NATURAL RESOURCES CONSERVATION AND DEVELOPMENT

Level-II

# Learning Guide-65

**Unit of Competence: Assist Operation and Maintenance of Irrigation and Drainage**

**Module Title: Assisting Operation and Maintenance Of Irrigation and Drainage**

**LG Code: AGR NRC2 M15 L01-LG-65**

**TTLM Code: AGR NRC2 M15 TTLM 0919v1**

## LO1: Prepare tools and materials for installation work

| **Instruction Sheet** | **Learning Guide #65** |
|---|---|

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

- Identifying potential areas of irrigation water sources and Irrigation Methods
- Identifying water contributors
- Identifying and interpreting Climatic variables
- Identifying Seasonal water ways
- Checking Soil moisture status & level of ground water
- Identifying appropriate practices to recharge underground water table
- Planning best trees species for afforestation purpose on degraded land

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

- Identify potential areas of irrigation water sources
- Identify water contributors
- Identify and interpreting Climatic variables
- Identify Seasonal water ways
- Check Soil moisture status & level of ground water
- Identify appropriate practices to recharge underground water table
- Plan best trees species for afforestation purpose on degraded land to improve water absorption and permeability characteristics of the soil.

**Learning Instructions:**

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 Sheet 4, Sheet 5, Sheet 6 and Sheet 7”.
4. Accomplish the “Self-check 1, Self-check 2, Self-check 3, Self-check 4, Self-check 5 and Self-check 6” **in page -2, 5, 14, 27, 29 and 32** respectively.

| | |
|---|---|
| **Information Sheet-1** | **Identify and selecting materials, tools, equipment and machinery** |

## 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, but not limited to:-

- ✓ 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.

| Self-Check -1 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. List down materials needed to install micro-irrigation system (5pts).

***Note:*** **Satisfactory rating 5 points** **Unsatisfactory - below 5 points**

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

**Answer Sheet**

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

| Information Sheet-2 | Identifying site to install micro-irrigation system |
|---|---|

## 2.1 Concept of micro-irrigation system

Micro irrigation is the slow application of continuous drips, tiny streams or miniature sprays of water above or below the soil surface. Micro irrigation system is effective in saving water and increasing water use efficiency as compared to the conventional surface irrigation method. Besides, it helps reduce water consumption, growth of unwanted plants (weeds), soil erosion and cost of cultivation. Micro irrigation can be adopted in all kinds of land, especially where it is not possible to effectively use flooding method for irrigation. In flooding method of irrigation, a field is flooded with water. This results in significant run-off, anaerobic conditions in the soil and around the root zone, and deep irrigation below the root zone, which does not supply sufficient water to the plants. It is, therefore, one of the most inefficient surface irrigation methods. Micro irrigation can be useful in undulating terrain, rolling topography, hilly areas, barren land and areas having shallow soils. According to depth, soil types can be classified as shallow (depth less than 22.5 cm), medium deep (22.5–45 cm) and deep soil (more than 45 cm).

Water is applied to the point of use through low pressure; low volume discharge devices (i.e., drip emitters, line source emitters, micro spray and sprinkler heads, bubblers) supplied by small diameter surface or buried pipelines.

## 2.2 Features of micro irrigation system

- ► Water is applied via pressurized piping system. Micro irrigation requires pumps for developing the required pressure for delivering water through pipelines, regardless of whether the source of water is surface or underground.
- ► Water is applied drop-by-drop for a long period in case of drip irrigation system.
- ► Water is applied at a low rate to maintain the optimum air–water balance within the root zone.
- ► Water is applied at frequent intervals as per the requirement of plants.
- ► Water is supplied directly to the plants and not to the other areas of the field, thus, reducing wastage.
- ► Soil moisture content is always maintained at ‘field capacity’ of the soil. Hence, crops grow at a faster rate, consistently and uniformly.

## 2.3 Identifying site

Irrigation application method and system selection should result in optimum use of available water. The selection should be based on a full awareness of management considerations, such as water source and cost, water quantity and quality, irrigation effects on the environment, energy availability and cost, farm equipment, product marketability, and capital for irrigation system installation, operation, and maintenance.

The consultant and irrigation decision maker should compare applicable methods and systems on common grounds. These can include:

- ✓ Gross irrigation water needs
- ✓ Energy requirements
- ✓ Effects on quantity and quality of ground water and downstream surface water
- ✓ Installation and annual operating costs
- ✓ Labor skills needed

Generally more than one irrigation method and system can be installed and efficiently operated on a specific site. The owners or operator’s desire, rather than economics and water application uniformity, may be key to the selection. To get acceptable irrigation efficiencies (minimize losses), management skills required of the operator and flexibility of available labor must be considered. Local regulations may provide the motivation to select and manage a specific irrigation system that would provide the least negative effect on ground and surface water. Whatever basis is used for the decision, the consultant and owner or operator both need to be aware of the applicability, capability, and limitations of all irrigation methods and systems that could be used on a specific site.

Political, legal, and regulatory issues are of primary importance. Included are such issues as land reform, water rights, containment of runoff and drainage water, taxation, financial incentives from governments, zoning and site application, and construction permits. These issues must be fully understood at the beginning of the selection process.

**Other factors to consider in site selection include:**

**Farm, land, and field**—Field size(s) and shape, obstructions, topography, flood hazard, water table, and access for operation and maintenance.

**Energy and pumping plant**—Type, availability, reliability, parts and service availability, and pumping efficiency.

**Environmental effects**—on quantity and quality of surface and ground water for water removal and for return flows, on local air quality, on local and regional wildlife and fish.

