** If the intensity of irrigation for a specific crop is high then more region goes under the irrigation framework and the water requirement of crops is more and the other way around.
5. **Type of Soil:** In sandy soil water permeates rapidly and can't be held. In this way, the water requirement of crops is all the more however the clayey soil can hold water close to the root zone of the crops, so it requires less water.

2.2. Soil Moisture Measurement

2.2.1 What is Soil moisture?

Soil moisture refers to the relative water content in the soil. It can be expressed in the form of:

1. Dry -weight basis

Whenever field soil moisture samples are collected and the contents oven dried, the soil moisture content is reported as a percentage of the dry -weight of the soil sample. i.e.

$$MC = \frac{\text{Sample wet wt.} - \text{Sample dry}}{\text{Sample dry wt.}}$$

$$MC (\%) = \frac{\text{Wt. of water (Mw)} \times 100}{\text{Wt. of solid (Ms)}}$$

2. Volumetric basis

It is the ratio of volume of water to the total volume. i.e.

$$V = V_w/V_t = \frac{V_w}{V_s + V_a + V_w} \times 100$$

If the bulk density of the soils is known, the volumetric moisture content can be expressed in terms of MC as:

$$V = \rho_b \times MC$$

Where: ρ_b is the bulk density of the soil

$$\rho_b = M_s/V_t$$

Sometimes the level of water in the soil is expressed in terms of degree of saturation, which is a measure of the portion of the pore space filled with water. It is given by:

$$S = V_w/V_v = V_w/V_a + V_w$$

When all the pore spaces are filled with water, the soil is said to be fully saturated and the value of S is 100 percent. This means, in simple words, the maximum amount that a given soil can hold water.

2.2.2 Soil-Water Measuring Methods and Devices

A variety of methods and devices can be used to measure soil-water. These include the feel method, gravitational method, tensiometer, electrical resistance blocks, neutron probe, Phone cells, and time domain reflectometer. Most of these methods and devices do not measure soil-

water directly; they measure a property of the soil that can be related to soil-water status and are therefore called indirect methods. These methods differ in their ease of use, reliability, cost, and amount of labour required.

Methods and Devices:

1. Tensiometers
2. Soil probe or soil sampling
3. Electrical resistance blocks
4. Neutron moisture meters or neutron probs
5. Dielectric soil moisture sensors
6. Feel Method
7. Gravimetric Method
8. Phene Cell
9. Time Domain Reflectometer

1. Feel Method

As its name implies, the feel method involves estimating soil-water by feeling the soil. This method is easy to use, and many growers schedule irrigation in this way. However, this method is entirely subjective; the results depend on the experience of the individual making the measurement. The reliability of this method is usually poor unless the operator is very experienced. The feel method is not generally recommended and should be used only as a last resort.

2. Gravimetric Method

With the gravimetric method, soil moisture is determined by taking a soil sample from the desired soil depth, weighing it, drying it in an oven (for 24 hours at 220 degrees F), and then reweighing the

dry sample to determine how much water was lost. This method is simple and reliable. Unfortunately, it is not practical for scheduling irrigation because it takes a full day to dry the sample. In a sandy soil that dries quickly, irrigation may be needed before the results of the measurement are obtained. The gravimetric method is most useful for calibrating other devices for measuring soil-water.

3. Tensiometer

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A tensiometer is a sealed, airtight, water-filled tube (barrel) with a porous tip on one end and a vacuum gauge on the other. A tensiometer measures soil water suction (negative pressure), which is usually expressed as tension. This suction is equivalent to the force or energy that a plant must exert to extract water from the soil. The instrument must be installed properly so that the porous tip is in good contact with the soil, ensuring that the soil-water suction is in equilibrium with the water suction in the tip. The suction force in the porous tip is transmitted through the water column inside the tube and displayed as a tension reading on the vacuum gauge. Soil-water tension is commonly expressed in units of bars or centibars. One bar is equal to 100 centibars (cb).

4. Electrical Resistance Blocks

Electrical resistance blocks consist of two electrodes enclosed in a block of porous material, as shown in Figure 2. The block is often made of gypsum, although fiber glass or nylon is sometimes used. Electrical resistance blocks are often referred to as gypsum blocks and sometimes just moisture blocks. The electrodes are connected to insulated lead wires that extend upward to the soil surface.

Resistance blocks work on the principle that water conducts electricity. When properly installed, the water suction of the porous block is in equilibrium with the soil-water suction of the surrounding soil. As the soil moisture changes, the water content of the porous block also changes. The electrical resistance between the two electrodes increases as the water content of the porous block decreases. The block's resistance can be related to the water content of the soil by a calibration curve.

5. Neutron Probe

The neutron probe uses a radiation source to measure soil-water. An empty tube (access tube) with a 2-inch inside diameter must be installed vertically in the soil at each field location where the soil-water is to be measured. When properly calibrated, the neutron probe is easy to use, reliable, and accurate, but it is expensive (\$3,000 to \$4,000 per unit).

One of its advantages is that soil-water measurements can be made easily at different depths in the soil profile. Because of its cost, a neutron probe is not as practical as other methods for on-farm use. It may be a viable option for operators with large acreages of irrigated land. At present, it is used by some irrigation consultants to perform the technical tasks required to schedule irrigation.

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6. Phene Cell

The Phene cell works on the principle that a soil conducts heat in relation to its water content. By measuring the heat conducted from a heat source and calibrating the conductance versus water content for a specific soil, the Phene cell can be used reliably to determine soil-water content. Because the Phene cell is placed at the desired soil depth, a separate cell is needed for each depth at each location to be monitored. A cell costs about \$100, and the instrument required to measure the heat dissipation costs an additional \$1,000. For irrigating small acreages, the total cost of using the Phene cell is less than that of the neutron probe. For large acreages, the neutron probe may be more cost effective.

7. Time Domain Reflectometer

The time domain reflectometer (TDR) is a new device developed to measure soil-water content. Two parallel rods or stiff wires are inserted into the soil to the depth at which the average water content is desired. The rods are connected to an instrument that sends an electromagnetic pulse (or wave) of energy along the rods. The rate at which the wave of energy is conducted into the soil and reflected back to the soil surface is directly related to the average water content of the soil. One instrument can be used for hundreds of pairs of rods. This device, just becoming commercially available, is easy to use and reliable.

2.2.3 Soil moisture principles

Important soil characteristics in irrigated agriculture include:

- The water-holding or storage capacity of the soil;
- The permeability of the soil to the flow of water and air;
- The physical features of the soil like the organic matter content, depth, texture and structure; and
- The soil's chemical properties such as the concentration of soluble salts, nutrients and trace elements.

2.3. Soil Water Retention Testing Techniques

2.3.1. What is Soil Retention?

If you have ever taken a walk along a sandy beach, you probably observed that there is a place quite near the water's edge where the ground is dry enough and firm enough to easily walk on. In contrast, if you have walked along the edge of a lake or pond where the surrounding soil was fine-textured, you probably found that the ground near the water's edge was wet and muddy. The

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differences you experienced in those two cases can be partly explained by the differing capabilities of coarse- and fine-textured soils to retain, or store, water.

Soil water retention is a major soil hydraulic property that governs soil functioning in ecosystems and greatly affects soil management. Soil moisture form a major buffer against flooding and water capacity in subsoil is a major steering factor for plant growth. Soil is generally made up of varying mixtures of three sizes of soil particles, sand, silt and clay, known as texture.

Generally, water retention is inversely related to permeability. Sandy soils have the lowest water retention, followed by silt, and then soils high in clay. Soil can process and contain considerable amounts of water. They can take in water until they are full, or until the rate at which they can transmit water into and through the pores is exceeded. Some of this water will steadily drain through the soil and end up in the waterways and streams but much of it will be retained, away from the influence of gravity for use of plants and other organisms to contribute to land productivity and soil health.

2.3.2. Soil Water Retention Testing Techniques

1. Penetration Rates

Puddles that linger around your trees for days after a moderate rainfall indicate soil with too much clay. Soil that dries within hours of watering is likely to have too much sand. You can duplicate the process yourself. If an inch of water penetrates the soil in a bucket down to about 12 inches, your soil is sandy and doesn't retain water well. A 7-inch penetration rate indicates a loamy soil, and 4 to 5 inches of penetration indicates a soil high in clay, according to the editors of “Sunset” magazine.

2. The Squeeze Test

On a day when the soil is neither too wet nor too dry, a fistful of soil formed into a ball with your hand tells you a lot about its structure and capacity to retain water. Sandy soil that has not retained much moisture will fall apart immediately or may not even form a ball at all. Clay soil, that retains too much water, will form a hard lump. If the soil holds together in a ball but breaks apart when you tap it, you have loam, which holds the perfect amount of water.

3. The Ribbon Test

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Similar to the squeeze test, the ribbon test measures a small bit of soil and water. This test begins with dry soil and a few tablespoons of water formed into a ball and kneaded into a flat ribbon of soil. If the ribbon reaches under 1 inch before breaking or if it isn't even able to form a ball, the soil doesn't retain water well. If the ribbon reaches 1 to 2 inches before breaking, it is a good mix of clay and loam, and if it reaches longer than 2 inches, it is clay.

4. Soil Drainage in a Hole

A 2-foot deep hole offers another way to measure water retention. The hole is filled with water and allowed to drain. It is filled a second time and the time it takes to drain again is measured. If the water drains away within 2 to 3 hours, the drainage is good. If the water remains for 5 to 10 hours, it has only moderate draining capacity, and if it remains for 12 hours or longer the soil is mostly clay, with poor drainage.

2.4 Carryout Pre-Operational and Safety Checks on Tools, Equipment, and Machinery

The pre-operational check is important for the workers safety. It involves a daily check of the machines health. Currently the pre-ops check is often skipped or not conducted in the right way.

Any forklift or warehouse machine that needs repairs, maintenance or is observed to be unsafe to operate has to be taken out until such repair or maintenance has been done.

How can you then tell if the forklift has to go to maintenance? The operator is responsible to perform the pre-operational check before operating the machine.

Performing the pre-operational check is important for the safety of the operator and everyone in its working environment. Unfortunately this safety check is often forgotten or ignored. Not every operator is aware about the items that need to be checked before he can start his machine and begin to perform his daily tasks.

Once the pre-operational check has been performed the truck can be started and the operator can start his daily task.

For big operation it is possible to call for help. The supervisor can log-in and help the operator with potential issues.

2.4.1 Benefit of Pre-Operational and Safety Checks

1: Lowering the Risk of Workplace Injuries through regular safety checks

Using a pre start checklist prior to starting projects is a smart workplace habit. By preventing workplace injuries, you can save a lot of money from paying hospital bills, insurance, fines, and

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workplace compensation. You can also prevent legal suits that could damage the credibility and profitability of the business.

2: Save money through regular machine maintenance

Regular inspection of the equipment with a pre start checklist can also decrease the amount spent by your company on repair and replacement. The routine check-ups can provide early identification of the parts that need adjustments, repair, or replacements. This can prevent the gradual deterioration and break down of the entire machinery. Monitoring and maintaining equipment can help keep the equipment in its best shape and extend its years of service.

3: Increase workplace productivity

Most importantly, a smooth and problem-free operation automatically translates to increased productivity. The resources, time, and energy can be redirected towards other functions like increasing capacity and marketing which can all contribute to overall business profitability.

What should the inspection cover?

The coverage of machinery inspection depends on the type, use, and condition of your equipment. In any form, an inspection always focuses on the parts and components of the equipment which are related to safety.

Heavy equipment often requires more extensive inspection. Qualified workplace inspectors survey the exterior and interior parts of the heavy equipment especially the safety features like emergency brakes and warning devices. They also perform hands-on testing to see the performance and functionality of the equipment. The final evaluation combines the results of the component checkup and testing.

What does Pre Start Checklist cover?

There are 2 types of pre start checks. The first is a daily inspection that ensures safety of the equipment before each work day. The second is a more thorough inspection of machine safety and maintenance requirements. There is also a place to track and record machinery repair logs.

Daily pre start inspections usually include the following elements for evaluation:

- Safety features
- Communications
- Doors
- Heating/Cooling
- Visible leaks
- Lights
- Wheels
- Glass
- Bodywork

Weekly pre start inspections covers components such as:

- Brake and clutch
- Engine performance
- Oil level and condition
- Tyres and wheel parts
- External windows and accessories
- Warning systems
- Load resistance
- Cabin heating and cooling
- External windows and mirrors
- Battery
- Electrical wires
- Meters
- Transmission Functions
- Exhaust System

The scope of each Inspection

The scope of inspection also varies with the type of check-up.

1. The pre start check-up is usually a quick assessment of vital components like electric cables, hand-held power tools, brakes, and lights.
2. The weekly check-up, on the other hand, ensures the functionality of more components like safety devices, tyre pressures, mirrors, and cameras.
3. Preventive maintenance takes a longer time to complete because of a more in-depth examination of the equipment. This is conducted by the manufacturer or third-party technician annually or quarterly, depending on recommendations and agreements.

Who should carry out the inspection?

The inspection of your equipment can be carried out by any qualified individual who knows the parts and operation of machinery.

Normally, individuals with long experience in using and handling the same equipment are preferred and employed by the companies to conduct the routine and quick pre start check-ups. Their familiarity with the components and the system enables them to monitor and detect minor problems efficiently.

However, more complex and heavier equipment often requires a higher level of competence and qualifications of the inspector. Engineers and technicians are frequently hired by the company to do in-house maintenance and repair of equipment.

The preventive maintenance and extensive repair services are commonly referred to and conducted by the manufacturers or another company that specializes in the field.

2.5. Undertaking Measurement and Marking Out of Irrigation Lines

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2.5.1 Measuring and marking-out

Accurate measuring and marking out is needed for well-made products

Measuring and marking-out is a key part of any practical project. Planning for this will help ensure the success of the project and reduce the chance of mistakes and waste.

The aim is to prepare the materials you are working with for the next stages of the production process. Failure to measure and mark-out materials properly can lead to joints that do not match up or are incorrectly aligned and connected.

There are several key points to measuring and marking out correctly:-

- reading dimensions from sketches or drawings correctly
- choosing appropriate tools for your task and material
- using tools correctly and accurately
- checking over your measuring and marking out to ensure it is accurate

2.5.2 Types of Measuring and marking-out tools and their uses

Proper development of an item in the engineering world can be determined from the marking-out and how the operator has used it. Marking out and measuring is a crucial stage that can never be left behind when developing an item; I am sure any engineer can relate.

If a project is wrongly measured and mark out, hence not planned. There is a 95% probability that there will waste materials, and mistakes will occur.

The followings will help you know how to use measuring and marking-out tools correctly:

1. Knowing tools and where it is ideally used
2. Reading dimensions from drawings or sketches correctly
3. use the right tools for the right job, don't compromise
4. know how to use tools correctly and accurately
5. make a review of any measuring and marking-out to ensure its accuracy

2.5.3 Measuring and Marking-out tools

The followings stated below are different types of measuring and marking-out instruments used in irrigation for various operations. It includes:

1. Measuring tape:

The measuring tape is an instrument that contains a thinning sheet in a rubber case labeled with numbers on it. It can measure at least 5m long, making it applicable on large projects.

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2. Marking gauge:

The marking indicators are types of marking-out tools that scribe lines parallel to edges so that waste material can be clean off.

2.6. Confirming equipment operation and work practices

At this point, you need to hand over equipment that has been repaired, or on which some form of maintenance activity has taken place, and to confirm that the equipment is now ready to return to service. Following the maintenance activity, you will be required to, either set up the equipment and hand it over to a another person to complete the required start-up procedures, or complete the run-up operation yourself, ensuring that the equipment is ready for operation before handover. This will involve checking that all the required equipment and safety devices are operable and correctly set and/or calibrated, and that the equipment functions safely and correctly to the required specification.

On handing over the equipment, you will be expected to highlight any new, current or changed operating features of the equipment, and to inform the appropriate person of any future maintenance requirements. You must also ensure that you receive confirmation that everyone involved in the handover accepts that the maintained equipment is in a satisfactory condition to return to service.

Confirm that the equipment is ready for restart by carrying out all of the following checks, as applicable to the equipment being handed over:

- the maintenance activity has been completed and the equipment functions to specification
- all safety systems or features are functioning correctly
- any waste materials, safety barriers and warning signs have been removed (where appropriate)
- any auxiliary systems or equipment involved are connected and operable
- any environmental controls are operable (where appropriate)
- others involved in using the equipment are aware that the equipment is about to be operated/used

Carry out correct handover procedures for one type of equipment/service from the following:

- manual
- process/control
- medical equipment
- semi-automatic
- computer controlled
- other specific equipment
- fully automatic
- engineering services

Carry out all of the following during the handover procedures:

- operate/use the maintained equipment through a complete cycle in the presence of the appropriate person
- confirm that the other person accepts that the equipment functions satisfactorily to specification
- highlight to the appropriate person any modifications that would result in unusual features in the operating procedure
- inform the appropriate person of any future maintenance activities that may be required
- obtain agreement from the other person that they now accept responsibility for the equipment to be returned to service
- complete any necessary handover documentation
- confirm the other person knows how and who to contact for future maintenance requirements

Carry out handover procedures to one of the following:

- production/process operator
- maintenance supervisor
- supervisor of production/process
- other specific person

Carry out the handover following two of the following maintenance activities:

- breakdown
- scheduled servicing
- preventative maintenance activity
- modification to equipment

Complete the relevant paperwork from **one** of the following, and pass it to the appropriate people:

- job card
- company-specific documentation
- maintenance log or report
- other handover paperwork

Self-Check – 2

Written test

Name..... ID..... Date.....

