# R.C.Patel College Of Engineering & Polytechnic, Shirpur

## Department of Civil Engineering

**Course Title-** Water Resource Engineering **Course Code -** 315314

**Programme Name -** Civil Engineering **Semester-** Fifth

| Unit | Title | COs | Learning hours | R Level | U Level | A Level | Total Marks |
|---|---|---|---|---|---|---|---|
| II | Crop water requirement and Reservoir Planning | CO2 | 09 | 00 | 04 | 12 | 16 |

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# Unit II Crop Water Requirement and Reservoir Planning

## 2.1 Crop Water Requirement:

Definition → Crop water requirement is the total amount of water needed by a crop from sowing to harvesting for healthy growth and good production.

The water is used for:

1) Seed germination
2) Plant growth
3) Flowering and fruit formation.
4) Replacing water lost due to evaporation and transpiration.

### Cropping Seasons

A cropping season is the period during which a particular crop is grown.

There are three main cropping seasons in India.

#### 1. Kharif Season

- starts with the rainy season.
- Sowing : June - July
- Harvesting : September - October.
- Depends mainly on rainfall.

Examples: Rice, cotton, Maize, soybean.

#### 2. Rabi Season

- Grown during Winter.
- Sowing : October - November
- Harvesting : March - April.
- Irrigation is usually required.

Examples: Wheat, Gram, Mustard.

#### 3. Zaid Season

- Grown between Rabi and Kharif
- Short duration crops.

- Requires irrigation.
Examples: Watermelon, Muskmelon, Vegetables.

## Important definitions

### 1) Crop period
Crop period is the total time from sowing the crop until it is harvested.

Example: Wheat is sown in November and harvested in April.

- Crop period = About 150 days.

### 2) Base period
Base period is the time during which water is supplied to the crop through irrigation.

(OR) Base period is period in days from first watering before sowing to the last watering before harvesting. Base period is different for different crops.

- The base period is generally a little shorter than the crop period because irrigation is stopped before harvesting.

### 3) Duty (Ha/cumec) (D)
Duty is the area of land that can be irrigated by one cubic metre per second (1 cumec) of water during the base period.

Example: if crop is sown in an area of 2000 hectares and for this area 2 cumecs of water is required then duty of irrigation water is

$\frac{2000}{2}$ = 1000 hectares/cumec.

4) Delta (Δ)

Delta is the total depth of water required by a crop during the entire base period.

Unit : centimetre (cm) or metre (m)

Example → If a crop needs 120cm of water from sowing to harvesting.

Delta = 120cm.

5) Average duty

Average duty is the flow duty calculated at the head (beginning) of distributors (a type of canal) or main canal for small project.

- It is always less than duty as it takes all types of losses in account.

6) Gross duty | tank duty

Gross duty is the area under different crops irrigated by one million cubic meters of stored in the tank in one year.

7) Crop rotation

To maintain fertility of soil there is change in the crop after every season on a particular land to maintain fertility of soil, this is called rotation of crop.

Jawar - Gram - Fallow

Wheat - Jawar - Gram

Cotton - Jawar - Groundnut

cotton - wheat - Gram

Rice - Gram.

8) Kor Water

Kor water is the first water applied to the crop after sowing the crop. This water must be applied within fixed limited period. This period is known as kor period and depth of water applied is called kor depth.

9) Crop Ratio

The ratio of proposed areas under the crop of two main season (Kharif and Rabi) is called as crop ratio.

10) Time Factor.

It is the ratio of number of days canal has actually run to the number of days of irrigation period.

11) Capacity Factor

It is ratio of mean supply discharge to the full capacity discharge.

12) Command Area:

It is the area on the downstream side of a project to which water can reach by gravity.

There are three types of command area;

1. Gross Command Area (GCA)
2. Culturable Command Area (CCA)
3. Irrigable Command Area (ICA)

1) Gross Command Area (GCA):

Gross Command Area is the total area that receives water from a canal.

It includes: → Agricultural land, Roads, Villages, Rivers, Forests, Buildings, wasteland.

2) Culturable Command Area (CCA)

Culturable command area is the part of gross command area that is suitable for cultivation.

It does not include:-

- Roads, Buildings, Rivers, Rocky land, Forests.