**Local laws**—Laws regarding tail water runoff reuse, reuse pits, and quality of tail water (runoff).

**Type and amount of effluent**—animal, municipal, and industrial waste. Water rights, allocations, and priority.

| Self-Check -2 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Define Micro irrigation (5pts)
2. Elaborate Features of micro irrigation system(5pts)
3. Discuss factors to consider in site selection(5pts)

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

## Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

| | |
|---|---|
| **Information Sheet-3** | **Adjust Power requirement for suction and delivery head** |

## 3.1 Adjust 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.

### 3.1.1 Types of Pumps

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

- ➢ Rotodynamic pumps (centrifugal pumps, mixed flow pumps and axial pumps)
- ➢ Positive displacement pumps (piston pumps, and helical-rotorpumps).

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 rotodynamic pumps. Centrifugal pumps are widely used in agriculture and are a good example of the rotodynamic pump group. However, for small systems requiring pump discharge less than 2 Ls-1 positive displacement pumps can be used under certain conditions. These are normally used in fertilizer injection equipment. In irrigation terms, a pumping rate of 2 Ls-1 is a very low flow and would be applicable to nurseries with misting jets, vegetable growers using drip irrigation, and domestic irrigation situations.

### Rotodynamic Pumps

Rotodynamic 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 rotodynamic pumps are the volute pump and the turbine pump.

### 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 pumpedagainst 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 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 eject or 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.

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.

**Size of Pumping Unit**

**Pump Performance Parameters**

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

**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).

**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).

#### 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 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.

#### 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

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

### 3.1.2 Power Requirement and Pump Selection

#### 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.

**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).

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:

$$H_t = H_n + H_m + H_j + H_s$$

Where,

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

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

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

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

Hs = 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).

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

Where,

H = total head loss, m

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

ɳp = Efficiency of pump, fraction

$\eta m$ = Efficiency of motor, fraction

### 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 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.

### 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.

### 3.1.3 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.

### 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.

### 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.

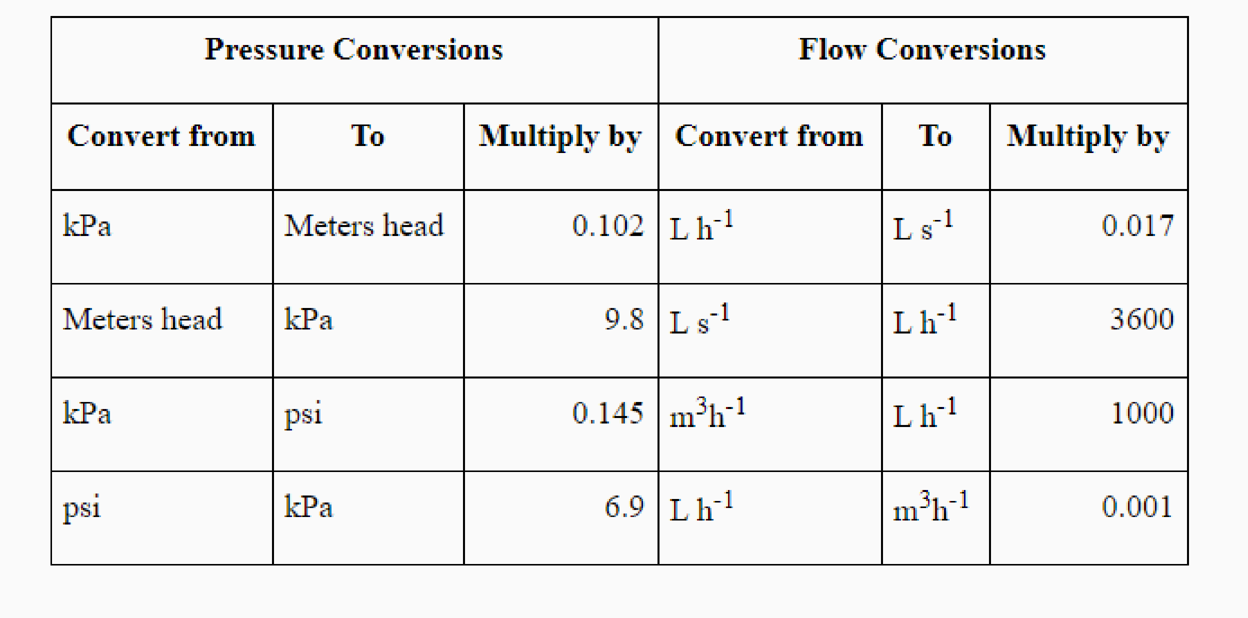
**Brake power Vs pump capacity**

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.

**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 9.1provides 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 | $m^3h^{-1}$ | $L\ h^{-1}$ | 1000 |
| psi | kPa | 6.9 | $L\ h^{-1}$ | $m^3h^{-1}$ | 0.001 |

Table.1 Pressure conversions and flow conversions for different units

**Example 9.1:** A field has 20 rows of tree with 30 trees per row. One 50 Lh-1microsprinkler 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 m3h-1, 516 L m-1 or 8.6 L s-1.

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

& 265 kPais 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 Lh-1at 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 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 Ls-1discharge 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.

| **Self-Check -3** | **Written Test** |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What are the two most factors to select a pump?(5pts)
2. What are the types of pump? (5pts)

***Note:*** **Satisfactory rating – 10 points** **Unsatisfactory - below 10 points**

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

**Answer Sheet**

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

| | |
|---|---|
| **Information Sheet-4** | **Carrying out Irrigation system after pumping** |