Directions: Answer all the questions listed below.

Test I: Short Answer Questions/15pt/

1. What is the importance of pre-operational and safety check
2. What information you have to confirm regarding of Equipment operation and work practices?
3. What are the factors that affect the crop water requirement?

Test II: Multiple choices/5pt/

1. The following are losses includes crop water requirement: Except;
 - A. Transpiration
 - B. Rainfall
 - C. percolation loss
 - D. Runoff loss
2. Which one of the followings are not the benefit of pre-operational and safety check.
 - A. Lowering the Risk of Workplace Injuries through regular safety checks
 - B. Save money through regular machine maintenance
 - C. Increase workplace productivity
 - D. extravagancy
3. Which one of the following moisture content measurement method is a sealed, airtight, water-filled tube (barrel) with a porous tip on one end and a vacuum gauge on the other?
 - A. Tensiometers
 - B. Soil probe or soil sampling
 - C. Electrical resistance blocks
 - D. Neutron moisture meters
4. _____ is a climatic parameter expressing the evaporation power of the atmosphere

Note: Satisfactory rating - 20 points Unsatisfactory - below 20 points

You can ask your teacher for the copy of the correct answers.

Instruction sheet - 3

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Undertake installation work
- Micro-irrigation system
- Assembling and connecting components
- Completing and testing joints
- Maintaining a clean and safe work area
- Restoring the site and removing and disposing of waste material

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Undertake installation work
- Install Micro-irrigation system
- Assemble and connecting components
- Complete and testing joints
- Maintain a clean and safe work area
- Restore the site and removing and disposing of waste material

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet 3

3.1 Undertake installation work

The work consists of installing a complete underground sprinkler system as specified hereafter. When performing the work, you should furnish all labor, equipment, materials and permits necessary for the completion of the system. For example, the construction of the sprinkler system shall include furnishing, installing and testing of all pipe, fittings, valves, sprinkler devices, controllers, backflow preventers, inlet and discharge piping, manual drain valves, valve boxes, water meters, and all other components pertinent to the plans and specifications of this system. You should perform all trenching, excavating, boring, backfilling, concrete installation, electrical work, and any other work necessary for the completion of the project.

For example, if the work is drainage, it involves the construction, installation, replacement, repair, alteration, maintenance, relining, testing or commissioning of any part of:

- a. below-ground sanitary drainage system from the above-ground sewage or waste pipes to and including:
 - i. the land application system
 - ii. the connection to a holding tank; or
 - iii. the connection with the discharge reticulation system exclusively vested in an authority that has a sewerage district
- b. a below ground storm water drainage system from the above-ground storm water pipes to the point of discharge
- c. Any design work that is incidental to, or associated with

Typical Drainage and irrigation work

Drainage plumbing removes sanitary waste or storm water from a site. Experienced Drainage plumbers typically do the following work (and more):

- prepare trenches for installing irrigation pipes and laying of storm water and sanitary drains
- installing, connecting and testing underground sewerage treatments systems such as septic tanks and pressurized treatment systems
- installing grease traps
- installing drains, while ensuring the use of adequate support systems
- cutting and sealing disused underground drains
- repairing and replacing below ground drains and irrigation systems

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- installing onsite disposal systems such as mulchers, neutralizer tanks, above ground grease interceptors and septic tanks
- installing overflow provisions, including overflow relief gullies and reflux valves
- installing drainage vents and inspection shafts
- Locating and clearing blockages in underground drains.

3.2 Micro-irrigation system

Micro irrigation is a low pressure low-flow rate type of irrigation that can reduce the likelihood of watering a landscape.

This form of irrigation delivers water directly to where it is needed most the root zone of the plants.

Micro irrigation can increase yields and decrease water, fertilizer and labor requirements by applying water directly to the root zone; the practice reduces loss of water through conveyance, runoff, deep percolation and evaporation.

3.2.1 Methods and techniques of micro irrigation

Micro-irrigation system is a modern method of irrigation. In this method which we deliver water slowly. Usually delivered in the form of discrete droplets, continuous drops, and streams, etc.

There are mainly Five Types of Micro Irrigations System:

- A. **Sprinkler irrigation**; is a system or a device that delivers water for irrigation. It works in a pressurized form similar to rainfall. This form of irrigation provides water efficiently.

Devices used in this irrigation include

- High pressure sprinklers
- Sprays or guns

They supply the plant with the exact amount of water necessary for their optimum growth.

- B. **Drip irrigation**; in drip irrigation emitters directly deliver water to the plant root in to the soil. These emitters optimize and distribute the pressure from the water source using vents, twisters, and a convoluted or long flow path which allows only a limited amount of water to pass through. you can place the emitter on the ground and also planted deep in the soil. The water flowing through emitters moves with no barrier at the desired pace.

- C. **Spray irrigation** ; you can use a jet spray to deliver water and it is in wide use. it can move about easily in any size and you can place it in a lawn or use large farms to watering the crops.

- D. **Sub surface irrigation**; in this irrigation system, it applies water to plants from below the soils surface. This micro irrigation is beneficial and highly efficient. It needs only low

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levels of water pressure to perform efficiently. In this system, tubes and pipes are hidden under the soil for water delivery, which means there is no water at all.

It uses if the size of the subsurface irrigation system, water application can be exceedingly efficient and uniform. Subsurface irrigation prevents disease and weeds by eliminating stagnation of surface water.

A well- designed subsurface irrigation system can enhance the efficiency of water and fertilizer applications for the better quality of crop yields.

E. Bubbler Irrigation

You can install this system in the area where water needs are high. It applies the water through small streams and fountains, which dissipate water at the rate of approximately 230 liters per hour. It is preferred in which a large amount of water needs to be applied in a short span of time.

3.2.1 Micro-irrigation system components

The Basic Components of a Micro-Irrigation System are:

1. Pressure regulators and filter

The basis of micro-irrigation is always the pressure regulator, which is placed at the beginning of the micro-irrigation pipeline. You actually always need this. The only exception would be that you already have such a low pressure innately. Micro irrigation systems are typically rated at around 22 to 30 psi pressure. All irrigation manufacturers have pressure reducers in their range, whereby there are two basic types of pressure reducers:

- Pressure regulators with integrated filter
- Pressure regulators without integrated filter

Pressure regulators with integrated filters also ensure that no impurities get into the micro-irrigation system in parallel with the pressure reduction. Due to the low pressure and the small, easily clogged outlets, micro-irrigation has little opportunity to free itself from impurities and therefore a filter is mandatory here. To clean the filter, the pressure regulator can be opened and the filter removed. If no filter is integrated in the pressure regulator, a separate filter must be used instead.

The mesh size is the key figure for the filter. This is given in units of mesh and indicates the number of openings per inch. The higher this number, the tighter the mesh and the finer impurities are filtered out.

A mesh size of 100 means that there are 100 holes per inch. In Europe and many other regions the measure microns is used instead of mesh. The following blog post explains what this means and how mesh can be converted into micrometers and vice versa:

2. Micro Irrigation Pipeline

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Two types of pipe are used in micro-irrigation: ½ inch diameter pipe used as a pipeline to transport water between each micro-irrigation component. And thin ¼ inch diameter hose-like pipes that you can couple to the larger pipe to carry the water the last few feet. In this way, for example, individual flower pots or flower boxes can be supplied with water elegantly and unobtrusively.

With micro-irrigation, too, the sizes are normally the same across manufacturers, so that here too components can be mixed without problems or, if a component is replaced, another manufacturer can be bought. Don't be fooled by the different sizes given by individual manufacturers. This is because some manufacturers specify the inner diameter, but usually the outer diameter is given.

As with the pipes for lawn irrigation, you can alternatively use commercially available ½ inch PE pipes from sanitary technology without any loss of quality. This alternative does not exist with the thinner distributor hoses; here one has to rely on products from the garden irrigation manufacturers.

3. Connectors

To install the pipeline, only the fittings are missing to connect the pipeline pipes to each other or to lead them around corners, these are called connectors. In contrast to ordinary irrigation, which uses clamp connectors, micro-irrigation uses plug connectors. The tube is not inserted into the connector and then screwed tight with a clamp, but the connector is inserted into the tube. This is not as stable as a clamp connection, but it is sufficient for the low pressure that prevails in micro irrigation. If you can't do without clamp connectors, you can find a small range of micro-irrigation clamp connectors with a bit of searching.

The selection of different connectors is similar to that of lawn irrigation, although there is an additional type with the cross piece. Below is a brief list of the available connector types:

- Coupling fitting (for connecting the micro-irrigation pipeline to another piece of pipeline, to a thread, the lawn irrigation pipeline etc.)
- Elbow fitting (to realize 90 degree changes of direction)
- Tee fitting (to split a pipeline string into two strings)
- Cross fitting (to split a pipeline string into three strings)
- End fitting (to close the end of a tube)

The connector types listed above are available for both the large 1/2 inch pipeline and the small 1/4 inch distribution hoses. In addition, there are reducers to connect the large 1/2 inch pipeline with the small 1/4 inch pipeline:

- **Reducer fitting** (to reduce the large pipeline to the small distribution hose, usually designed as a Tee-piece: the pipeline continues straight, the small distribution hose branches off at a right angle)

4. And pieces for connecting drippers or sprayers:

- T-piece for spray nozzles (the pipeline continues straight, the outlet for the spray nozzle branches off at a right angle)
- T-piece with built-in dripper (the pipeline continues straight, a dripper built into the T-piece branches off at a right angle)

5. Pipe holders and guides

In addition to the connectors, there are a few assembly aids to make laying the pipes easier and to ensure that the pipes stay in the intended place:

- Pipe holder
- Pipe guides
- Pipe clamps

This lists all the components that are required for the micro-irrigation pipeline, i.e. for transporting the water to the consumers. The following points present the various options for supplying plants with water using drip irrigation.

6. Drip tubes

Drip tubes are tubes into which drippers are screwed or outlet openings are made at regular intervals, e.g. every inch. Each of these drippers or openings slowly drips a certain amount of water per hour, e.g. 0.5 gallons. There are drip tubes ready-made, i.e. you can buy them with drippers/openings already screwed in, or you can use a pipeline tube as described above and screw the drippers into the tube yourself at the desired distances. Only one dropper can be screwed into the thin 1/4 inch distribution hoses at the end of the hose. An overview of the range of different drippers can be found in the next point.

7. Dripper

A variety of different drippers are available. These can be distinguished according to the following criteria:

8. Fixed or adjustable amount of water

Most drippers release a fixed, predefined amount of water, but there are also models that allow the amount of water to be adjusted within a specified range.

9. According to the amount of water

There is a wide range of sizes for the drippers, which release a predefined amount of water: the most common sizes are 0.5, 1.0 or 2.0 gallons per hour, but models with up to 16 gallons per hour are also available. Hunter and Rain Bird color code their drippers based on their water volume.

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10. With or without pressure compensation

This may seem unnecessary at first glance; as it says a few lines before that the drippers release a certain amount of water. However: First of all, this only works approximately and only if there is a certain pressure in the line. If the assumed pressure is exceeded or not reached, if the pressure in the line fluctuates, or if the pressure in a longer tube at the beginning of the tube is significantly different than at the end of the tube, then the performance of the drippers deviates from that specified. In order to avoid this and to ensure that the desired amount of water is poured absolutely reliably and evenly, pressure compensating drippers are offered. These regulate the pressure down to a certain level, so that there is always the same pressure on all drippers. Visually, these are very easily recognizable by the more “beefy” design. Rain Bird and Hunter only offer pressure compensating drippers

11. Micro-Sprays

In contrast to drippers, from which the water only drips out, micro-sprays release the water in a fine shower of droplets. This fineness of the spray pattern and the comparatively smaller throw distance as well as the lower water consumption also distinguish the micro-irrigation spray nozzles from the spray sprinklers of lawn irrigation.

Compared to drippers, they have the advantage that you don’t have to run a pipe to all the places to be irrigated, but can irrigate the entire area from one or more points. This can be an advantage if, for example, you don’t want to have any pipes lying around in the vegetable patch that would interfere with your work. When placing it, it should be noted that plants grow tall and, if not planned ahead, can possibly change the throwing range of the sprayer, e.g. if the tomato plant in the vegetable patch piles up right in front of the sprayer. Here it is often advisable to attach the sprayers to ground spikes or extensions.

Micro-sprays are differentiated according to the following criteria:

12. By spray pattern

Either as a full-surface water umbrella (most common variant) or divided into thin water jets or swirled into individual droplets.

13. By irrigated circle sector

There are full-circle nozzles, nozzles that only water a semicircle (180 degrees) or a quarter circle (90 degrees). Some models also allow manual setting of the circle sector to be irrigated. One possible application, for example, is to place two 90-degree nozzles diagonally opposite one another in a bed in order to cover the bed area well.

14. By throw distance

There are sprayers with a very short throw and those with a slightly longer throw.

15. Throw range fixed or adjustable

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Some models have a fixed throw distance that only depends on the water pressure. Other models also allow manual adjustment of the throw distance. Instead of adjustable nozzles, some manufacturers use a separate control valve that is placed between the pipeline and the sprayer and allows the throw distance to be adjusted sleeplessly.

16. Submersible or not

Micro-irrigation sprayers are typically not submersible, but are fixed to a pipe, hose, stake or extension. However, there are a few retractable models: The Rain Bird Xeri-Pop is a pop-up sprinkler specially developed for micro-irrigation, which is connected to a 1/4 inch connecting line with a simple snap lock. In addition, both Rain Bird and Hunter offer their own micro-irrigation nozzle that can be installed in the housings of ordinary irrigation.

17. On spikes or not

Some of the micro-irrigation spray nozzles are already available in a fixed combination with a ground spike or a height extension.

18. Underground fleece mats

This is a whole new trend. Everyone has to decide for themselves to what extent it makes sense in the private sector. The product consists of non-woven mats approximately 32 inches wide with drip tubes incorporated into them. If the drip tubes start to release water, then the flow mats will gradually fill with water. This ensures an absolutely even watering, which also has the advantage that the fleece mats store the water for a very long time after the end of the watering and thus a water reservoir is available for a longer period of time.

According to the manufacturer, this makes sense below surfaces that should not get wet, such as areas in amusement parks or public parks that have a very high frequency of visitors. Another area of application is green roofs. The system also has the advantage that it is protected from vandalism by being installed underground. At the moment I'm only aware of Hunter's Eco-Mat system in this area.

19. Root Zone Irrigation

Both Rain Bird and Hunter offer solutions for targeted root zone irrigation of trees or large shrubs. A sieve tube is placed underground in the ground to the left and right of the tree or shrub, close to its root area. Depending on the model, these reach a depth of 10 to 36 inches and are connected to the irrigation pipeline just below the surface of the earth. During irrigation, the water is let directly into the screen pipes and thus reaches the roots of the trees directly.

3.2.3 Identifying the site for installation of the micro-irrigation system

How to Prepare for Using Micro-Irrigation Systems?

Plan the Micro-Irrigation System

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Before you proceed with the technical installation of the micro-irrigation system, first you need to make a plan.

Check out the four main steps to make a piping plan for a functional micro-irrigation system:

- Measure and draw the garden space
- Determine irrigation areas
- Estimate water flow and pressure
- Draw the pipeline of pipes

Constructing a brief plan is all it takes to ensure you are prepared for the installment process and that the irrigation system would work properly and effectively. Respectfully, you can purchase the right parts, drippers and sprinklers according to respective irrigation areas. With that in mind, do your best to avoid measurement errors.

A major reason for the use of micro-irrigation is also the much more sensitive irrigation, compared to the rather coarse jet of sprinklers. With this one would flush the soil out of a vegetable patch or injure young plants. With the fine droplets of micro-irrigation, this is not an issue.

From the above, the following areas of application for micro-irrigation result:

- hedges
- vegetable and plant beds
- flower pots and boxes
- plants in greenhouses
- planting in uneven or small-scale, irregular terrain
- root irrigation of trees
- balcony watering

3.3. Enterprise work procedure

3.3.1 Installation of Micro Irrigation System

Installation of an irrigation system is very important and a crucial part that greatly affects the system performance.