3) Irrigable Command Area (ICA): It is that part of culturable command area which can be actually irrigated.

## Intensity of Irrigation

Intensity of irrigation is the percentage of cultivable land that is actually irrigated in one season.

Formula → Intensity of Irrigation (%) = $\left(\frac{\text{Area Irrigated}}{CCA}\right) \times 100$

## Factors Affecting Duty :

The duty of water depends on many factors:

1) Type of crop: Duty depends upon the kind of crop. duty for rice is 550 while for Jawar it is 2000.

2) Season: In hot season evaporation is more and hence duty gets reduced as crop requires more water.

3) Rainfall: If the rainfall is more then water required for irrigation is less and thus duty will be more.

4) Soil type: If the soil is free draining soil then losses are more and thus reduces duty while black cotton soil hold water thus increases duty.

5) Method of irrigation: If method of irrigation is not proper duty will be less i.e in case of sprinkler as optimum use of water is possible.

6) Method of tilling - If proper method of tilling is adopted there will be less wastage of water thus duty is more.

7) Canal Condition: Canal should be kept in proper condition by proper maintenance and lining which reduces losses like seepage, leakage which increases duty.

8) Mode of assessment: The tendency of using more water is checked by adopting volumetric assessment which gives more duty than area wise assessment.

## 2.2 Relation between duty, delta and base period.

A relation established between duty and delta by equating the total volume of water required for a crop in a season as below.

Let, $D$ = duty in hectares/ cumec.

$\Delta$ = Delta for crop in m.

$B$ = Base period of crop in days.

If 1 cumec flowing for base period (B) and irrigates field of 'D' hectares then total volume is given by

$$= 1 \times (24 \times 60 \times 60)\, B\ m^3 \quad \text{—— (1)}$$

$$= 8.64 \times 10^4 \times B \text{ cubic m.}$$

Volume calculated from delta $\Delta$ cm of depth required in base period $= \Delta \times 10^4$

and for $D$ hectares the volume $= 10^4 \times \Delta \times D$ cubic m —— (2)

Equating Equations ;

$$1 \times 24 \times 60 \times 60 \times B = \Delta \times D \times 10^4$$

$$\boxed{D = \frac{8.64\, B}{\Delta}}$$

$$\boxed{\Delta = 8.64 \frac{B}{D} \text{ meters.}}$$

Note: 1 acre : 0.4047 hectares

1 hectare $= 10^4$ sq.m

1 cusec = 0.0283 cumec

1 cumec/day = 8.64 hectare-meter.

## 2.3 Numericals on water requirement and capacity of of Canal.

1) Find the design discharge of a canal for irrigating the crops as detailed given:

i) Transit losses = 15%.
ii) Time factor = 0.7
iii) Capacity Factor = 0.8

| Sr No. | Name of crop | Area under Irrigation Ha | Duty of field in Ha/cumec |
|---|---|---|---|
| 1 | Sugarcane | 350 | 700 |
| 2 | Rice (Kharif) | 150 | 600 |
| 3 | Bajri (Kharif) | 600 | 1500 |
| 4 | Wheat (Rabi) | 1200 | 1800 |
| 5 | Vegetables (H.W) | 400 | 800 |

Solution →

| Sr No | Name of Crop | Area under irrigation in Ha | Duty at Field in Ha/cumec | Discharge = $\frac{\text{Area}}{\text{Duty}}$ |
|---|---|---|---|---|
| 1 | Sugarcane | 350 | 700 | 0.5 |
| 2 | Rice (Kharif) | 150 | 600 | 0.25 |
| 3 | Bajri (Kharif) | 600 | 1500 | 0.40 |
| 4 | Wheat (Rabi) | 1200 | 1800 | 0.667 |
| 5 | Vegetables (H.W) | 400 | 800 | 0.50 |

Kharif Season = Rice + Bajari + Sugarcane

$$Q_K = 0.25 + 0.40 + 0.50 = \underline{1.15 \text{ cumec}}$$

Rabi season = Wheat + Sugarcane

$$Q_R = 0.667 + 0.50 = \underline{1.167 \text{ cumec}}$$

Hot weather season

vegetable + sugarcane, = $Q_H = 0.50 + 0.50 = \underline{1.00 \text{ cumec}}$

$\boxed{\text{Maximum Seasonal discharge} = 1.167 \text{ cumec (Rabi)}}$

Apply time Factor: = 0.7

$$\boxed{Q_1 = \frac{1.167}{0.7} = 1.667 \text{ cume}}$$

Apply Capacity factor, = 0.8

$$\boxed{Q_2 = \frac{1.667}{0.8} = 2.084 \text{ cumec}}$$

Consider, Transit losses

Transit losses = 15 %.