## 4.1 Carrying out 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 (see Fig. 1).

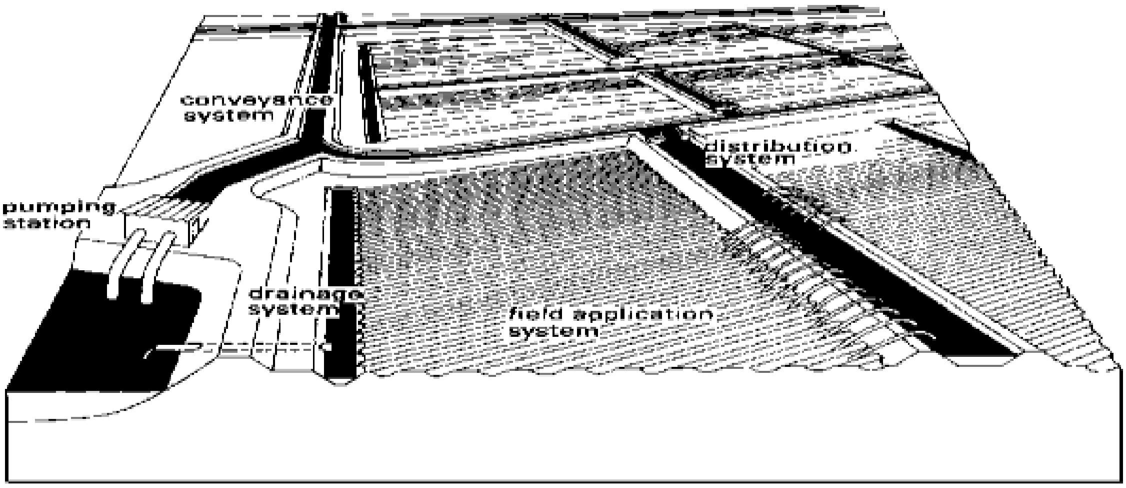


**Fig. 1 An irrigation system**

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.

### 4.1.1 Main intake structure and pumping station

#### 4.1.1.1 Main intake structure

The intake structure is built at the entry to the irrigation system (see Fig. 2). Its purpose is to direct water from the original source of supply (lake, river, reservoir etc.) into the irrigation system.

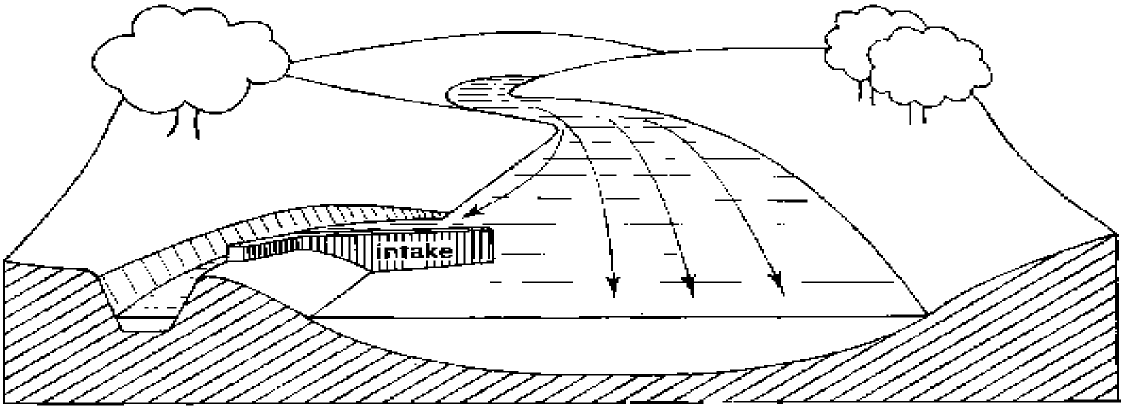


Fig. 2 An intake structure

### 4.1.1.2 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 (see Fig. 3).

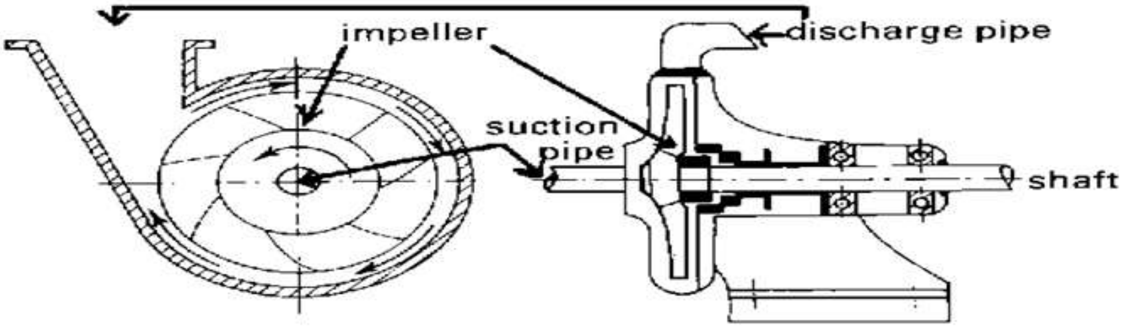


Fig. 3a. Diagram of a centrifugal pump

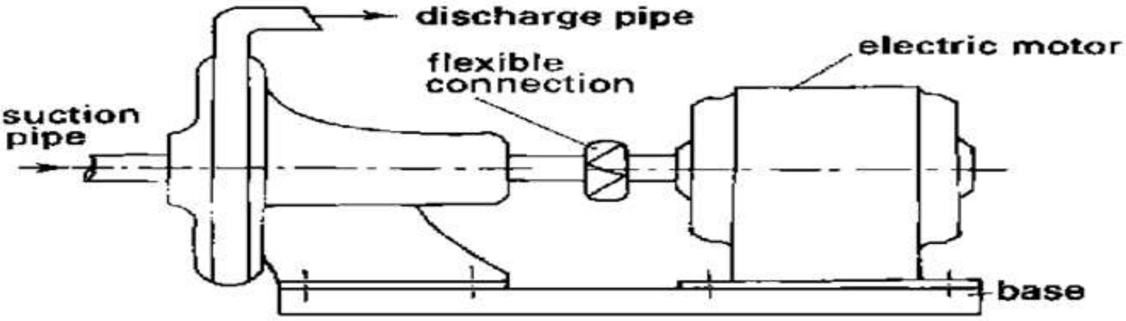


Fig. 3b Centrifugal pump and motor

The centrifugal pump will only operate when the case is completely filled with water.