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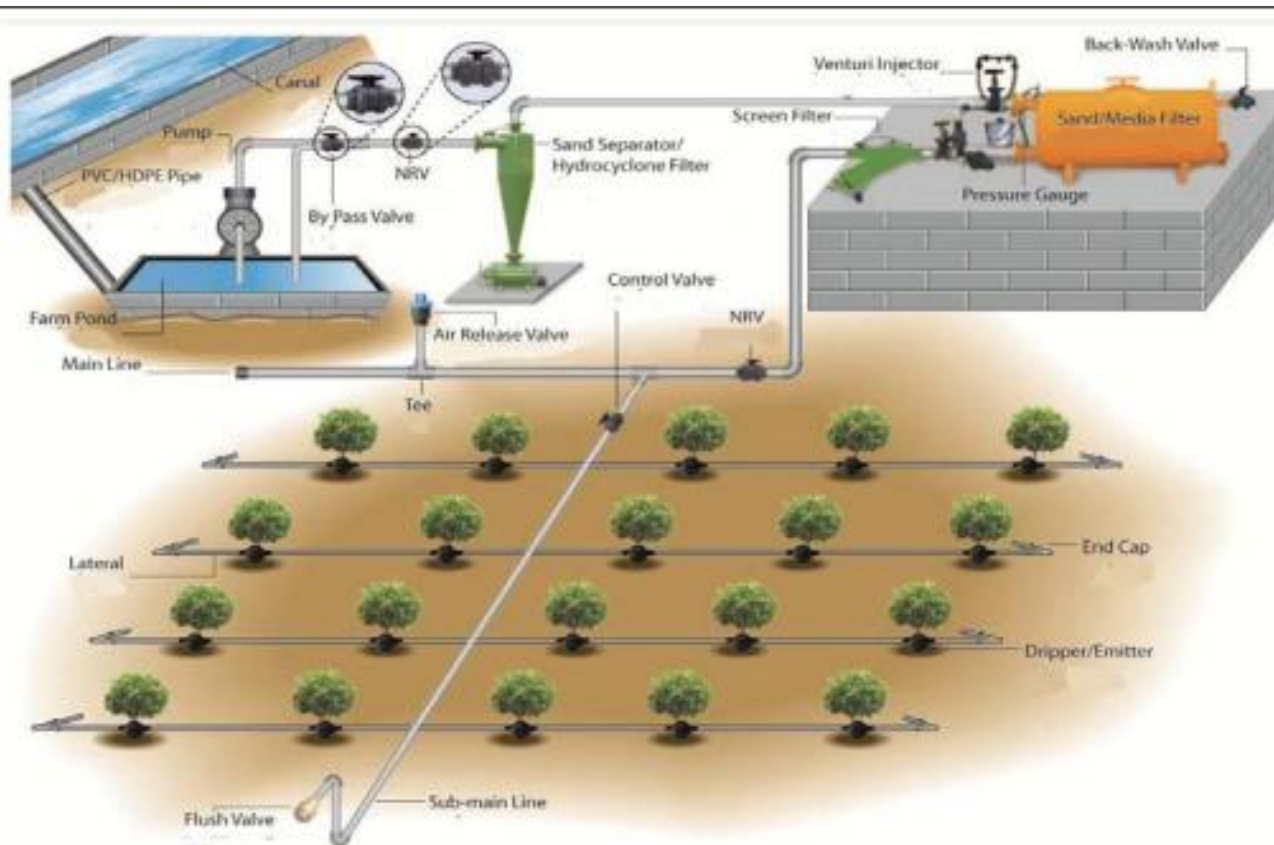


Figure 3.1 micro irrigation system components

1. Interpretation of Design Layout

Design layout should be readable and self-explanatory so as field technicians may be able to install the system properly and accurately as per layout. For this, the technician must thoroughly check/study the layout and the legends on it and locate the different main and sub main pipes on the layout. If the technician is unable to understand the layout, he, must then consult the site/design engineer to clarify the doubts in his mind. Subsequently, it should be checked that the physical situation on site are in accordance with that mentioned in the design layout. The installation of the system must be carried out strictly adhering to the design layout.

2. Installation Tools and Accessories

The necessary tools required for installation of micro irrigation system include

- Pipe wrench,
- spanner set,
- drill machine,
- screwdriver & pliers,
- cutting blade with frame,
- measuring tape,
- ejecto punch and
- Sand paper etc.

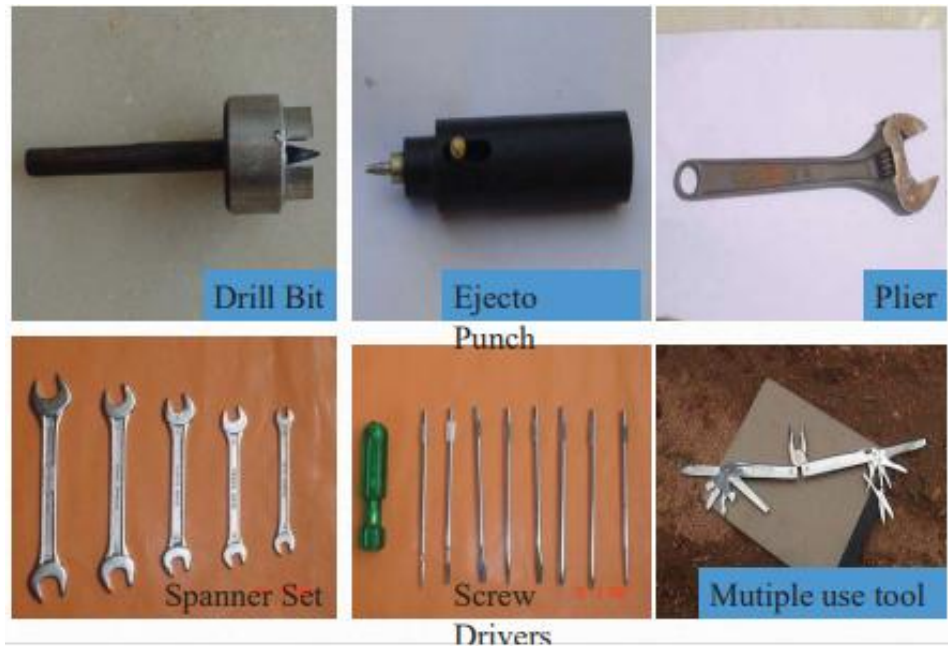


Figure 3.2 Installation Tools and Accessories

3. Head Unit Installation

Fixing of head unit is the first step in installation of HEIS scheme. The installation follows with the construction of platform. The platform should be leveled and large enough to provide ample space for hosting system component and necessary room for mixing fertilizers to be used in fertigation system. Pump set should be attached with platform via grouted bolts and connected with suction and delivery line as well as to the electric connection. Pressure gauges, flow meter and non-return valve should be installed as per manufacturer's recommendation.



Figure 3.3 Head Unit Installation

4. Trenching

Dimensions of trenches should be such that technician may have sufficient room for installation and jointing of pipes. Recommended trench dimensions should be 60-75 cm deep and 60 cm wide. The bottom of the trenches must be smooth, level and free of any sharp material such as stones or roots. A layer of river sand may be placed at the bottom of the trench in case of hard/rocky soil.

5. Laying PVC

During the installation/lying of the PVC pipe following steps must be taken into account;

- Cut the pipe to length with a hacksaw or pipe cutter. Make your cut straight so the pipe is fully seated in the fitting.
- Smooth and level the edges slightly with a knife or fine file.
- Insert the pipe into the fitting and adjust to the correct position. Mark the pipe and fitting with a reference line to make it easy to find the position again after you have added the jointing solvent.
- Remove the pipe from the fitting.
- Clean the surfaces to be mated with a jointing solvent.
- Brush both the outside of the pipe and the inside of the fitting with jointing solvent.

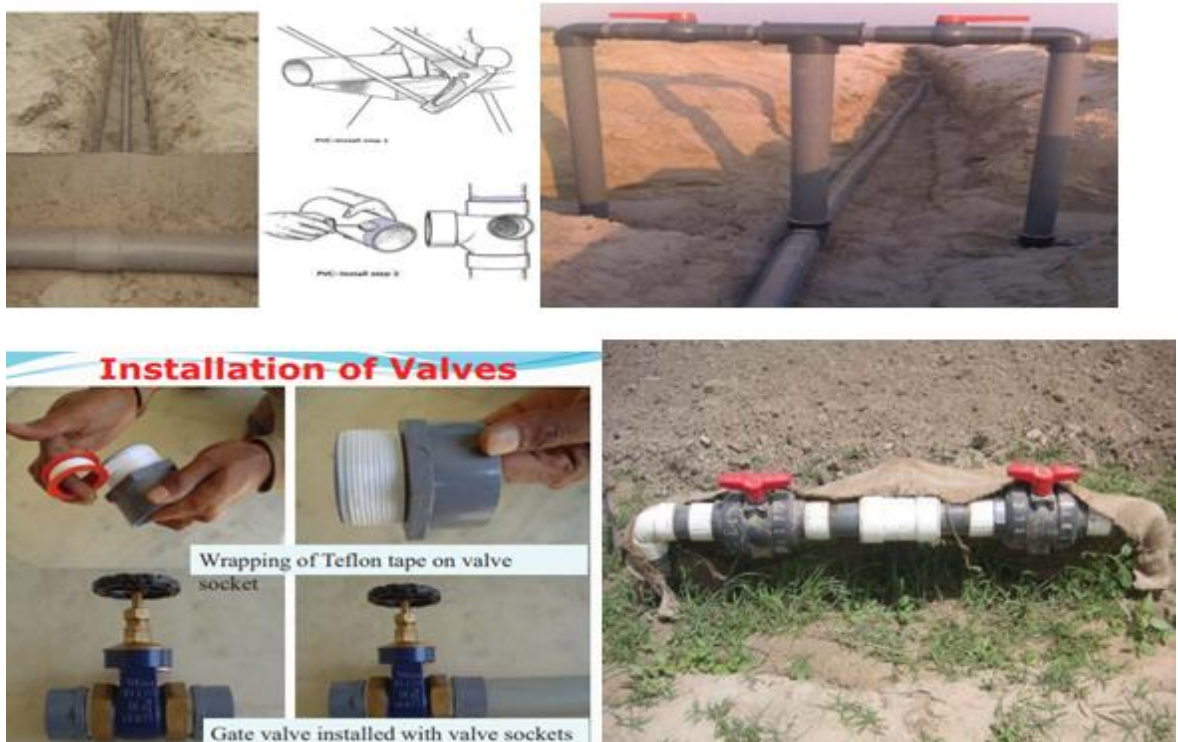


Figure 3.4 Installation of pipe and valves

6. Laying Lateral Lines

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Lateral should be laid as per design layout along the plant rows. Length of lateral should be cut about 3% more to be turn and locking the lateral from the end. Care should be taken to lay the lateral line early in the morning or in the evening so as lateral length should not be cut short as it will be stretched in the sun. When cutting the lateral for inserting into sub mainline or to close the end, cut should be straight enough to control leakage.



Figure 3.5 Laying Lateral Lines

7. Punching and Inserting Emitters

Always use the Ejecto Punch to make holes in the lateral line and care should be taken to install the dripper at required location. The distance between the emitters should be kept as per design. The residual punch material should not fall inside the lateral. Emitter should be inserted in the punched hole and the then pull out to fix it tightly.



Figure 3.6 Punching and Inserting Emitters

8. Back Filling

Backfilling is the process of refilling all trenches with soil again, covering all pipes, tubing and wires. Before you replace the dirt, screen the soil to remove large pieces. The dirt may contain rocks and other materials that can damage your pipes. Only fill the trenches half full, allow the water to move through the pipe line so that to assess any leakage or fault during installation. During the backfill with in roadways and side walk areas, all PVC pipe shall be bedded with crushed stone (less than $\frac{3}{4}$ - inch diameter) to 12 inches over crown of pipe. Remaining backfill shall be compacted thoroughly. Trenches shall not be backfilled until all required inspections and tests are performed. Backfill shall conform to the line and elevation of adjacent fields with no surface irregularities.

9. Testing and Commissioning

- Check whether the installation is carried out as per the set guidelines and to the drawing.
- The system should be tested before the final back filling of trenches.

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- Ensure all the control and flush valves of submains and lateral ends are open.
- Start the pump and allow the pressure to become stable.
- Ensure that there is no leakage at the joints in the sub & main line and at the grommet take off.
- Close sub main flush valves.
- Allow the lateral to completely flush out, then close their ends with end cap.
- Again check the sub main and lateral for leakage.
- Maintain the pressure at filters (1.5-2 bars at filter inlet), If excess pressure-open the bypass valve slowly.
- Check the discharge of dripperrandomly-use volumetric method.
- Check working of ARV (provided at submain inlet) and sub main pressure.
- In case of Gravel filter as a primary filter, back flush the same and maintain adequate sand level. Fertilizer tanks should be thoroughly cleaned. Use only 100% water soluble fertilizers.
- Check for the pressure at lateral end. Always maintain minimum 1 bar pressure at lateral end for proper discharge through emitters and minimize clogging chances.
- Always run the system with proper pressure to get maximum life / benefit of it.

3.4. Assembling and connecting components

3.4.1 Assembling Components

Assembly is a Process by which part samples (belonging to the same assembly standard are connected to one another. Assembling two basic parts always results in a new, larger composite part that can be used in future assemblies.

Assemble PVC piping consists of:

- Apply PTFE (Teflon) tape to the threaded (male) pipe end. Teflon tape (polytetrafluoroethylene, or PTFE), is a thin film used to seal pipe threads. Too much tape is as bad as too little. It will prevent a good seal. With the proper amount the pipe should thread together smoothly, sealing all gaps in the thread.
- Glue the PVC pipes:
 - ✓ Clean the pipe end and the inside wall of the connector collar.
 - ✓ Apply PVC primer to the ends, both inside and out.
 - ✓ Apply PVC cement everywhere primer was applied. The primer and cement combine to weld the pieces of PVC together.

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- ✓ Insert the pipe end into the connector using a twisting motion and hold the assembly in place for at least 30 seconds.
- ✓ Wipe off any excess solvent.
- ✓ Allow the pipe to dry for at least 15 minutes before allowing water to pass through.
- Assemble polypropylene piping:
 - ✓ Slide stainless steel adjustable clamps over the ends of the pipes to be connected.
 - ✓ Connect the pipes.
 - ✓ Tighten the adjustable clamps.

Steps to Install Micro-Irrigation System

Your seedlings are ready to be transplanted; you have drawn your plan and bought the parts accordingly: it is time to take action. Before you start, make sure you have all the necessary parts. Just like an electrical circuit, if a room is missing, the entire system will be paralyzed. Think about it!

Step 1; Wear suitable personal protective equipment

Step 2; Install the irrigation timer (optional)

If you want to automatically start watering, install a timer directly to your water outlet. The watering timer is optional, but remains one of the greatest benefits of micro-irrigation.

1. Place the battery
2. Attach the timer to the faucet
3. Set your program.
4. Connect your regular watering hose to the end of the timer

Step 3; connect the irrigation plant

The irrigation plant is the starting component needed to reduce the water pressure to 1.5 bar. Previously, using your plan, you have determined the maximum capacity of the water flow of each irrigation zone so that the number of drippers does not exceed this maximum. The 1000 plant has a flow rate of 1000 liters of water per hour, while the 2000 plant spins 2000 liters per hour.

1. Connect the irrigation unit directly to the water outlet or the garden hose;
2. Make sure it is tight.

Step 3; arrange your main network

Your main network provides water for the entire system over long distances. It is mainly composed of your big pipes (1/2 inch).

1. Cut the predetermined length of the main pipe (1/2 inch) with scissors.

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2. Be sure to walk around the area before cutting. Keep a few extra inches in case of miscalculation.
3. Place your pipes above the areas indicated on your plan.
4. Plant Gardena 8328 supports to secure the (1/2 ") pipes to the ground. If your piping is placed on a rigid floor, use Gardena 8380 jumpers designed to securely secure (1/2 ") lines to fixed surfaces.

Step 4; Add connectors

There are several types of connectors available in 2 sizes (1/2 "and 3/16"). The connectors allow to divide the pipes at 90 degrees ("L" junction), to divide them together ("T" shunt) and to divide them into 4 (cross bridging "X"). Note that the only connector that can switch from a large 1/2 "pipe to a small 3/16" pipe is the 8333 tee. Thanks to Gardena's patented Quick & Easy technology, the connectors are easy to install on the pipes. In order to be able to adjust and control water requirements per plantation area, shut-off valves to cut your lines separately will be required. There are shut-off valves for your lines (1/2 "and 3/16").

1. First, install the connectors that divert your main lines (1/2 ") between them.
2. Install your connectors' connectors (able to go from a large pipe 1/2 "to a small pipe 3/16").
3. Install your shutoff valves per planting area.

Step 5; connect your secondary network

Your secondary network provides water to a plant individually (end of line) and watering a row of plants for a short distance (in line). The latter is composed of small pipes (3/16 "). Drippers can also be installed directly on the large pipe (1/2 ").

1. Using scissors, cut your small pipes (3/16 ") according to the measurements designated in your plan.
2. Keep a few extra inches in case of miscalculation.
3. The pipes should be placed near the roots of your plants.
4. Connect the small pipes to your connectors.
5. Plant supports to secure small (3/16 ") earth pipes. If your pipes are laid on a rigid floor, use jumpers designed to secure small pipes (3/16 ") to fixed surfaces.