Water reaching the field = 100 − 15 = 85 %

$$\boxed{Q = \frac{2.084}{0.85} = 2.542 \text{ cume}}$$

OR Design discharge = $\frac{1.167}{0.85 \times 0.7 \times 0.8}$

$$\boxed{\text{Design discharge} = 2.451 \text{ m}^3/\text{s}}$$

Q. 2) Calculate the storage required in Ha.m. for irrigating following crops. Consider reservoir loss as 12 %. and canal losses 15 %.

| SrNo | Crop | Base period days | Duty of filled Ha / cumec | Area under crop Ha. |
|---|---|---|---|---|
| 1 | wheat | 150 | 2000 | 12000 |
| 2 | Rice | 120 | 900 | 4500 |
| 3 | Sugarcane | 320 | 700 | 4200 |
| 4 | Cotton | 210 | 1600 | 8000 |
| 5 | Vegetable | 120 | 600 | 2400 |

solution →

| Sr No. | Crop | Bare Period days | Duty of filed Ha / cumec | Area Under Crop Ha | $\Delta$ in m = $\frac{8.64B}{D}$ | Volume = (D×A) Ha.m |
|---|---|---|---|---|---|---|
| 1 | Wheat | 150 | 2000 | 12000 | 0.648 | 7776 |
| 2 | Rice | 120 | 900 | 4500 | 1.152 | 5184 |
| 3 | Sugarcane | 320 | 700 | 4200 | 3.9497 | 16588.74 |
| 4 | cotton | 210 | 1600 | 8000 | 1.134 | 9072 |
| 5 | vegetable | 120 | 600 | 2400 | 1.728 | 4147.2 |

Cumulative volume = 42767.94 ha.m

Considering reservoir loss as 12% and canal losses 15%.

Storage capacity of reservoir = $\frac{42768}{0.85 \times 0.88}$ [Reservoir loss = 100 - 12 = 88%]

= 57176.47 Ham [Canal loss = 100 - 15 = 85]

$\boxed{\text{Storage capacity of reservoir} \approx 57176.5 \text{ Ham}}$

Q 3) Determine delta of crop having duty 432 Ha/cumec on the field and base period 45 days.

Duty (D) = 432 ha/cumec

Bare period (B) = 45 days.

∴ Using duty delta equation,

$$\Delta cm = \frac{8.64 \times B}{D} \quad \frac{(\text{DAYS})}{(\text{ha/cumec})}$$

$$= \frac{8.64 \times 45}{432}$$

$$\boxed{\Delta cm = 0.9 cm}$$

## 2.4 Methods of Irrigation :

The following are the methods of irrigation.

1) Sub surface irrigation

2) Surface irrigation

3) over head irrigation

### 1) Sub surface Irrigation

Water is supplied below the ground directly near the roots.

It is again divided into two types:

a) Natural subsurface irrigation

b) Artificial Sub surface irrigation.

a) When water is applied to the plants through Capillary movement from water table then it is called as natural sub surface irrigation.

b) In this method water from drains and pipes directly infiltrate into root zone of soil.

### 2) surface irrigation

In this irrigation water is flooded over the field to a cm and to control flow the surface is first smoothened and then modified with borders furrows corrugations.