### 4.1.2 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.

#### 4.2.2.1 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.

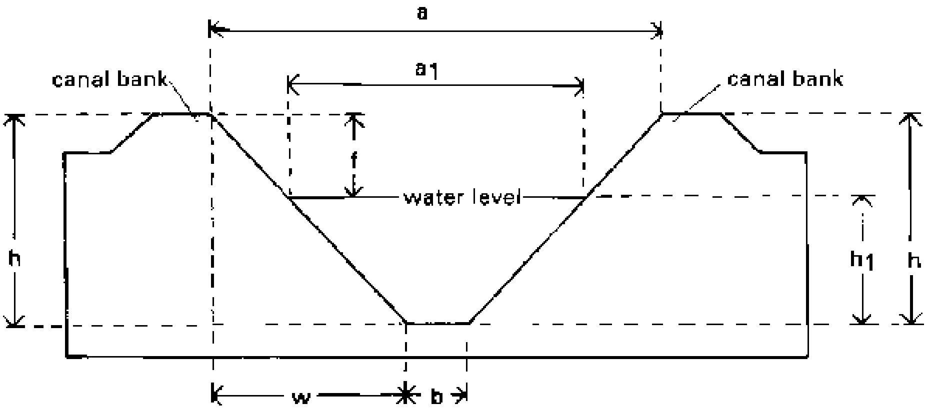
#### i. Canal characteristics

According to the shape of their cross-section, canals are called rectangular (a), triangular (b), trapezoidal (c), circular (d), parabolic (e), and irregular or natural (f) (see Fig. 4).

**Fig. 4 some examples of canal cross-sections**

The most commonly used canal cross-section in irrigation and drainage is the trapezoidal cross-section. For the purposes of this publication, only this type of canal will be considered.

The typical cross-section of a trapezoidal canal is shown in Figure 4.



a = top width of the canal
$a_1$ = top width of the water level
h = height of the canal
$h_1$ = heigth or depth of the water in the canal
b = bottom width of the canal
h:w = side slope of the canal
f = free board (= h–$h_1$)

**Fig. 4 A trapezoidal canal cross-section**

The freeboard of the canal is the height of the bank above the highest water level anticipated. It is required to guard against overtopping by waves or unexpected rises in the water level.

The side slope of the canal is expressed as ratio, namely the vertical distance or height to the horizontal distance or width. For example, if the side slope of the canal has a ratio of 1:2 (one to two), this means that the horizontal distance (w) is two times the vertical distance (h) (see Fig. 5).

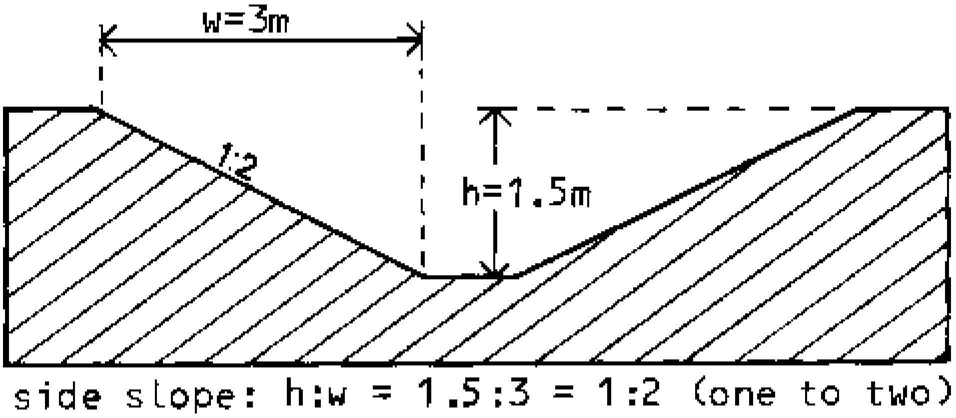


**Fig. 5 a side slope of 1:2 (one to two)**

The bottom slope of the canal does not appear on the drawing of the cross-section but on the longitudinal section (see Fig. 6). It is commonly expressed in percent or per mil.

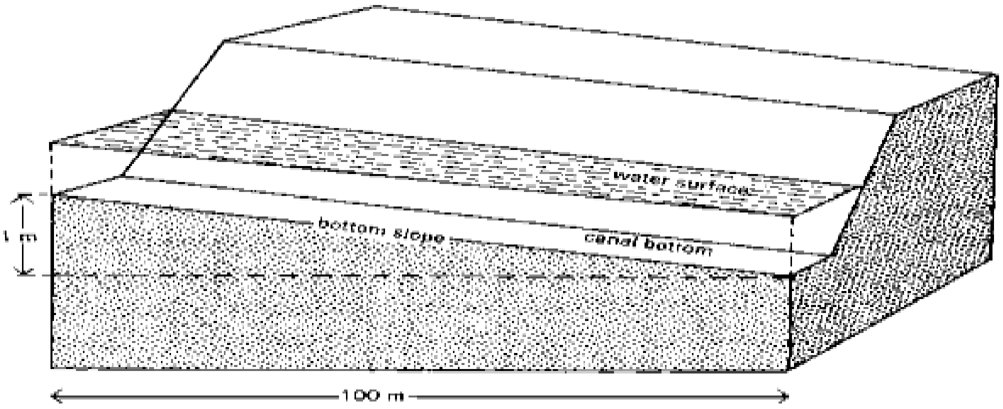


**Fig. 6 a bottom slope of a canal**

An example of the calculation of the bottom slope of a canal is given below (see also Fig. 6):

$$\text{the bottom slope } (\%) = \frac{\text{height difference (metres)}}{\text{horizontal distance (metres)}} \times 100 = \frac{1\,\text{m}}{100\,\text{m}} \times 100 = 1\%$$

or

$$\text{the bottom slope } (\text{‰}) = \frac{\text{height difference (metres)}}{\text{horizontal distance (metres)}} \times 1000 = \frac{1\,\text{m}}{100\,\text{m}} \times 1000 = 10\text{‰}$$

### ii. 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.

### iii. Lined Canals

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 labour is required.