Step 6; Install the drippers

At this stage, your pipes should be connected together to make way for drippers. Their main function is to bring the water as close as possible to the roots of each plant, without loss of water by evaporation. There are two types of emitters: online drippers and end-of-line emitters. Usually, you should have previously chosen them based on your watering areas.

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1. To place a dripper on an end-to-end line, make a hole with the installation tool, then push in the dripper. Do not use a nail or other pointed object other than a punch because you could create irregular holes that cause leaks.
2. End-of-line emitters are installed directly at the end of a small pipe. Because you have chosen the right type of dripper to the size of your 3/16 “.

Step 7; Install the micro-sprinklers

The micro-sprinklers (spray nozzle) allow the water to be diffused in fine mist stably or in rotation at 365, 180 or 90 degrees. They are usually installed directly on a pipe (1/2 “).

1. Using the installation tool, drill the tubes where you want to put your sprinklers.
2. Screw the sprinklers firmly.

Step 8; Close your lines

Before closing a line, see if you can install an end-of-line drip to optimize watering, otherwise, there are two types of caps for your pipes: small and large.

1. Place the small caps to close your small pipes (if applicable).
2. Place the large caps to close your large lines (if applicable).

Step 9; Add conduit brackets

The brackets allow you to firmly hold your pipes on the ground or fix the drippers used to water potted plants. For a long segment, provide one support per meter.

Push the brackets directly to the floor. Avoid crushing them.

Step 10; Test the watering system

The ultimate step is to test your irrigation system to check for leaks! If you break a pipe, use the small caps to plug a hole.

1. Set the timer to manual mode
2. Open the faucet just enough so that the sprinklers emit light streams of water.
3. Once this is done, repeat the test to its full capacity.
4. Set the timer to automatic mode by choosing the times when watering will trigger according to the needs of the plants in your garden.

3.4.2 Advantages of Micro-irrigation Systems:

These systems are popular for a number of reasons, such as:

- They conserve water (making better use of water resources) than conventional hose sprinklers or a regular hose pipe, particularly when delivering water to garden beds, crops or individual trees.
- They are relatively cheap to install.

- They are easy to install, only basic hand tools are usually required.
- They only need relatively low water pressure to operate. This can be a real advantage in areas where water pressure may be a problem, and/or at times of high water demand.
- A pump can be fitted ahead of the system to increase water pressure if necessary.
- They can be easily repaired, maintained, or modified to suit changing needs.
- The pipes and tubes used in such systems are made from low density plastics, and are flexible and easy to hide among rocks and plants. Laterals can be buried and outlets placed in very obscure positions if so desired. If laterals are not buried, the gardener has even greater flexibility in being able to move the position of the outlet if desired.
- Systems can be automated for greater flexibility. You can simply turn them on, leave them, and they will turn off after a set time, or you can install a programmable controller that will turn your system on and off according to your instructions. This can be very valuable if you are away for extended periods.
- Both drippers and sprinklers can easily get clogged, but they are also both easily unblocked.

Drippers

- They are good for watering individual plants such as potted plants and isolated trees and shrubs.
- They work better in heavy clay soils where water penetration is slow.
- The concentrated wetting pattern they provide means they are better on severe slopes (they should be located up the slope from the plant) to minimise erosion.
- They are preferable for plants (e.g. roses) which may suffer from an increased likelihood of fungal diseases if watered from above.
- They will still work when water pressure is extremely low.
- They help keep weeds down as there is less damp soil surface for weed seed germination.

Micro-sprays / Sprinklers

Micro sprays can either be spray jets discharging a coarse to fine spray, or sprays which discharge the water in streams or fingers.

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Both are suited to:

- Fitting into any garden shape with a variety of watering patterns and flow rates available.
- Free draining soils because of the strongly vertical draining patterns of such soils (as opposed to a more horizontal pattern in heavy clay soils).
- Shallow rooted ornamentals, shrubs and annuals generally.

Micro sprays are better for:

- Exposed areas subject to wind.
- Penetrating dense foliage and compact garden beds.

Spray Jets are suited to:

- Protected areas and shade-houses.
- Areas requiring a moist microclimate, such as a fernery.

Also available are Mistlers to increase humidity and Rotor sprays for larger areas.

Some Design Considerations:

- When installing micro-jets or sprays make sure you have plenty of overlap of the spray patterns. This helps ensure a more even coverage, and reduces the risk of damage to plants from lack of water if one of the nozzles gets blocked.
- Pressure reduction valves may be required to reduce water pressure, otherwise you are likely to have leaks in your system or to have fittings blown off.
- Backflow valves are also necessary to prevent water from the irrigation system re-entering your water tap, which could possibly affect water quality in your mains system (e.g. contaminants from the irrigation system such as pests/diseases, or sediments).
- Filters should always be installed in each main line to reduce the likelihood of sediments building up and clogging the pipes or attachments.
- When installing a system it can be either above or below ground (or both). Lay it down first on the surface while you follow your plan. Use connection pieces rather than forcing the hose round sharp bends.
- Flush out the system well before connecting any nozzles.

How long and when to water

- In sandy soils you can usually apply a lot of water quickly and it will be easily absorbed.
- In heavy clay soils you should water slowly over a long period. Heavy applications will not soak in quickly enough, and a lot will be lost as run off.
- Deep rooted plants such as trees should be watered slowly over a long period, so as to wet the soil to a greater depth.

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- Deep rooted plants can be watered less often than shallow rooted ones. Shallow rooted plants such as annual flowers and vegetables need frequent watering, but of a shorter duration at each watering.
- Consider the time of day when you are watering. It is best to water when the plants will gain the most benefit and won't lose a lot of water through evaporation and transpiration. This is normally worse when it is windy, hot, dry, and sunny. So if these conditions apply in full or part, try to water early in the morning or/and evening.
- Just because the garden looks wet doesn't mean that the water has reached the plant roots. Take a stick and dig under the soil in your garden to see how deep the water has penetrated. Infrequent deep watering is far more preferable to frequent light shallow watering as it encourages the roots to expand downwards and outwards seeking the deeper water.
- In cold climates, particularly winter, water with micro-sprays in mid-morning, and not at all during the evening due to the risk of water freezing on the plants overnight which can cause damage to some plants.

Prevention of Clogging

the advantages of this type of irrigation are numerous, but these can be nullified by clogging of the delivery points. This in turn can lead to isolated dry spots in a crop, and in the extreme, death of the effected plants.

To help counteract this problem, the following measures should be considered.

- Installation of a reliable filtration system for the irrigation system.
- Regular inspection of all watering points to check for blockages.
- Regular flushing or washing of filters.
- Flushing of the whole system, ideally at least once a year, with clean water to remove any debris. Nozzles can be removed, washed clean in a bleach solution, and then replaced.
- If your irrigation water is of poor quality then pre-treat it (e.g. run it through a large scale filter or through a settling pond to remove sediments) before using it for irrigation.

3.5. Completing and Testing Joints

3.5.1. Flushing and checking

You should flush and check your system as soon as it is finished to make sure it is working properly. Do one section at a time.

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- Open the ends of the main pipe.
- Flush the system out with fresh water until it runs clear (a minute or so.) use as much water pressure as possible to help remove any dirt.
- Seal the ends of the main pipe; fold over and tie with wire or use a plug and clamp.
- Manually check every joint for leaks and also check every dripper and spray for proper functioning

Finish earth works: make sure all the trenches are filled in and the sign is clean up properly

3.5.2 Maintenance of irrigation system

A. General Maintenance Tips

Drip/Sprinkler irrigation systems requires very frequent maintenance on daily, weekly, monthly and seasonal basis. Maintenance tips if done regularly prior, during and after the operation of systems prove very useful in smooth running of the system without any unnecessary breakdowns. Some general maintenance tips are being listed below that may help in keeping the system trouble free for most of the times.

- Spare Parts of commonly required items should be kept at farm in secure place to protect them from rodents, theft and sunlight.
- Filter, Emitting Devices, Lines, Couplers and Connector should be checked most frequently as these are more sensitive parts of the system that require routine maintenance.
- Any leakage, blockage, and pressure variation should never be left unattended.
- Regular maintenance of equipment will reduce repairing costs, increase the system life and reduce the risks of any unnecessary interrupting during irrigation cycle.
- Carry-out regular and frequent filtration until the best cleaning/back flushing and washing schedule for the system is determined.
- Fluctuation in the operating pressure against the working/designed pressure is always an indication of some problem e.g. leakage, clogging or blockage in any of the system component.
- Always follow the instructions and guidelines given in the user's manual provided by the supply company.
- Always consult with the specialists, if problems cannot be easily handled by the farmer/operator.
- Maintain the system even it is not in operation for a longer period of time, remove easily detachable components (e.g. Laterals) from the system and keep them in a safe place.

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B. Checking Prior to Starting (Daily Checks)

General checking prior to running a system will take only few minutes but can save from many possible faults in the system. It is very important to check the following system components before running a system as a routine.

- Water in the Water Storage Tank (if system has been installed on WST).
- Voltage on the electric penel (if power source is electricity) and diesel in the engine (if power source is diesel engine) to ensure that sufficient quantity of diesel is available to complete irrigation cycle for the day).
- Inlet and out-let valves (these should be open).
- Status of the filter(s), flush once immediately after running the system.
- Valves connecting water supply line to fertilizer tanks are closed.
- Gauges on the system: immediately after running systems to check that system is running at designed/working pressure.
- Main delivery line is intact.
- Fertilizers are available, if fertilizer is to be injected during the irrigation cycle

C. Checking of Pressure Gauges and System Flushing

It is very important to keep an eye on the pressure gauges at frequent intervals during system operation. Increase in the pressure on the inlet pressure gauges tells the operator that there are some blockages in the filters and cleaning/flushing/back washing is needed. Similarly, increase in the pressure at the out let gauges shows that flow rate have been increased than the designed flow rate. It happens when mesh in the filter has been busted and required replacement. Pressure gauge at the inlet point of the main line shows pressure variation in the mainline that indicates blockage in the line if pressure has increased and indicates busting or heavy leakage at some point in the line if pressure has suddenly dropped. Hence, it can be stated that pressure gauges provide early warning from the potential damage to the systems and therefore must be monitored while operating a system. After having experience of running a system for quite some time operators can learn that how often he has to back flush his filter and flush system lines that mainly depend upon the water quality and capacity of the filters. By knowing the flushing requirement in general, operator must perform flushing of filters/system at specific intervals without waiting for increasing the systems pressure at pressure gauges. This practice may save the operators and system for any potential hassle and breakdowns during operation. Addition of

automated valves at drainage outlets of filters however can provide flexibility and ease to the operator besides better safety of the system.

1. Daily Maintenance

- Start the pump and allow pressure to become stable.
- Open the drain valves of hydro cyclone and screen filters.
- Back wash the sand media filter.
 - ✓ Open the back wash valve
 - ✓ Close the outlet valve
 - ✓ Open the bypass valve
 - ✓ Close the inlet valve
- Operate by pass valve to maintain pressure in the system
- Visit the field to rectify leakage/damage, if any

2. Fortnightly Maintenance

- Check the inlet & outlet pressure difference of sand media filter (≤ 0.5 bar / 5 m of water)
- Due to deposition of salts the top surface of bed becomes hard and back washing is not effective.
 - ✓ Open the lid of filter
 - ✓ Adjust the flow using bypass valve so that sand does not come out of the opening
 - ✓ Allow water to come out through lid openings
 - ✓ Stir the sand from top to bottom carefully
 - ✓ Break the lumps of sand by squeezing in hand
 - ✓ Ensure the sand up to marked level 9
 - ✓ Allow the water to flow till clean water starts flowing out of opening
 - ✓ Put the lid back in position tightly

3. Monthly Maintenance

- Deposition of fine particles and sand on filtering element of screen filter.
 - ✓ Open the lid of and take out the filtering element
 - ✓ Remove the rubber seals from both end, clean and fix them again
 - ✓ Rinse the element in flowing water gently with hand
 - ✓ Do not use wired brush, as it may damage the screen

4. Half Yearly Maintenance

- Change the sand of media filter with new one as particles becomes rounded off

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- Check out system wear and tear
- Lubricate the pump and motor

Lateral Protection from Rats

- Always maintain wetted strip in the field (Row Crops)
- Bury (3-4'' below ground) the lateral between two drippers (Orchards)
- Place bowls of water at different locations in the field for squirrels
- Wrap plastic/polyethylene sheet around the trunk of trees to stop climbing of squirrels
- Start “**Rat destroy campaign**” in the area by all farmers

3.5.3 Remedies to Prevent Damage

1. Rodents puncture the drip line/tape for search of water or cool place during hot days. Placing water at different location can prevent the laterals from potential damage.
2. Burying of lateral line 3-4 inches below the ground in-between the emitters can save it from damage by the rodents.
3. Careful intercultural operations with trained labour can avoid the physical damage to the drip lines.
4. The problem of poor water quality can be handled by acidification/chemigation to minimize clogging.

3.6. Maintaining a clean and safe work area

3.6.1 Maintaining clean and safe work area

- ✓ The job site shall be kept in a neat, clean, and orderly condition at all times during the installation process.
- ✓ All scrap and excess materials are to be regularly removed from the site and not buried in trenches.
- ✓ Trenching, laying pipe and backfilling shall be continuous so that the amount of open trench at the end of each work day is minimized. Any open trench or other excavations shall be barricaded and marked with high visibility flagging tape.

Irrigation work sites are expected to be clean, tidy, comfortable, good and well maintained to create conducive environment for work.

Cleanliness is the most essential elements in maintaining a healthy and safe work environment. Not only does a clean workplace reflect the professionalism of a business or facility and help motivate employees, it also promotes a healthy workforce as a clean environment prevents accidents and the spread of germs.

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Many office managers strive to maintain a clear work site policy, few succeed. However, each employee

Like Health & Safety, maintaining a clean work environment is the responsibility of everyone. However, there is only so much cleaning the team can do during each shift and in such cost conscious times it makes sense for employees to adopt some simple good housekeeping practices and allow the cleaning team to concentrate on hygiene and deep cleaning tasks.

3.7. Restoring the site and removing and disposing of waste material

3.7.1. Restore the site

Restoring site and removing waste material is using wastes as an input material to create valuable products as new outputs. The aim is to reduce the amount of waste generated, thereby reducing the need for landfill space, and optimizing the values created from waste. Restoring site delays the need to use raw materials in the manufacturing process. Materials found in municipal solid waste, construction and demolition waste, commercial waste and industrial wastes can be used to recover resources for the manufacturing of new materials and products. Plastic, paper, aluminum, glass and metal are examples of where value can be found in waste.

3.7.2. Disposal of waste material

After installing and landscaping there is often a range of unwanted waste material left behind the needs to be dealt with. Things such as a matting, old pipe, broken sprinkler, pots/tubes, unused root bound plants, soil fertilizer cartons, plastic wrapping, stakes mulch and plant debris. It is best practice when finished to leave a completely clean site free of rubbish.

Methods of waste disposal could include

- Organic waste: mulch and composting
- Inorganic waste: plastic/metal/paper based material may be recycled, reused or returned to manufacturer.

Self-Check – 3

Written test

Name..... ID..... Date.....

Directions: Answer all the questions listed below.

Test I: Short Answer Questions/15 pt. /

1. What is the aim of restoring site and removing waste material?
2. What is the importance of Maintaining clean and safe work area?
3. List down A micro irrigation system components.

Note: Satisfactory rating - 15 points Unsatisfactory - below 15points

You can ask you teacher for the copy of the correct answers.

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Operation Sheet 3: Installation of Micro-Irrigation System

3.1 Installation of Micro-Irrigation System

A. Tools and equipment's

- Pipe wrench
- spanner set
- drill machine
- screwdriver & pliers
- cutting blade with frame
- measuring tape
- ejecto punch
- Pressure regulators
- filter
- Micro Irrigation Pipeline
- Connectors
- Coupling fitting
- Elbow fitting
- Tee fitting
- Cross fitting
- End fitting
- Reducer fitting
- T-piece
- Pipe holder
- Pipe guides
- Pipe clamps
- Drip tubes
- Dripper
- Micro-Sprays
- By spray pattern
- nozzles
- hose, stake or extension On spikes or not
- Underground fleece mats
- sand paper

B. Steps to Install Micro-Irrigation System

Step 1; Wear suitable personal protective equipment

Step 2; Install the irrigation timer (optional)

1. Place the battery
2. Attach the timer to the faucet
3. Set your program.
4. Connect your regular watering hose to the end of the timer

Step 3; connect the irrigation plant

1. Connect the irrigation unit directly to the water outlet or the garden hose;
2. Make sure it is tight.

Step 3; arrange your main network

1. Cut the predetermined length of the main pipe (1/2 inch) with scissors.
2. Be sure to walk around the area before cutting. Keep a few extra inches in case of miscalculation.
3. Place your pipes above the areas indicated on your plan.
4. Plant supports to secure the (1/2 “) pipes to the ground. If your piping is placed on a rigid floor, use jumpers designed to securely secure (1/2 “) lines to fixed surfaces.