### 4.2.2.2 Canal structures

The flow of irrigation water in the canals must always be under control. For this purpose, canal structures are required. They help regulate the flow and deliver the correct amount of water to the different branches of the system and onward to the irrigated fields.

There are four main types of structures: erosion control structures, distribution control structures, crossing structures and water measurement structures.

### i. Erosion control structures

#### a. Canal erosion

Canal bottom slope and water velocity are closely related, as the following example will show. A cardboard sheet is lifted on one side 2 cm from the ground (see Fig. 79a). A small ball is placed at the edge of the lifted side of the sheet. It starts rolling downward, following the slope direction. The sheet edge is now lifted 5 cm from the ground (see Fig. 79b), creating a steeper slope. The same ball placed on the top edge of the sheet rolls downward, but this time much faster. The steeper the slope, the higher the velocity of the ball.

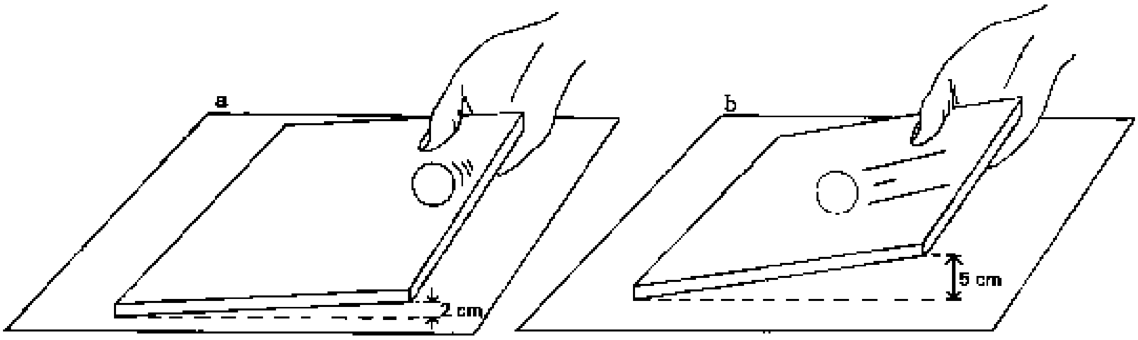


**Fig. 7 The relationship between slope and velocity**

Water poured on the top edge of the sheet reacts exactly the same as the ball. It flows downward and the steeper the slope, the higher the velocity of the flow.

Water flowing in steep canals can reach very high velocities. Soil particles along the bottom and banks of an earthen canal are then lifted, carried away by the water flow, and deposited downstream where they may block the canal and silt up structures. The canal is said to be under erosion; the banks might eventually collapse.

### b. Drop structures and chutes

Drop structures or chutes are required to reduce the bottom slope of canals lying on steeply sloping land in order to avoid high velocity of the flow and risk of erosion. These structures permit the canal to be constructed as a series of relatively flat sections, each at a different elevation (see Fig. 8).

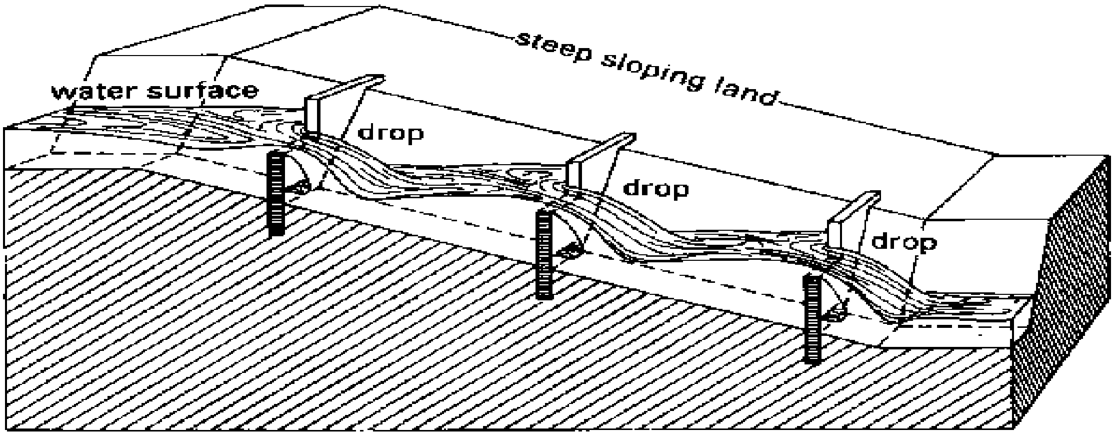


**Fig. 8 Longitudinal section of a series of drop structures**

Drop structures take the water abruptly from a higher section of the canal to a lower one. In a chute, the water does not drop freely but is carried through a steep, lined canal section. Chutes are used where there are big differences in the elevation of the canal.

### ii. Distribution control structures

Distribution control structures are required for easy and accurate water distribution within the irrigation system and on the farm.

#### a. Division boxes

Division boxes are used to divide or direct the flow of water between two or more canals or ditches. Water enters the box through an opening on one side and flows out through openings on the other sides. These openings are equipped with gates (see Fig. 9).

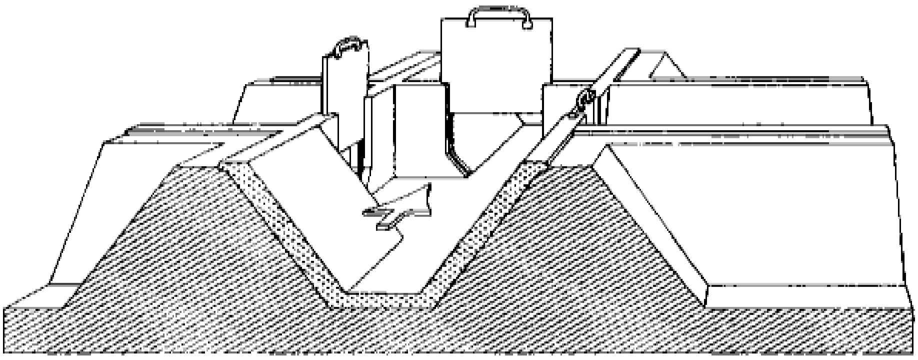


**Fig. 9 a division box with three gates**

#### b. Turnouts

Turnouts are constructed in the bank of a canal. They divert part of the water from the canal to a smaller one.

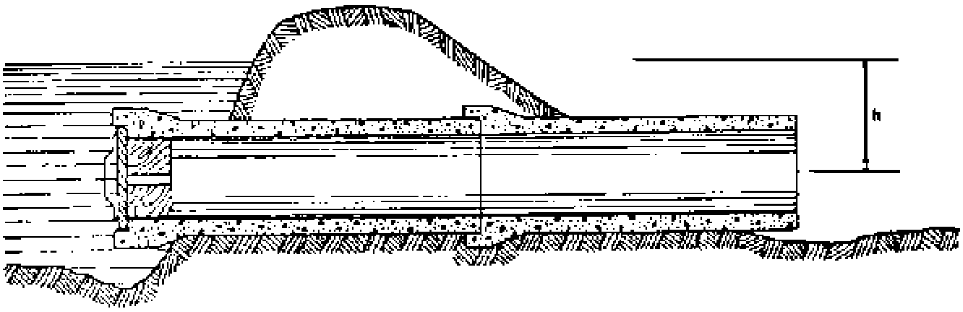


**Fig. 10 A pipe turnout**

### c. Checks

To divert water from the field ditch to the field, it is often necessary to raise the water level in the ditch. Checks are structures placed across the ditch to block it temporarily and to raise the upstream water level. Checks can be permanent structures (Fig. 10a) or portable (Fig. 10b).

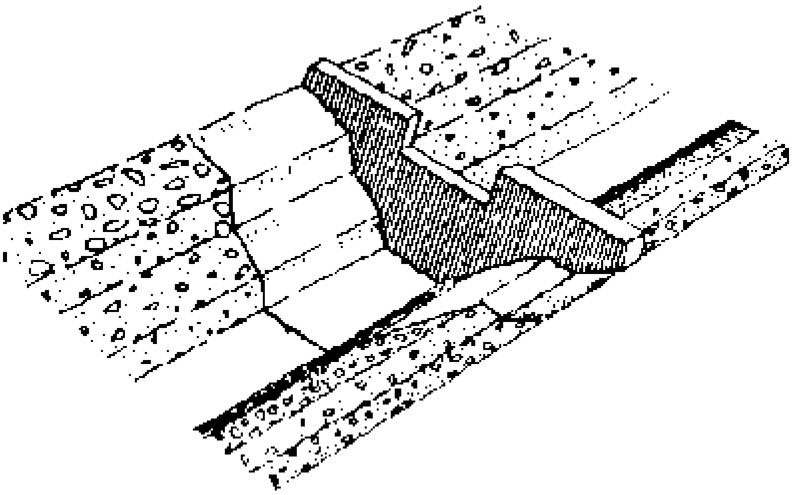


**Fig. 10a a permanent concrete check**

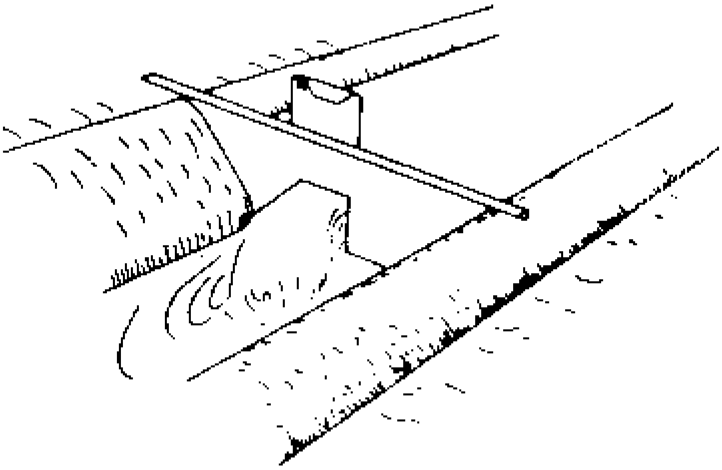


**Fig. 10b a portable metal check**

### iii. Crossing structures

It is often necessary to carry irrigation water across roads, hillsides and natural depressions. Crossing structures, such as flumes, culverts and inverted siphons, are then required.

### a. Flumes

Flumes are used to carry irrigation water across gullies, ravines or other natural depressions. They are open canals made of wood (bamboo), metal or concrete which often need to be supported by pillars.

### b. Culverts

Culverts are used to carry the water across roads. The structure consists of masonry or concrete headwalls at the inlet and outlet connected by a buried pipeline (Fig. 11).