Step 4; Add connectors

1. First, install the connectors that divert your main lines (1/2 “) between them.
2. Install your connectors’ connectors (able to go from a large pipe 1/2 “to a small pipe 3/16”).
3. Install your shutoff valves per planting area.

Step 5; connect your secondary network

1. Using scissors, cut your small pipes (3/16 “) according to the measurements designated in your plan.
2. Keep a few extra inches in case of miscalculation.
3. The pipes should be placed near the roots of your plants.
4. Connect the small pipes to your connectors.
5. Plant supports to secure small (3/16 “) earth pipes. If your pipes are laid on a rigid floor, use jumpers designed to secure small pipes (3/16 “) to fixed surfaces.

Step 6; Install the drippers

1. To place a dripper on an end-to-end line, make a hole with the installation tool, and then push in the dripper. Do not use a nail or other pointed object other than a punch because you could create irregular holes that cause leaks.
2. End-of-line emitters are installed directly at the end of a small pipe. Because you have chosen the right type of dripper to the size of your 3/16 “.

Step 7; Install the micro-sprinklers

1. Using the installation tool, drill the tubes where you want to put your sprinklers.
2. Screw the sprinklers firmly.

Step 8; Close your lines

1. Place the small caps to close your small pipes (if applicable).
2. Place the large caps to close your large lines (if applicable).

Step 9; Add conduit brackets

Step 10; Test the watering system

1. Set the timer to manual mode
2. Open the faucet just enough so that the sprinklers emit light streams of water.
3. Once this is done, repeat the test to its full capacity.
4. Set the timer to automatic mode by choosing the times when watering will trigger according to the needs of the plants in your garden.

LAP Test 3	Performance Test
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Name.....

ID.....

Date.....

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **6** hour. The project is expected from each student to do it.

Task 1: install micro irrigation system.

LG #17

LO #4 - Lower and Position Pipes & Clean Up

Instruction sheet4

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Laying and consolidating bedding materials
- Installing/ lowering pipes into position with appropriate mechanical equipment
- Installing pipe joints and fittings
- Backfill pipes and cover the left level
- Clearing the site and excess soil, debris, and removing unwanted materials

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Lay and consolidating bedding materials
- Install or lower pipes into position with appropriate mechanical equipment
- Install pipe joints and fittings
- Backfill pipes and cover the left level
- Clear the site and excess soil, debris, and removing unwanted materials

Learning Instructions:

5. Read the specific objectives of this Learning Guide.
6. Follow the instructions described below.
7. Read the information written in the information Sheets
8. Accomplish the Self-checks
9. Perform Operation Sheets
10. Do the “LAP test”

Information Sheet - 4

4.1 Laying and consolidating bedding materials

4.1.1 Laying and Bedding the Pipe

Plastic pipe conduits complete with fittings and other related appurtenances shall be installed to the lines and grades shown on the drawings. The pipe shall be firmly and uniformly bedded throughout its entire length, to the depth and in the manner specified on the drawings. Bedding material, if necessary, shall be placed and spread in uniform layers and in such a manner as to fill the trench so there are no unfilled spaces (air pockets) below the pipe. Holes shall be dug in the bedding at belled couplings and other fittings to permit the body of the pipe to be in contact with the bedding along its entire length.

The pipe and the couplings shall be free of foreign material when assembled. At the termination of pipe laying, the open end(s) of the pipeline shall be closed off by a suitable cover or plug until laying operations are resumed.

Care shall be taken to prevent permanent distortion and damage when handling the pipe. To minimize stresses and movement due to expansion and contraction, the pipe shall be allowed to come within a few degrees of the temperature it will have after it is completely covered before placing the backfill, other than the backfill needed for shading, or before connecting the pipe to other facilities.

4.1.2 Determining Location and depths of trenches

A trench is a hollow cut into the ground, usually with parallel sides and which is typically deeper than it is wide. Trenches were used in the First World War as a means of conducting combat as they offered a degree of protection and cover from enemy fire.

The trench excavation should not be too far ahead of the pipe-laying team to ensure a better control of the trench and for safety reasons. The excavated soil should be placed on one side of the trench leaving the other side, clear for equipment and pipe handling. If the trench consists of various layers of soils, these should be placed separately in order to use the stone-free granular material for backfill.

Trench Width

The trench width must be maintained within certain limits. A very wide trench will increase the volume of backfill material required, and compaction labor and effort. A very narrow trench will

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render laying, handling and joining of pipes, as well as compaction of side backfill difficult. The minimum recommended trench width is given in figure 1.

Notes:

1. In poor native soil conditions and depending on pipe stiffness and burial depth, a wide trench (up to 4 X DN (Diameter Nominal)) might be required. During trench excavation, a pipe bedding thickness of at least 150 mm must be provided. In case of very poor native soils (silt, clay or mud) additional 150 mm thick foundation layer must be provided below the bedding. Selected backfill material should be placed at the foundation and bedding levels and thoroughly compacted by plate vibrators or by hand tamping. Wetting of sand bedding/foundation material prior to compaction will improve and facilitate the achievement of the degree of compaction required.
2. The distance between the pipe and the trench wall should be at least 10cm wider than the width of the equipment used for compaction of the backfill material.

Trench Depth

Generally the cover depth of pipe is specified by the design Engineer. When there is no traffic load over the pipe, the minimum burial depth is 0.6m. In the presence of traffic loads, a minimum cover above the pipes shall always be maintained as follows for all stiffness classes.

In case of high ground water table, a minimum cover depth equal to 0.75 times the pipe diameter of granular soil (minimum dry density of 1900 Kg/m³) must be provided to prevent WAVISTRONG® (H₂O) WATER SERIES pipes from floating. Always insure that this minimum cover is available before turning off dewatering systems.

Cover Height

The maximum cover height depends on the type of installation, backfill material and its compaction, as well as native soil conditions.

4.1.3 Setting out and marking Trench location

A trench is a long and narrow ditch dug in the ground, usually deeper than it is wide. They have many practical uses, such as installing pipelines, irrigating land, and gardening. The layout of trenches establishes the excavation size, shape and direction, as well as the width and position of walls. Trenches are excavated once the building outline has been set out. The width is often marked with a line of dots of dry lime powder for accurate excavation by hand, whereas the center line is marked for accurate machine excavation.

Outline profile boards are often used to control trench positioning, width and depth. In order that they do not obstruct the excavation work, profile boards should be set up at least 2m clear of the trench positions. The level of the profile cross board should be related to the site datum and

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fixed at a convenient height above ground level, often with cords strung between two profiles at either end of the trench. Bands can be painted on the cross board for identification purposes.

Pegs are often driven into the bottom of the trench to mark the top of the concrete strip that is subsequently poured. The corners of walls are transferred from intersecting cord lines to mortar spots on the concrete foundations, using a spirit level for accuracy. The cutting of trenches needs to be undertaken with great care, especially if they are to be left open for an extended period as there is the possibility of the sides caving in.

Steps to marking trench locations are:-

Step 1 - Measure dimensions

Step 2 - Mark points

Step 3 - Set up batter-boards

Step 4 - Suspend brick lines (external)

Step 5 - Check alignment

Step 6 - Suspend brick lines (internal)

Step 7 - Dig trench

Step 8 - Back fill the trench

These steps involve the following actions:-

1. Determine location based on purpose

2. Determine the trench dimensions

- ✓ Knowing the depth, width, and length of your trench will help you save effort and keep your trench the shape you desire. It may help you to mark widths, lengths and route of your trench using stakes and string. If available, you can use sandbags or other markers to outline the path of your trench.
- ✓ If you are using the trench to install or replace electrical utilities or pipelines, you will want to dig at least 2.5 feet deep in order to protect the pipes from frost, but no deeper than 4 feet. The width of your trench will depend on your pipes, but will likely be narrow.
- ✓ If you are digging a trench for a sprinkler system, you may only need to dig 9-12 inches deep depending on the height of the sprinkler, and 5 inches wide depending, again, depending on your sprinkler system. Consult the instructions that came with your sprinkler system before installation.

3. Purchase supplies

- ✓ You'll need a D-handle sharp shooter shovel and a trenching or clean-out shovel. These can be purchased at any hardware or gardening store. For clearing roots, pruning shear or a Pulaski digging tool can help you quickly remove this obstruction. Wearing gloves will protect your hand from blisters and splinters, and comfortable work boots will provide foot protection and traction.

4. Avoid obstructions.

- ✓ Be careful when you dig around trees or other pipes. Roots can add a significant time to your excavation, and a ruptured gas line will require you to call your gas provider immediately. Severed utility lines could also leave you without power until your electric company can fix the problem.
- ✓ If you're digging near trees, make sure that your trench will not invade the tree's protected root zone (usually the part of the roots that lie directly below its branches).
- ✓ If you're digging near pipes, try to determine where any other pipes may be. New pipes should be at least 1.5 feet away from another.

5. Break up the dirt.

- ✓ Use the D-handle shovel to loosen the dirt along both sides of the soon-to-be trench. This will make it easier to dig out the dirt in the middle while physically establishing your dig line alongside the guideline you laid.^[4] Cut both sides of the hole with your shovel, break up the topsoil, and then work both sides of your trench until you have loosened enough soil to merit clearing.

6. Dig out the trench middle.

- ✓ Once you have accumulated enough loose soil, use the trenching shovel to remove it out of your way. This may be a pile off to the side, or it may be a location you choose prior specifically for backfill.

7. Continue loosening and clearing the soil.

- ✓ Depending on the depth and length of your trench, this could take a considerable amount of time and effort. Use your D-handle shovel to break up the soil and the trench shovel to clean it out until your trench is the desired length and depth.
- ✓ Running into roots might require you to place the pointed end of your shovel on the root and stomp, which should sever most small-medium sized roots. More developed root systems might require a Pulaski digging tool. Pruning shears are another good option, if your shovel fails and you do not have a Pulaski digging tool on hand.

8. Take safety measures with deep trenches.

- ✓ An unsupported trench can be extremely dangerous, as collapsing soil can kill someone standing in the trench. Any trench 3 feet (0.91 m) (0.9m) deep, and some shallower trenches in soft soil, should be supported by side walls (such as timber posts and panels) before digging any deeper. You can increase safety by "benching" (digging in tiered levels), or by digging the walls at a slope instead of vertically.
- ✓ An experienced trench excavator may choose to keep the trench unsupported at depths up to 5 ft (1.5 m), but only under stable soil conditions.[8] Follow the 3 ft (0.9 m) rule if you do not have expert supervision.

4.2. Installing/ lowering pipes into position with appropriate mechanical equipment

4.2.1 Installing/ lowering Pipes

Installing an in-ground irrigation system in your yard lets you program when your yard gets water and makes watering plants less time-consuming. A key component of setting up a system is properly installing irrigation pipe in the ground. If not installed correctly, you could experience pressure loss or other problems that reduce the coverage and efficiency of your irrigation system. Proper installation requires planning and care, but pays off in efficiency and consistent water pressure.

To install irrigation pipes, following actions can be included:-

1. Clearing of the new field e.g. removing bushes, trees
2. Terrain rehabilitation of dongas, anthills, dips etc.
3. Land preparation (liming, ripping, ridging)
4. Pegging out of new blocks
5. Ordering materials according to design plan
6. Digging trenches
7. Laying of main and sub main-lines
8. Laying of laterals and emitters
9. Flushing of system
10. Irrigating and system testing
11. Planting of the crop

Things You Will Need to install pipes are:-

- Spray paint or chalk-based marking
- Mechanical trencher (optional)
- Trenching shovel
- Carpenter's level
- PVC pipe

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- PVC pipe cutter
- PVC pipe fittings
- PVC pipe joint primer and adhesive
- Drill
- Measuring tape
- Sprinkler heads
- Drip irrigation units or other external system components
- Grass seed (optional)

Mechanical lowering is used for larger diameter pipes, especially when combined with pipe assembly in the trench. Two straps or slings can be used from an excavator boom if no separate lifting equipment is available.

Pipes are installed in trenches as follows:

- Before installing pipes in trenches, ensure that the trenches are free of stones and sharp edges.
- Asbestos cement pipes and large PVC pipes must be laid on a bed of sand.
- Place the first pipe into the trench and secure it by backfilling the trench near the ends of the pipe.
- Place a collar over the end of the pipe. Make sure that the collar and the end of the next pipe is clean.
- Lubricate the inside of the collar and the end of the next pipe with pipe lubricant. Do not use oil because this will cause the rubbers to perish.
- Insert the end of the second pipe into the collar.
- Place a wooden block against the open end of the second pipe and tap the block with a hammer to force the pipe into the collar. The force that is required depends on the size of the pipe.
- Drive the pipe up to where the depth is marked on the pipe. Take care not to pinch the rubbers.
- If the pipe refuses to go into the collar, remove the pipe and inspect the collar as the rubbers may have shifted.
- Ensure that there are no foreign objects inside the pipes that can cause blockages in the irrigation system.
- As the pipes are laid they can be backfilled near the edges. Joints must be left open at first to check for leaks.

General steps to install pipes are:

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1. **Mark the path of your pipes in your yard using spray paint.** Check the plan for your irrigation system, making corrections to reduce the number of bends and turns in the pipe because each bend will reduce water pressure slightly.
2. **Dig a trench** approximately 6 to 12 inches deep along your marked lines using a trenching shovel or mechanical trencher. Although they're more work, deeper trenches provide better protection against freezing or other pipe damage. Dig trenches for your main irrigation lines first, then come back and dig the trenches for branches off the main lines.
3. **Check the grade** of your trenches, digging portions of them out with a trenching shovel to create a level trench bottom. If the trenches aren't level, you may lose water pressure within your pipes.
4. **Lay out the pipes** beside the trenches, cutting them with a pipe cutter, as needed and installing fittings to create branches or turns. Apply a joint primer compound and adhesive to the pipe and inside the fittings during assembly to join them together.
5. **Drill holes** in the pipes, as needed, to connect sprinkler heads to according to the spacing on your installation plan. Depending on the specific pipes you use and whether your installation plan was created by an irrigation supply company, the pipes may have pre-drilled holes.
6. **Connect the main line pipes** to your irrigation system's valve manifold, the valve and backflow prevention system that connects to the water supply and any pumps included in the system. Each main pipe should connect to the outlet on one of the manifold valves.
7. **Continue placing** your irrigation pipes in the trenches, working out from the manifold and orienting them so the holes for sprinkler head connections face up.
8. **Connect the hoses** attached to the sprinkler heads to the holes in your pipe, pressing the heads into the soil so they are at ground level while the system is unpressurized. Connect any additional system components, such as drip irrigation units, for your garden or flower beds that connect to one of the main line branches.
9. **Turn on the irrigation system to test it**, checking for any sprinkler heads that don't function properly or signs of leaks. Leave the system running for a few minutes to ensure the pipes can handle sustained water pressure, and then turn it off.
10. **Fill in the trenches**, the cover them with sod or sow grass seed to match the rest of your yard.

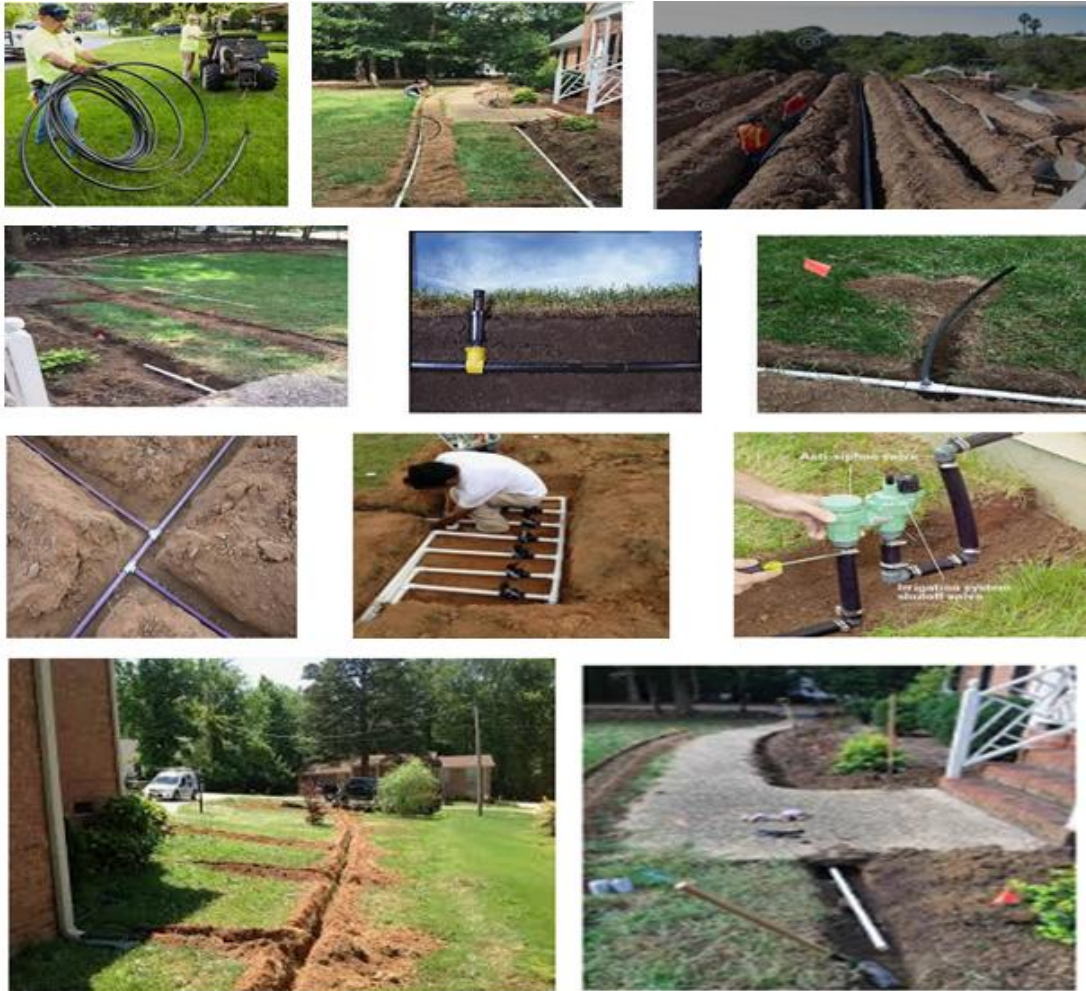


Figure 4.1: Different Images of pipe installation

4.2.2. Testing of the Irrigation System

The various components of the irrigation system are tested as they are installed, and the performance of the entire system is tested once the installation is complete.

As the pipes are laid and flushed, joints are inspected for leaks. Once the pipes are partially backfilled with the joints exposed, the system is slowly brought up to working pressure. The blocks that are grouped in operations are opened. Pressure readings are taken before and after the valves, and these are compared with the values noted on the irrigation design plan in the Pressure and Flow at Nodes table. If the readings are not correct, it may be an indication of wrong pipe size, incorrect hydraulic valve settings, or pump or filter malfunction.

Hydraulic valves are calibrated at this time. The pressure gauge is inserted downstream after the valve and the valve is opened. Note the pressure reading. Once the pipes in the block are filled, the valve is switched to automatic. If the pressure reading drops, the screw on the pilot is turned slowly in a clockwise direction. If the pressure rises, the screw on the pilot is turned

anticlockwise. The process is repeated by adjusting the pilot, checking the pressure again after a while, and adjusting the pilot again if necessary.

Once the hydraulic valves have been calibrated, the pressures in the lateral lines can be checked.

Check the pressure at the end of each lateral which should be close to the pressure that the valve is set at. Alternatively, each lateral can be assessed visually and the pressure of the laterals measured that appears to have a different distribution pattern than the other lines.

Emitter delivery can also be checked to see if it corresponds with the irrigation plan. Place the emitter in a suitable container. After a while (1 to 30 minutes), remove the container and measure the amount of water. Calculate the emitter delivery per hour. When this test is done with a representative sample of at least 25 points over the whole block, the CU (Coefficient of Uniformity) can be calculated. If the CU is 90% or above the uniformity is good.

After this test is done and the system has been operating for a couple of days, inspect joints for leaks. If no leaks are found, the trenches can be backfilled completely.

Hand loading should be executed by at least two men. It is recommended that the weight carried by one man should not exceed 30 kg. Pipes weighing up to 175 kg can be lowered by means of two ropes.

4.3. Installing pipe joints and fittings

Irrigation system installations consist of various pipes, fittings, valves and other equipment depending on the kind of system and the type of installation. Most installations have the same structure, and thus a relatively small range of equipment can meet the requirements of a whole region.

Laying PVC

During the installation/lying of the PVC pipe following steps must be taken into account;

- Cut the pipe to length with a hacksaw or pipe cutter. Make your cut straight so the pipe is fully seated in the fitting.
- Smooth and level the edges slightly with a knife or fine file.
- Insert the pipe into the fitting and adjust to the correct position. Mark the pipe and fitting with a reference line to make it easy to find the position again after you have added the jointing solvent.
- Remove the pipe from the fitting.
- Clean the surfaces to be mated with a jointing solvent.
- Brush both the outside of the pipe and the inside of the fitting with jointing solvent.

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- Push the pipe into the fitting with the marks 1/4 turn apart. Twist the pipe to align the marks. This spreads the solvent and makes a bead along the edge of the fitting. The bead should extend all the way around the pipe. Work quickly, the adhesive sets in about 30 seconds. If there occur any mistake, separate the parts quickly. Once the joint is set, it's stuck for good.

4.3.1 Pipe Fittings

Pipe fittings are an important component of the plumbing system. In plumbing, many types of fixtures are joined with the help of various types of material as per the requirement. Fittings are fixed in the plumbing system to join straight pipes or any section of tubes. We can say that the water-supply fittings like elbow, tee, socket, reducer, etc., are fitted to change the direction of flow, distribute the water supply from the main pipe to other pipes of equal size or lower size, etc. Any part used in connection with water supply, distribution, measurement, controlling, use and disposal of water is known as a pipe fitting.

Type of Fittings

1. **Collar:** While joining two pipes in the same length, collar is used. Collar is fitted in the end of pipe.
2. **Elbow;** It is installed at the time of joining two pipes. With the help of an elbow, the direction of liquid is changed. Normally a 45° or 90° elbow is used. When the two sides of pipes differ in size, an elbow of reducing size is used. This is called reducing type elbow or reducer type elbow.

Elbows are categorized as follows.

- ✓ Long Radius (LR) Elbows, Here, the radius is 1.5 times the diameter of pipe.
 - ✓ Short Radius (LR) Elbows, In this, the radius is 1.0 times the diameter of pipe.
 - ✓ 90° Elbow, This is used when the change in direction required is 90°
3. **Gasket;** they are mechanical seals, generally ring-shaped type and fitted for sealing flange joints. A flange joint is a plate or ring to form a rim at the end of a pipe when fastened to the pipe. Gaskets are made as per by construction, materials and features. Important gaskets used are non-metallic, spiral-wound and ring-joint type.
 4. **Union;** when two ends of pipes are joined, the pipe fitting used is called union. A union is made of three parts namely a nut, a male end and a female end. The male and female ends are assembled with the support of the nuts, and necessary pressure is made to connect the

joint. Since the pairing ends of the union are interchangeable, the union can be changed easily in a short time

5. **Reducer;** It is used to connect pipes of different diameters. A reducer may be of various types like reducer tee, reducer elbow and reducer socket.
6. **Tee;** It is an important fitting with a side outlet at 90° to the run of the pipe. Tees connect pipes of various diameters and help in changing the direction of water or material in a pipe. Tees are made in various sizes like equal or unequal. The equal tee is most commonly used.
7. **Nipple,** it is a piece of pipe having thread at both sides, and could be used for short extension of plumbing lines. It can also be used for connecting two fittings within small distance
8. **Trap;** Traps are fitted near a plumbing fixture. The trap bend is fitted to prevent sewer gases from entering the building. If the gases are inserted back into home, then it could lead to people inhaling foul smell, which could cause illnesses. It could even explode.
9. **Cross;** when four pipes are joined, a cross is formed. It is also called a cross branch line or a four-way fitting. This fitting has three outlets and one inlet. Cross fittings may deteriorate when temperatures change, because cross fitting is made at the center of the four connection points.
10. **Offset;** when an assembly of fittings on a pipeline makes one section of pipe out of line and parallel to a second section, then it is known as an offset.

4.3.2 Pipe Joints

Pipes are connected with the help of joints. A variety of joints are used in an assembly of pipes. Connecting two or more pipes together is called a fitting. Various types of joints could be used in a pipe as per the requirement. Joints are also used for multiple pipe connections, and are an important component of the plumbing system. Generally, the pipe joint fitted can easily sustain the pressure created in the pipe.

Types of pipe joints

Various types of pipe joints are as follows.

- | | |
|--|----------------------|
| 1. Threaded joint | 4. Soldered joint |
| 2. Welded joint (butt welded, socket welded) | 5. Grooved joint |
| 3. Brazed joint | 6. Flanged joint |
| | 7. Compression joint |

Valves for proper functioning of the pipeline, valves made of iron or brass are used in the water-supply mains. Valves stop or control the flow of fluid like liquid, gas, condensate, etc. These are classified according to their usage like isolation, throttling and non-return corrector. Various types of valves are manufactured depending upon their use and type of construction.

Fitting are used to join and redirect pipes and components to form complete plumbing systems. Due to the variety of designs of plumbing system components, fittings also facilitate adaptations from one size diameter of pipe or fitting to another. While many styles of fittings are used in most all types of systems, plumbing codes only allow some fittings to be used in particular type of plumbing system (supply or DWV) and have strict requirements as to how they are to be incorporated into the system (ex: compression fittings and unions should never be used inside of walls).

4.4 Backfill pipes and covers the left level

Either water packing or hand or mechanical methods may be used for backfill consolidation for pipes. All pipelines with a pressure rating of less than 80 psi shall be filled with water prior to backfilling for either method.

4.4.1 Initial Backfill

The backfill is the material used to refill the trench after the pipe and the embedment have been placed. The cover is the depth of backfill over the top of the pipe.

When water packing, the pipeline shall be filled with water and maintained near design working pressure during backfilling. The initial backfill, before wetting, shall be of sufficient depth to insure complete coverage of the pipe after consolidation occurs. Water packing is accomplished by adding enough water to diked reaches of the trench to saturate the initial backfill thoroughly without excessive pooling. After the initial fill is saturated, the pipeline shall remain full until after final back filling. The water packed backfill shall be allowed to dry until firm enough to walk on before final backfill is begun.

If hand or mechanical methods of backfill are used, the initial backfill shall be placed in layers and compacted around and above the pipe to the soil density required to provide adequate lateral support to the pipe. Compaction by hand or by hand-directed mechanical means shall be accomplished in lifts not to exceed 6 inches for all pipe sizes. The initial backfill shall be compacted firmly and evenly around and above the pipe to provide adequate lateral support, free from voids, to the pipe. The pipe shall not be displaced, deformed, or damaged by the backfilling operation.

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The initial backfill shall be soil or granular material that is free from rocks, gravel, and frozen material larger than 0.75 inch or earth clods greater than 2 inches in diameter and shall be installed to an elevation no less than 6 inches above the top of the pipe (refer to Figure 2 below).

The degree of compaction for all pipe sizes shall be such that lateral deflection of the pipe sidewalls will be minimal. Unless special compaction requirements are noted on the drawings, or water packing methods are used, the initial backfill material shall be compacted firmly to achieve a soil density at least equal to the density of the undisturbed side walls of the trench.

4.4.2 Final Backfill

Unless otherwise shown on the drawings, the final backfill material within 6 inches of the top of the pipe to the top of the trench shall be free of rocks, frozen clods or other debris larger than 3 inch in diameter. The material shall be placed and spread in approximately uniform layers so there are no unfilled spaces in the backfill. Rolling equipment or heavy tampers shall not be used to consolidate the final backfill until after the minimum depth of cover has been placed, or where the pipe has a wall thickness less than that of DR or SDR 41. Final backfill may be mounded over the top of the trench above ground level, but in no case shall the final backfill be lower than the natural ground along the top of the trench. All special backfilling requirements of the pipe manufacturer shall be met.

Bedding material for use below the water table or in wet trenches shall be pea rock, drain field lime rock or washed sand as approved by the Engineer. Pipe bedding material for use in dry trenches for water lines and force mains shall be lime rock screenings, sand or other fine inorganic material as approved by the Engineer. Bedding material for gravity sewer shall be angular rock or washed sand.

Additional Backfill Material

- Additional backfill material shall be classified as A-1, A-3 or A-2-4 in accordance with AASHTO Designation M 145 and shall be free from vegetation and organic material. No stones or rocks shall be larger than 6-inches in diameter, and when placed within 1-foot of piping and appurtenances stones or rocks shall be no larger than 2-inches in diameter (1-inch for PVC).
- Backfilling of utility trenches will not be allowed until the work has been approved by the Engineer and the Engineer indicates that backfilling may proceed. Any work which is covered or concealed without the knowledge and consent of the Engineer shall be

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uncovered or exposed for inspection at no cost to the Owner. Partial backfill may be made to restrain the pipe during pressure testing.

- Backfill material shall be non-cohesive, non-plastic material free of all debris, organic material, clods and broken paving. Backfill material placed within 1-foot of piping and appurtenances shall not contain any stones or rocks larger than 2-inches in diameter (1-inch for PVC) and no stones or rocks larger than 6-inches in diameter will be permitted in any backfill.
- If a sufficient quantity of suitable backfill material is not available from the trench or other excavations within the site of the work, the Engineer will order the Contractor to provide additional material suitable for this purpose. The additional material shall be installed as specified herein. When the Engineer has determined that additional material is required, and has ordered the Contractor to furnish same, it shall be paid for at the unit price stated in the Proposal for “Additional Backfill Material”. However, no payment will be made for additional backfill material used to replace non-plastic material (rock) over 6-inches in diameter.
- Selected backfill material containing no stone or rocks larger than 2-inches (1" for PVC) shall be placed in 6-inch layers and thoroughly tamped to a depth of 12-inches over the top of the pipe. Particular attention and care shall be exercised in obtaining thorough support for the branch of all service connection fittings. Care shall be taken to preserve the alignment and gradient of the installed pipe.
- After the backfill has been placed to a level 12-inches over the waterline or force main pipe, the remainder of the back-fill shall be placed in layers, not to exceed 9-inches, and compacted with mechanical vibrators or other suitable equipment to obtain a density of the backfilled material of not less than 95 percent of its maximum density as hereinafter defined.
- After selected backfill has been placed to a depth of 12-inches over the sewer pipe, backfilling shall proceed to a depth of 30-inches over the pipe by placing the backfill material in 6-inch layers and thoroughly compacting it with mechanical vibrators. Backfill in this portion of the work shall be compacted to 90 percent of maximum density of the material as hereinafter defined.
- After the backfill has been placed to a level 30-inches over the sewer pipe, the remainder of the backfill shall be placed in layers, not to exceed 9-inches, and compacted with

mechanical vibrators or other suitable equipment to obtain a density of the backfilled material of not less than 95 percent of its maximum density as hereinafter defined.

4.5. Clearing the site and excess soil, debris, and removing unwanted materials

4.5.1. Clearing and removing unwanted materials

The job site shall be kept in a neat, clean, and orderly condition at all times during the installation process. All scrap and excess materials are to be regularly removed from the site and not buried with the pipes. Laying pipe and backfilling shall be continuous so that the amount of open trench at the end of each work day is minimized.

Irrigation work sites are expected to be clean, tidy, comfortable, good and well maintained to create conducive environment for work.

Generally, Waste /unwanted materials may include,

- ✓ Unused construction and excavated materials
- ✓ Plant debris
- ✓ Litter and broken components
- ✓ Waste may be removed to designated areas for recycling, reuse, and return to the manufacturer or disposal
- ✓ Plant-based material may be mulched or composted
- ✓ Plastic, metal, paper-based materials may be recycled, re-used, returned to the manufacturer, or disposed of according to enterprise work procedures

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Self-Check – 4

Written test

Name..... ID..... Date.....

Directions: Answer all the questions listed below.

Test I: Short Answer Questions/15 pt. /

1. Laying and consolidating bedding materials
2. How to Installing/ lowering pipes into position with appropriate mechanical equipment
3. How to Installing pipe joints and fittings
4. How to Backfill pipes and cover the left level
5. How to Clearing the site and excess soil, debris, and removing unwanted materials

Test II: CHOOSE THE BEST/5 pt. /

1. Which of the following fittings is used to connect two pipes with each other? (5pts.)
(a) Tee (b) Connector (c) Elbow (d) All of the above
2. Which of the following fittings is used to connect four pipes? (5pts.)
(a) Offset (b) Union (c) Cross (d) Reducer
3. The valve which avoids both overflow and back flow of water is_____. (5pts.)
(a) Float valve (b) angle valve (c) foot valve (d) check valve

Note: Satisfactory rating - 20 points Unsatisfactory - below 20points

You can ask you teacher for the copy of the correct answers.

Operation Sheet 4	
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4.1 Preparation of a list of fittings available in your college

Material Required

1. Different types of fitting
2. Notebook
3. Pen

Procedure

1. Identify the fittings available in your college.
2. Prepare a list of the identified fitting items seen
3. Note down the fitting items and their use

4.2 Practicing of joining irrigation pipe

Material Required

1. Joints
2. Pipe
3. Tools

Procedure

1. Collect the pipe joints, pipes and tools
2. Identify the components
3. Collect the joints
4. Join the pipe with the help of proper pipe joining tools

LAP Test 4	Practical Demonstration
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Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4:30 hour.