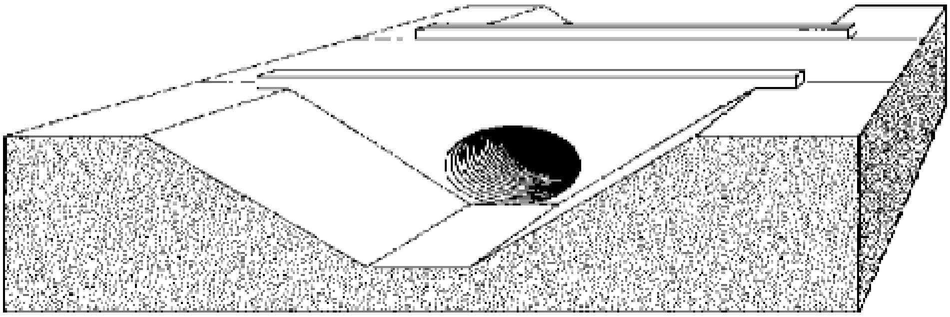


**Fig. 11 a culvert**

### c. Inverted siphons

When water has to be carried across a road which is at the same level as or below the canal bottom, an inverted siphon is used instead of a culvert. The structure consists of an inlet and outlet connected by a pipeline (Fig. 12). Inverted siphons are also used to carry water across wide depressions.

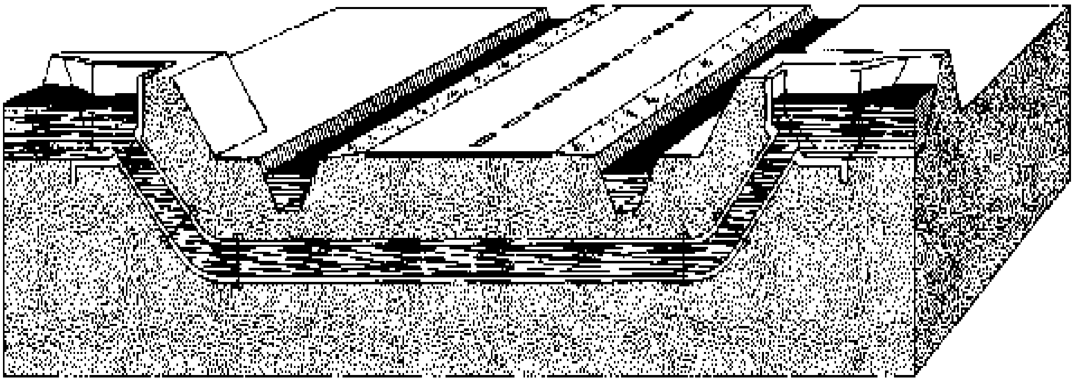


**Fig. 12 An inverted siphon**

### iv. Water measurement structures

The principal objective of measuring irrigation water is to permit efficient distribution and application. By measuring the flow of water, a farmer knows how much water is applied during each irrigation. In irrigation schemes where water costs are charged to the farmer, water measurement provides a basis for estimating water charges.

The most commonly used water measuring structures are weirs and flumes. In these structures, the water depth is read on a scale which is part of the structure. Using this reading, the flow-rate is then computed from standard formulas or obtained from standard tables prepared specially for the structure.

#### a. Weirs

In its simplest form, a weir consists of a wall of timber; metal or concrete with an opening with fixed dimensions cut in its edge (see Fig. 13). The opening, called a notch, may be rectangular, trapezoidal or triangular.

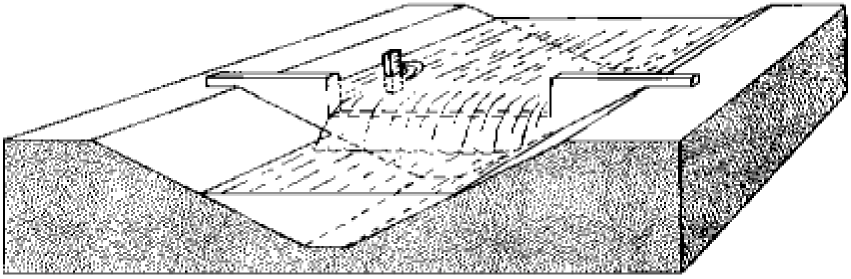


**Fig. 13 some examples of weirs (A rectangular weir)**

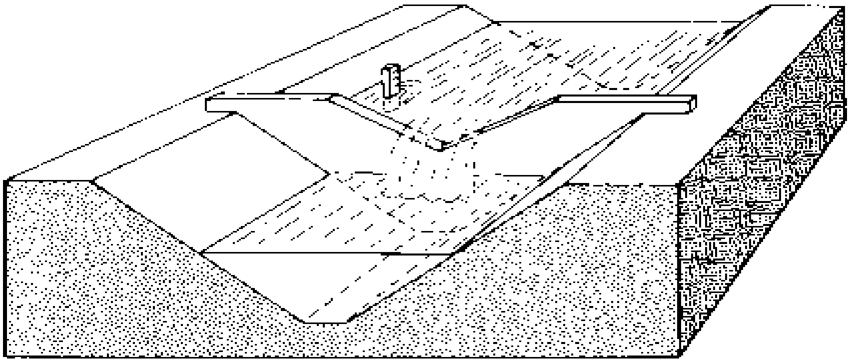


**Fig. 14 A triangular weirs**

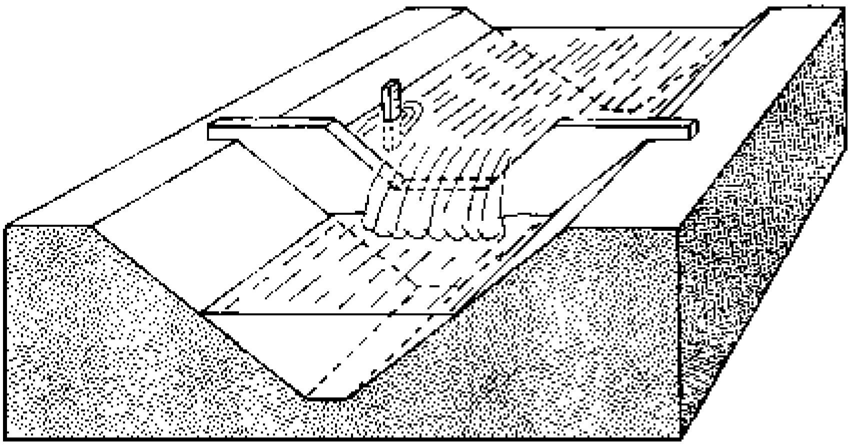


**Fig. 14 a trapezoidal weir**

**b. Parshall flumes**

The Parshall flume consists of a metal or concrete channel structure with three main sections: (1) a converging section at the upstream end, leading to (2) a constricted or throat section and (3) a diverging section at the downstream end (Fig. 14).