Task1. Prepare a list of fittings available in your college

Task2. Join the pipe

Task3. Store tools and equipment according to 5s standard.

LG #18

LO #5- Maintain Drainage Systems

Instruction Sheet 5

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Preparing tools and equipment used to maintain drainage system
- Checking drainage systems for defects
- Maintaining drainage systems
- Documenting and reporting work outcomes

This guide will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Prepare tools and equipment used to maintain drainage system
- Check drainage systems for defects
- Maintain drainage systems
- Document and reporting work outcomes

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

Information Sheet 5

5.1. Preparing tools and equipment used to maintain drainage system

Perhaps the most common plumbing problem faced by homeowners is clogged drains that aren't working efficiently to do their job. Fortunately, with the right drain cleaning tools you can usually keep such issues to a minimum and fix them quickly when they arise. Additionally, if you ever need professional assistance, David Leroy Plumbing and our qualified technicians are more than happy to provide you with the help you need. Here are five of the most essential tools to have for cleaning your drains.

Standard Tools

Having some standard tools on hand is a smart idea for loosening and removing the top of the drain. Wrenches, screwdrivers, and other basic resources are the easiest to use when gaining access to the actual clog.

1. Snake: One of the most flexible drain cleaning tools is the snake. This long, wire, tube-like tool is used to push blockages the rest of the way down the pipe. Often, it has a grip handle which you hold firmly while carefully pushing the remaining wire down the drain. Some snakes are made with a small clasp on the end that can be manipulated to grab and remove some of the junk that may be obstructing water flow.

2. Plunger

Plungers are quite common and can be used to suction and release backup in order to get drainage working again. Plungers often come in many sizes so you can find something that will work for the size drain you have.

3. Wire Brushes

Many supply stores sell small wire brushes that can be used to clean some of the gunk after removing blockages from a drain. Used with hot water and soap, these brushes work similar to a toothbrush.

4. Drain Cleaning Chemicals

There are a variety of drain cleaning chemicals you can use to remove some of the buildup that may be in your drain. Remember to follow the instructions on the label.

5.2 Checking drainage systems for defects

5.2.1 Inspection and Maintenance Checklist

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Table 5.1 Maintenance Checklist for Collection and Conveyance System

Sediment	<ul style="list-style-type: none"> • Sediment exceeds 60% of sump depth. • Sediment depth within 6 inches of the invert of the lowest pipe.
Trash & Debris	<ul style="list-style-type: none"> • Trash or debris in front of catch basin opening or blocking inlet by more than 10%. • Trash or debris exceeds 60% of sump depth. • Trash or debris within 6 inches of the invert of the lowest pipe. • Trash or debris blocking more than 1/3 of any inlet or outlet pipe. • Trash and debris blocking more than 20% of grate surface. • Dead animals or vegetation that generates odors and cause complaints or dangerous gases (e.g., methane).
Vegetation	<ul style="list-style-type: none"> • Vegetation growing across and blocking more than 10% of the grate opening. • Vegetation growing in inlet/outlet pipe joints that is more than six inches tall.
Water Quality	<ul style="list-style-type: none"> • Any evidence of oil, gasoline, contaminants or other pollutants. • Water flowing in catch basin during dry weather – report as potential illicit discharge concern.
Water Flow	<ul style="list-style-type: none"> • Impeded water flow due to vegetation or sediment (use appropriate code from above).
Erosion	N/A
Cover/Frame/Grate	<ul style="list-style-type: none"> • Cover is missing or only partially in place. • One maintenance person cannot remove lid after applying normal lifting pressure. • Frame separated by more than 3/4 inch from top slab. • Frame not securely attached. • Locking mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread. • Grate with opening wider than 7/8 inch. • Grate damaged or missing.

Structure	<ul style="list-style-type: none"> • Top slab with holes larger than 2 square inches or cracks wider than 1/4 inch. • Fractures or cracks in basin walls or bottom. • Grout at inlet/outlet pipes has separated or cracked wider than ½ inch and longer than one foot. • Soil is entering the catch basin through cracks in the structure. • Settlement has created a safety, function, or design problem. • Field inspector judges that structure is unsound.
Damaged Pipes	<ul style="list-style-type: none"> • Inlet or outlet piping damaged or broken and in need of repair.
Mosquito Vector Breeding	<ul style="list-style-type: none"> • Suitable habitat exists for mosquito production (e.g. standing water for more than 72 hours in areas accessible to mosquitoes.)
Other	<ul style="list-style-type: none"> • Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges. • Catch basin insert requires replacement if: <ul style="list-style-type: none"> ✓ Sediment, trash or debris blocks water flow through the insert, ✓ Effluent water from the insert has a visible sheen, or ✓ Insert is saturated with water or oil and can no longer absorb.
Could Not Locate	<ul style="list-style-type: none"> • Field inspectors are unable to locate the catch basin or manhole.

Table 5.2 Maintenance Checklist for Control Structures

Type	Conditions When Maintenance Is Needed
Sediment	<ul style="list-style-type: none"> • Sediment depth exceeds 60% of sump depth. • Sediment accumulated within 6 inches of the orifice plate or lowest pipe invert.
Trash & Debris	<ul style="list-style-type: none"> • Trash or debris exceeds 60% of sump depth. • Trash or debris within 6 inches of the orifice plate or lowest pipe invert. • Trash or debris blocking openings in the control structure. • Trash or debris blocking more than 1/3 of any inlet or outlet pipe. • Dead animals or vegetation that generate odors and cause complaints or dangerous gases (e.g., methane).

Type	Conditions When Maintenance Is Needed
Vegetation	<ul style="list-style-type: none"> Vegetation growing in inlet/outlet pipe joints that is more than six inches tall.
Water Quality	<ul style="list-style-type: none"> Any evidence of oil, gasoline, contaminants or other pollutants.
Water Flow	<ul style="list-style-type: none"> Impeded water flow due to vegetation or sediment (use appropriate code from above).
Erosion	<ul style="list-style-type: none"> N/A
Cover/Frame/Grate	<ul style="list-style-type: none"> Cover is missing or only partially in place. One maintenance person cannot remove lid after applying normal lifting pressure. Frame separated by more than $\frac{3}{4}$ inch from top slab. Frame not securely attached. Locking mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than $\frac{1}{2}$ inch of thread.
Structure	<ul style="list-style-type: none"> Damaged or missing orifice plate. Control structure is not securely attached to manhole wall. Control structure is not in upright position. Connection between control structure and outlet pipe is not water tight. Holes (other than design openings) in the control structure. Cleanout gate is not watertight, is missing, is rusted, or cannot be moved up and down by one maintenance person applying normal pressure. Top slab with holes larger than 2 square inches or cracks wider than $\frac{1}{4}$ inch. Fractures or cracks in basin walls or bottom. Grout at inlet/outlet pipes has separated or cracked wider than $\frac{1}{2}$ inch and longer than one foot. Soil is entering the catch basin through cracks in the structure. Settlement has created a safety, function, or design problem. Field inspector judges that structure is unsound.
Damaged Pipes	<ul style="list-style-type: none"> Inlet or outlet piping damaged or broken and in need of repair.

Type	Conditions When Maintenance Is Needed
Mosquito Vector Breeding	<ul style="list-style-type: none"> Suitable habitat exists for mosquito production (e.g. standing water for more than 72 hours in areas accessible to mosquitoes.)
Other	<ul style="list-style-type: none"> Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.
Could Not Locate	<ul style="list-style-type: none"> Field inspectors are unable to locate the structure.

Table 5.3 Maintenance Checklist for Conveyance Systems (Pipes and Ditches)

Type	Conditions When Maintenance Is Needed
Sediment	<ul style="list-style-type: none"> Sediment or debris exceeds 20% of pipe diameter or 20% of debris barrier openings. Accumulated sediment that exceeds 20% of the design depth of the ditch.
Trash & Debris	<ul style="list-style-type: none"> Trash and debris accumulated in pipe or ditch. Visual evidence of dumping
Vegetation	<ul style="list-style-type: none"> Vegetation reduces movement of water through pipes. Excessive vegetation that reduces free movement of water through ditches.
Water Quality	<ul style="list-style-type: none"> Any evidence of oil, gasoline, contaminants or other pollutants. Water flowing in pipes or ditch during dry weather – report as potential illicit discharge concern.
Water Flow	<ul style="list-style-type: none"> Impeded water flow due to vegetation or sediment (use appropriate code from above). Standing water in the pipe or swale between storm events.

Type	Conditions When Maintenance Is Needed
Erosion	<ul style="list-style-type: none"> Erosion damage over 2 inches deep where cause is still present or there is potential for continued erosion. Native soil is visible beneath the rock lining of a conveyance ditch.
Cover/Frame/Grate	<ul style="list-style-type: none"> N/A
Structure	<ul style="list-style-type: none"> Debris barrier/trash rack is missing or not attached to pipe. Debris barrier/trash rack bars are bent by more than 3 inches. Debris barrier/trash rack bars are loose or rust is causing 50% deterioration to any part of the barrier.
Damaged Pipes	<ul style="list-style-type: none"> Protective coating is damaged or rust is causing more than 50% deterioration to any part of pipe. Any dent that decreases the flow area by more than 20% or puncture that impacts performance.
Mosquito Vector Breeding	<ul style="list-style-type: none"> Suitable habitat exists for mosquito production (e.g. standing water for more than 72 hours in areas accessible to mosquitoes.)
Could Not Locate	<ul style="list-style-type: none"> Field inspectors are unable to locate the pipe or ditch.

Table 5.4 Maintenance Checklist for Drywells

Type	Conditions When Maintenance Is Needed
Sediment	<ul style="list-style-type: none"> Sediment depth exceeds 2 feet or impedes flow from inlet pipes.
Trash & Debris	<ul style="list-style-type: none"> Trash or debris exceeds 2 feet or impedes flow from inlet pipes. Trash or debris blocks more than 1/3 of any inlet or outlet pipe. Dead animals or vegetation that generate odors and cause complaints or dangerous gases (e.g., methane).

Type	Conditions When Maintenance Is Needed
Vegetation	<ul style="list-style-type: none"> • Vegetation growing in inlet/outlet pipe joints that is more than six inches tall. • Root systems entering drywell.
Water Quality	<ul style="list-style-type: none"> • Any evidence of oil, gasoline, contaminants or other pollutants. • Water flowing into drywell during dry weather – report as potential illicit discharge concern.
Water Flow	<ul style="list-style-type: none"> • Facility does not drain within 72 hours. • Impeded water flow due to vegetation or sediment (use appropriate code from above).
Erosion	<ul style="list-style-type: none"> • N/A
Cover/Frame/Grate	<ul style="list-style-type: none"> • Cover is missing or only partially in place. • One maintenance person cannot remove lid after applying normal lifting pressure. • Frame separated by more than $\frac{3}{4}$ inch from top slab. • Frame not securely attached. • Locking mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than $\frac{1}{2}$ inch of thread.
Structure	<ul style="list-style-type: none"> • Top slab with holes larger than 2 square inches or cracks wider than $\frac{1}{4}$ inch. • Grout at inlet/outlet pipes has separated or cracked wider than $\frac{1}{2}$ inch and longer than one foot. • Settlement has created a safety, function, or design problem. • Field inspector judges that structure is unsound.
Damaged Pipes	<ul style="list-style-type: none"> • Inlet piping damaged or broken and in need of repair.

Type	Conditions When Maintenance Is Needed
Mosquito Vector Breeding	<ul style="list-style-type: none"> Suitable habitat exists for mosquito production (e.g. standing water for more than 72 hours in areas accessible to mosquitoes.)
Other	<ul style="list-style-type: none">
Could Not Locate	<ul style="list-style-type: none"> Field inspectors are unable to locate the drywell.

Table 5.5 Maintenance Checklist for Energy Dissipaters

Type	Conditions When Maintenance Is Needed
Sediment	<ul style="list-style-type: none"> Accumulated sediment exceeds 20% of the design depth. Over 1/2 of perforations in dispersion pipe are plugged with sediment.
Trash & Debris	<ul style="list-style-type: none"> Visual evidence of dumping Over 1/2 of perforations in dispersion pipe are plugged with trash or debris.
Vegetation	<ul style="list-style-type: none"> Excessive vegetation reduces free movement of water through the flow spreader or energy dissipater.
Water Quality	<ul style="list-style-type: none"> Any evidence of oil, gasoline, contaminants or other pollutants. Water flowing through facility during dry weather – report as potential illicit discharge concern.
Water Flow	<ul style="list-style-type: none"> Visual evidence of water discharging at concentrated points from the dissipator (normal condition is a “sheet flow” of water from the facility). Water in receiving area has potential to cause significant erosion or landslide.
Erosion	<ul style="list-style-type: none"> Only one layer of rock above native soil in an area five square feet or larger. Any exposure of native soil within rock pad area. Soil erosion in or adjacent to rock pad.
Cover/Frame/Grate	<ul style="list-style-type: none"> N/A

Type	Conditions When Maintenance Is Needed
Structure	<ul style="list-style-type: none"> Flow spreader has deteriorated to 1/2 of original size or concentrated worn spots exceeding one square foot making structure unsound. See Conveyance System standards for pipes and debris barriers/trash racks.
Damaged Pipes	<ul style="list-style-type: none"> See Conveyance System standards for pipes and debris barriers/trash racks.
Mosquito Vector Breeding	<ul style="list-style-type: none"> Suitable habitat exists for mosquito production (e.g. standing water for more than 72 hours in areas accessible to mosquitoes.)
Could Not Locate	<ul style="list-style-type: none"> Field inspectors are unable to locate the energy dissipator facility.

Table 5.6 Maintenance Checklist for Green Roofs (or Roof Gardens)

Type	Conditions When Maintenance Is Needed
Sediment	<ul style="list-style-type: none"> Inlets to roof drainage system clogged with sediment.
Trash & Debris	<ul style="list-style-type: none"> Inlets to roof drainage system clogged with trash or debris. Trash and debris accumulated on the roof.
Vegetation	<ul style="list-style-type: none"> Planted vegetation becomes excessively tall. Presence of poisonous or nuisance vegetation or noxious weeds. Planted vegetation is sparse or bare or eroded patches occur in more than 10% of roof garden.
Water Quality	<ul style="list-style-type: none"> Any evidence of oil, gasoline, contaminants or other pollutants.
Water Flow	<ul style="list-style-type: none"> Water stands in the green roof between storms and does not drain freely.
Erosion	<ul style="list-style-type: none"> Eroded or scoured areas due to wind or water.
Cover/Frame	<ul style="list-style-type: none"> N/A
Structure	<ul style="list-style-type: none"> Membrane or roof structure is compromised by either roots and/or water damage.

Type	Conditions When Maintenance Is Needed
Damaged Pipes	<ul style="list-style-type: none"> N/A
Mosquito Vector Breeding	<ul style="list-style-type: none"> Suitable habitat exists for mosquito production (e.g., standing water for more than 72 hours in areas accessible to mosquitoes)
Other	<ul style="list-style-type: none"> Irrigation system leaking or malfunctioning.
Could Not Locate	<ul style="list-style-type: none"> Field inspectors are unable to locate the facility.

Table 5.7 Maintenance Checklist for Infiltration Trenches

Type	Conditions When Maintenance Is Needed
Sediment	<ul style="list-style-type: none"> Two inches or more of accumulated sediment. Percolation test indicates infiltration rate is less than 90% of design capacity. Inlet pipe is clogged with sediment.
Trash & Debris	<ul style="list-style-type: none"> Trash or debris impeding water flow. Visual evidence of dumping. Inlet pipe is clogged with trash and debris.
Vegetation	<ul style="list-style-type: none"> Poisonous or nuisance vegetation constituting a hazard to maintenance personnel or the public. Evidence of noxious weeds.
Water Quality	<ul style="list-style-type: none"> Evidence of oil, gasoline, contaminants, or other pollutants.
Water Flow	<ul style="list-style-type: none"> Little or no water visibly flows through trench during heavy rain storms.

Type	Conditions When Maintenance Is Needed
Erosion	<ul style="list-style-type: none"> Erosion damage over 2 inches deep where cause is still present or there is potential for continued erosion.
Cover/Frame	<ul style="list-style-type: none"> N/A
Structure	<ul style="list-style-type: none"> N/A
Damaged Pipes	<ul style="list-style-type: none"> Protective coating is damaged or rust is causing more than 50% deterioration to any part of pipe. Any dent that decreases the flow area by more than 20% or puncture that impacts performance.
Mosquito Vector Breeding	<ul style="list-style-type: none"> Suitable habitat exists for mosquito production (e.g. standing water for more than 72 hours in areas accessible to mosquitoes.)
Could Not Locate	<ul style="list-style-type: none"> Field inspectors are unable to locate the trench.

Table 5.8 Maintenance Checklist for Media Filters (e.g. Storm filter)

Type	Conditions When Maintenance Is Needed
Sediment	<ul style="list-style-type: none"> Sediment depth on filters exceeds 1/4-inch. Sediment depth in vault exceeds 6-inches in first chamber. Drain pipes and/or clean-outs become full with sediment.
Trash & Debris	<ul style="list-style-type: none"> Trash and debris accumulated on compost filter bed. Drain pipes and/or clean-outs become full with trash or debris.
Vegetation	<ul style="list-style-type: none"> Root systems entering the structure.
Water Quality	<ul style="list-style-type: none"> Any evidence of oil, gasoline, contaminants or other pollutants. Water flowing into the system during dry weather – report as potential illicit discharge concern.
Water Flow	<ul style="list-style-type: none"> Drawdown of water through the media takes longer than 1 hour and overflow occurs frequently. Flows do not properly enter filter cartridges.

Type	Conditions When Maintenance Is Needed
Erosion	<ul style="list-style-type: none"> N/A
Cover/Frame/Grate	<ul style="list-style-type: none"> Cover is missing or only partially in place. One maintenance person cannot remove lid after applying normal lifting pressure. Locking mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.
Structure	<ul style="list-style-type: none"> Cracks wider than 1/2-inch. Evidence of soil particles entering structure through cracks. The vault is not structurally sound. Baffles corroding, cracking, warping and/or showing signs of failure.
Damaged Pipes	<ul style="list-style-type: none"> Any part of the pipes that are crushed or damaged due to corrosion and/or settlement. Inlet piping damaged or broken and in need of repair.
Mosquito Vector Breeding	<ul style="list-style-type: none"> Suitable habitat exists for mosquito production (e.g. standing water for more than 72 hours in areas accessible to mosquitoes.)
Other	<ul style="list-style-type: none"> Ladder is corroded or deteriorated, not functioning properly, not securely attached to structural wall, missing rungs, has cracks and/or is misaligned.
Could Not Locate	<ul style="list-style-type: none"> Field inspectors are unable to locate the facility.

Table 5.9 Maintenance Checklist for Oil/Water Separators

Type	Conditions When Maintenance Is Needed
Sediment	<ul style="list-style-type: none"> Sediment depth in bottom of structure exceeds 6-inches.
Trash & Debris	<ul style="list-style-type: none"> Trash and debris accumulation in vault, or pipe inlet/outlet, floatables and non-floatables.
Vegetation	<ul style="list-style-type: none"> Root systems entering the structure.

Type	Conditions When Maintenance Is Needed
Water Quality	<ul style="list-style-type: none"> • Discharge shows obvious signs of poor water quality. • Oil accumulations that exceed 1-inch at the surface of the water. • Water flowing into the system during dry weather – report as potential illicit discharge concern.
Water Flow	<ul style="list-style-type: none"> • Water is not flowing properly through the facility.
Erosion	<ul style="list-style-type: none"> • N/A
Cover/Frame/Grate	<ul style="list-style-type: none"> • Cover is missing or only partially in place. • One maintenance person cannot remove lid after applying normal lifting pressure. • Locking mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.
Structure	<ul style="list-style-type: none"> • Cracks wider than 1/2-inch. • Any evidence of soil entering the structure through cracks. • The vault is not structurally sound. • Baffles or walls corroding, cracking, warping and/or showing signs of failure.
Damaged Pipes	<ul style="list-style-type: none"> • Inlet or outlet piping damaged or broken and in need of repair.
Mosquito Vector Breeding	<ul style="list-style-type: none"> • Suitable habitat exists for mosquito production (e.g. standing water for more than 72 hours in areas accessible to mosquitoes.)
Other	<ul style="list-style-type: none"> • Ladder is corroded or deteriorated, not functioning properly, not securely attached to structural wall, missing rungs, has cracks and/or is misaligned.
Could Not Locate	<ul style="list-style-type: none"> • Field inspectors are unable to locate the facility.

5.3 Maintaining drainage systems

As a consequence of its function, the storm water conveyance system collects and transports urban runoff that may contain certain pollutants. Maintaining catch basins, storm water inlets,

and other storm water conveyance structures on a regular basis will remove pollutants, prevent clogging of the downstream conveyance system, restore catch basins' sediment trapping capacity, and ensure the system functions properly hydraulically to avoid flooding.

A. Catch Basins/Inlet Structures: Municipal staff should regularly inspect facilities to ensure the following:

- Immediate repair of any deterioration threatening structural integrity.
- Cleaning before the sump is 40% full. Catch basins should be cleaned as frequently as needed to meet this standard.
- Stenciling of catch basins and inlets (see SC-75 Waste Handling and Disposal). „

Clean catch basins, storm drain inlets, and other conveyance structures in high pollutant load areas just before the wet season to remove sediments and debris accumulated during the summer. Conduct inspections more frequently during the wet season for problem areas where sediment or trash accumulates more often. Clean and repair as needed. „

Keep accurate logs of the number of catch basins cleaned. „

Record the amount of waste collected. „

Store wastes collected from cleaning activities of the drainage system in appropriate containers or temporary storage sites in a manner that prevents discharge to the storm drain. „

Dewater the wastes with outflow into the sanitary sewer if permitted. Water should be treated with an appropriate filtering device prior to discharge to the sanitary sewer. If discharge to the sanitary sewer is not allowed, water should be pumped or vacuumed to a tank and properly disposed of. Do not dewater near a storm drain or stream. „

Except for small communities with relatively few catch basins that may be cleaned manually, most municipalities will require mechanical cleaners such as educators, vacuums, or bucket loaders.

B. Storm Drain Conveyance System

- Locate reaches of storm drain with deposit problems and develop a flushing schedule that keeps the pipe clear of excessive buildup. „
- Collect flushed effluent and pump to the sanitary sewer for treatment.

C. Pump Stations :

- Clean all storm drain pump stations prior to the wet season to remove silt and trash.

- Do not allow discharge from cleaning a storm drain pump station or other facility to reach the storm drain system.
- Conduct quarterly routine maintenance at each pump station. ,,
- Inspect, clean, and repair as necessary all outlet structures prior to the wet season. Sample collected sediments to determine if landfill disposal is possible, or illegal discharges in the watershed are occurring.

D. open Channel :

- Consider modification of storm channel characteristics to improve channel hydraulics, to increase pollutant removals, and to enhance channel/creek aesthetic and habitat value.
- Conduct channel modification/improvement in accordance with existing laws.

E. Illicit Connections and Discharges :

During routine maintenance of conveyance system and drainage structures field staff should look for evidence of illegal discharges or illicit connections:

- Is there evidence of spills such as paints, discoloring, etc.
- Are there any odors associated with the drainage system
- Record locations of apparent illegal discharges/illicit connections
- Track flows back to potential dischargers and conduct aboveground inspections.
- This can be done through visual inspection of up gradient manholes or alternate techniques including zinc chloride smoke testing, fluorometric dye testing, physical inspection testing, or television camera inspection.
- Once the origin of flow is established, require illicit discharger to eliminate the discharge.

Stencil storm drains, where applicable, to prevent illegal disposal of pollutants. Storm drain inlets should have messages such as “Dump No Waste Drains to Stream” stenciled next to them to warn against ignorant or intentional dumping of pollutants into the storm drainage

A. Illegal Dumping :

Regularly inspect and clean up hot spots and other storm drainage areas where illegal dumping and disposal occurs. ,,

Establish a system for tracking incidents. The system should be designed to identify the following:

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- Illegal dumping hot spots
- Types and quantities (in some cases) of wastes
- Patterns in time of occurrence (time of day/night, month, or year)
- Mode of dumping (abandoned containers, “midnight dumping” from moving vehicles, direct dumping of materials, accidents/spills)
- Responsible parties

B. Spill Response and Prevention

- Prevention, Control & Cleanup „ Have spill cleanup materials readily available and in a known location. „
- Cleanup spills immediately and use dry methods if possible. „
- Properly dispose of spill cleanup material.

5.4. Documenting and reporting work outcomes

5.4.1 Documentation

Technical writers and corporate communicators are professionals whose field and work is documentation. Ideally, technical writers have a background in both the subject matter and also in writing, managing content, and information architecture. Technical writers more commonly collaborate with subject matter experts (SMEs), such as engineers, technical experts, medical professionals, etc. to define and then create documentation to meet the user's needs. Corporate communications includes other types of written documentation,

The purpose of documentation is to:

- Describe the use, operation, maintenance, or design of software or hardware through the use of manuals, listings, diagrams, and other hard- or soft-copy written and graphic materials.
- Assign responsibilities and establish authority for business processes and practices (pertains mostly to policies and procedures).
- Standardize business practices.
- Reduce/eliminate fraud, waste, and abuse.
- Comply with federal, state, and local regulations.
- Comply with customer requirements.

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- Comply with contractual requirements.
- Train new employees.

5.4.2 Reporting Work Outcomes

An outcome report is a participatory effect assessment method centered on a success tale that provides proof of how the program has led to results and effects and is then evaluated by both technical professionals and program stakeholders, including group participants.

Steps to Make an Outcome Report

Step 1: Determine the Cause

By the name of it, outcome reports are made to determine the outcome of a project or an event. Hence, outcome reports can be of various types. This type is determined based on the objective of your report. For instance, if you want to determine the outcome of a meeting then you need to make a meeting outcome report. Before you start writing the report, think carefully about the goals that you want to achieve through the report.

Step 2: Take Records during the Event

To make a report, an important task is to take records while the event is occurring. These records do not have to elaborate descriptions of the event. Providing just enough information that you can use later to make the report is well. Take records of what is being discussed. This includes issues raised and the solutions provided to them, respectively, if any. Jot down or record using a recorder the main points of discussion of the event.

Step 3: Provide the Summary

The first part of writing the report is to provide a summary of the project or the event for which the report is being made. This part of the outcome report must give a general concept of how the venture progresses without getting into too much information at a look. A person who does not have time to read the entire report thoroughly must be able to get a picture of the current status of the project through the summary of the status report.

Step 4: Mark the Progress

There is no use of making an outcome report if the report is not able to show how much the individual, group or organization has progressed. The outcome report hence must include complete information on achievements, timelines and, most significantly, the milestones of the event. Project milestones are the fulfillment of duties of great importance. These milestones

function as a level of standard progress. During the scheduling phase of the event, what forms the specific milestones should be recognized.

Step 5: Provide a Comparison

The outcome report must be able to show a comparison between the current status of the event and the ideal status that the event should reach. It should incorporate a contrast between what was effectively accomplished at a specific stage of the task and what was expected to have been accomplished. It should inform us if the event is going according to plan, ahead of it, or behind it.

Step 6: Do the Analysis

An assessment of the effect on the event should be produced and submitted in the outcome report for any variances recorded and reported between the goals and real achievements. It is also necessary to state the grounds for such variations in the study. This assessment is normally done with the help of analysis. The kind of analysis that you will perform will depend upon the type of outcome report you are making.

Self-Check – 5	Written test
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Name..... ID..... Date.....

Directions: Answer all the questions listed below.

Test I: Short Answer Questions/20 pt/

1. Write steps to make an outcome report.
2. What is documentation?
3. Write all the components of drain age maintenance.
4. List all types of drainage Maintenance Checklist.
5. Write the standard tools used in drainage maintenance.

Note: Satisfactory rating - 20 points Unsatisfactory - below 20points

You can ask you teacher for the copy of the correct answers.

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LG #19

LO #6 - Finalize Work and Report

Instruction sheet6

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Cleaning, maintaining, and storing tools, equipment, and machinery
- Identifying and reporting operating faults
- Reporting problems or difficulties or hazards
- Documenting and reporting work outcomes

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Clean, maintain, and store tools, equipment, and machinery
- Identify and reporting operating faults
- Report problems or difficulties or hazards
- Document and reporting work outcomes

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

Information Sheet - 6

6.1 Cleaning, maintaining, and storing tools, equipment, and machinery

6.1.1 Handling irrigation equipment safely

These may include safe systems and procedures for the operation and maintenance of machinery and equipment, for outdoor work (including protection from solar radiation, dust and noise), manual handling, prevention of electrical injury, handling, transportation, protection against chemical residues, including that in/on foliage, water, soil and other items, and the use and maintenance of relevant personal protective clothing and equipment.

Any irrigation activity that requires squirting, spraying, or pressure release of fluid requires personal protective equipment that includes gloves, gown, mask with eye shield to prevent exposure to debris and aerosolization of microorganisms. Splash shield devices will still require wearing of gowns, and face protection due to splash potential

6.2 Identifying and reporting operating faults

Fault Reporting is a maintenance concept that increases operational availability and that reduces operating cost through three mechanisms.

- Reduce labor-intensive diagnostic evaluation
- Eliminate diagnostic testing down-time
- Provide notification to management for degraded operation
- Maintenance requires three actions.
- Fault discovery
- Fault isolation
- Fault recovery

Fault discovery requires diagnostic maintenance, which requires system down time and labor costs. Down time and cost requirements associated with diagnostics are eliminated for every item that satisfies the following criteria.

- Automated diagnostic
- Instrumented for remote viewing

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- Displayed in the viscosity of supervisory personnel

Fault reporting is an optional feature that can be forwarded to remote displays using simple configuration setting in all modern computing equipment. The system level of reporting that is appropriate for Condition Based Maintenance are critical, alert, and emergency, which indicate software termination due to failure. Specific failure reporting, like interface failure, can be integrated into applications linked with these reporting systems. There is no development cost if these are incorporated into designs.

Other kinds of fault reporting involves painting green, yellow, and red zones onto temperature gages, pressure gages, flow gages, vibration sensors, strain gages, and similar sensors. Remote viewing can be implemented using a video camera.

6.3. Reporting problems or difficulties or hazards

Hazard identification

Hazard identification is a process used to identify all possible situations where people may be exposed to injury, illness or disease, the type of injury or illness that may result from these and the way in which work is organized and managed. It is the first part of a risk management strategy described in Occupational Health & Safety Management System (OHSMS).

Workplace Health and Safety Regulations require employers to ensure that appropriate measures are undertaken to identify all hazards and to manage risk in the workplace.

Hazard: a situation at the workplace capable of causing harm (i.e. capable of causing personal injury, occupationally related disease or death).

Reporting Hazards and Accidents

Employees are required to report any situation or occurrence in the workplace that may present a risk or have the potential to affect the health and safety of employees or others in the workplace.

It is required that all injuries, incidents and hazards are properly reported, investigated and recorded in accordance with the procedures detailed below.

An accident is commonly used to describe an incident which has resulted in an injury.

An incident is any unplanned event resulting in or having the potential for injury, ill health, damage or loss.

A hazard is a source or a situation with the potential for harm in terms of human injury or ill health.

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Injury Reporting

- In the event of an injury the person involved should;
- seek first aid or medical attention as required;
- inform their supervisor as soon as possible;
- complete the Confidential Incident / Injury Report Form
- Assist their supervisor in the investigation and reporting on the incident or accident.

The Supervisor of the person(s) involved in the incident is required to;

- ensure that any injured person is promptly attended to;
- conduct an initial investigation into the cause of the incident;
- complete the Confidential Incident / Injury Report Form and ensure that it reaches the Safety and Health; and
- Notify and liaise with the local Safety & Health Representative and line management in relation to the incident.
- Ensure that all serious injuries are reported to the Safety and Health immediately after hours of assistance.

On identifying a hazard, staff must act as quickly as possible to eliminate it. This may mean a simple alteration, substitution or removal of the hazard.

Self-Check – 6	Written test
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Name..... ID..... Date.....

Directions: Answer all the questions listed below.

Test I: Short Answer Questions/20 pt/

1. _____ is a process used to identify all possible situations where people may be exposed to injury, illness or disease, the type of injury or illness that may result from these and the way in which work is organized and managed.
2. What is Hazard?
3. _____ is a maintenance concept that increases operational availability and that reduces operating cost through three mechanisms.
4. Handling irrigation equipment safely consist many activities. List them

Note: Satisfactory rating - 20 points Unsatisfactory - below 20points

You can ask you teacher for the copy of the correct answers.

Reference Materials

Books:

1. Dr. EZZAT FINDI(2012) Introduction To Irrigation Principles A Guideline Manual
2. SANTOSH KUMAR GARG(2006)Irrigation Engineering and Hydraulic Structures
3. Peter Waller • Muluneh Yitayew (2016) Irrigation and Drainage Engineering.
4. Kay M. /1983/ Sprinkler Irrigation: Equipment and Practice.
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8. Pandey, Krishna Chandra.1999. Building Material Textbook for Class XI. PSSCIVE, NCERT, New Delhi.
9. Shah, Charanjit S. 1998. Water Supply and Sanitation.
10. Shah, M.G., C.M. Kale and S.Y. Patki. 2012. Building Drawing with an Integrated Approach to Build Environment.

Web addresses

1. [http://www. Rainfor.net/services/pump-training/#System Curve](http://www.Rainfor.net/services/pump-training/#System Curve)
2. <https://realitymatters.eu › project › pre-operational-safety-check>
3. <https://realitymatters.eu › project › pre-operational-safety-check>
4. https://en.wikipedia.org › wiki › Thread_seal_tape
5. <https://www.techbelt.com>
6. <https://www.wikihow.com › Home and Garden › DIY › Plumbing › Piping>

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