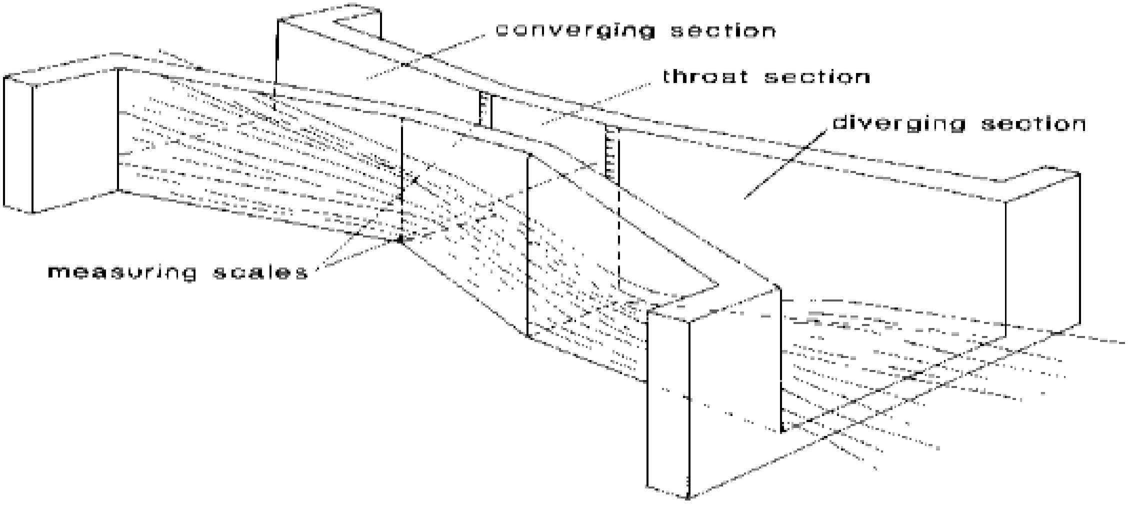


**Fig. 14 A Parshall flume**

Depending on the flow condition (free flow or submerged flow), the water depth readings are taken on one scale only (the upstream one) or on both scales simultaneously.

**c. Cut-throat flume**

The cut-throat flume is similar to the Parshall flume, but has no throat section, only converging and diverging sections (see Fig. 89). Unlike the Parshall flume, the cut-throat flume has a flat bottom. Because it is easier to construct and install, the cut-throat flume is often preferred to the Parshall flume.

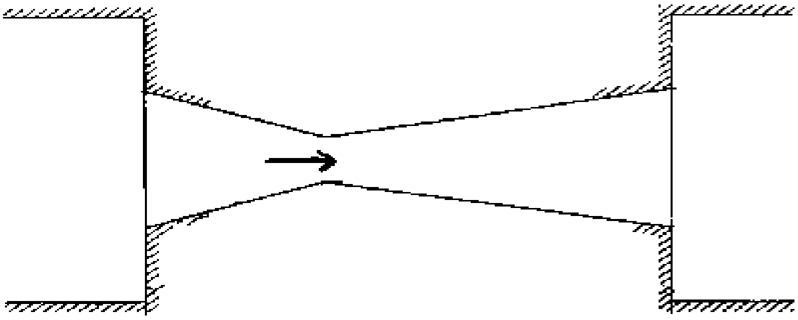


**Fig. 15. A cut-throat flume**

| Self-Check -4 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. List the main structures that irrigation system consists (5 pts.)
2. What are the commonly used water measuring structures? (5 pts.)

***Note:*** **Satisfactory rating - 3 and 5 points** **Unsatisfactory - below 3 and 5 points**

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

**Answer Sheet**

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

| Information Sheet-5 | Checking Parts and equipment delivered |
|---|---|

### 5.1 Checking Parts and equipment delivered

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.

| Self-Check - 5 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What things will be check on the delivered equipment (5 pts.?)

***Note:*** **Satisfactory rating -5 points** **Unsatisfactory - below 5 points**

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

**Answer Sheet**

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

| Information Sheet-6 | Checking Water supply |
|---|---|

## 6.1 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. Readying 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 Iocation of the farm irrigation structures. A good farm irrigation system should efficiently perform the following functions:

(a) Deliver water to all parts of the farm when needed,
(b) Deliver water in amounts needed to meet crop demands during peak use periods,
(c) Provide complete control of water,
(d) Measure the amount of water at entry into farm irrigation system,
(e) Divide water in required amounts for use in different fields,
(f) Dispose of waste water,
(g) Provide for reuse of water on the farm,
(h) Allow free, easy movement of farm machinery, and
(i) 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 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. Facilities to test water quality are available through state agricultural colleges, public health departments, and commercial laboratories.

| Self-Check -6 | Written Test |
|---|---|

**Directions:** Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What are the characteristics of a good irrigation farm system in terms of water supply? (5pts.)

***Note:*** **Satisfactory rating - 5 points** **Unsatisfactory - 5 points**

**Answer Sheet**

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

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