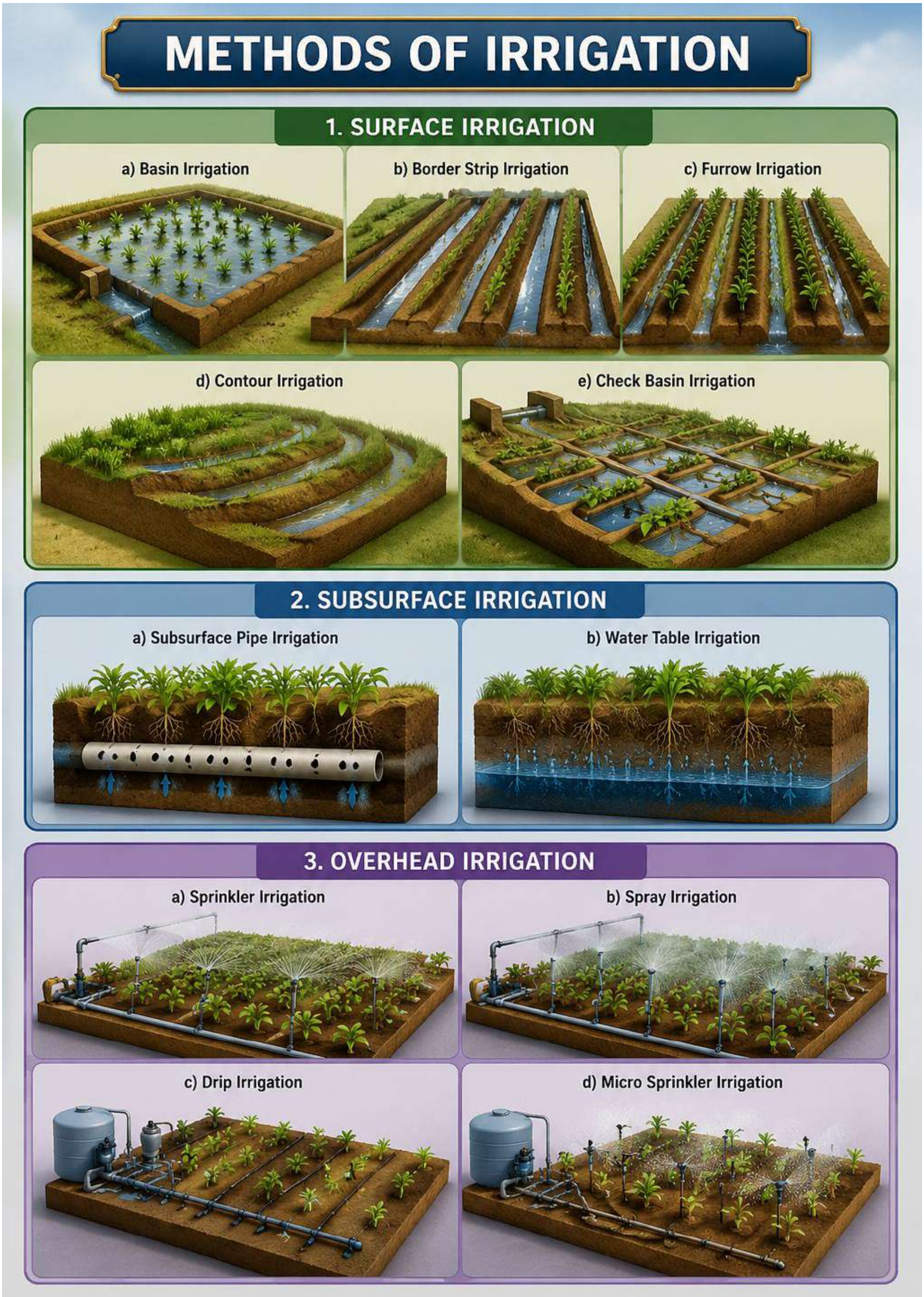
The surface irrigation is classified as,

1) Uncontrolled or free flooding method

- In this method water is applied by flooding over areas of smooth and flat land. This method is adopted in inundation irrigation system.
- This method may cause wasteful use of water.

2) Controlled flooding method

control flooding water is supplied through various methods the various methods are as follows:


METHODS OF IRRIGATION
1. SURFACE IRRIGATION
a) Basin Irrigation
b) Border Strip Irrigation
c) Furrow Irrigation
d) Contour Irrigation
e) Check Basin Irrigation
2. SUBSURFACE IRRIGATION
a) Subsurface Pipe Irrigation
b) Water Table Irrigation
3. OVERHEAD IRRIGATION
a) Sprinkler Irrigation
b) Spray Irrigation
c) Drip Irrigation
d) Micro Sprinkler Irrigation

i) Border strip method / border flooding
ii) Basin method
iii) check method
iv) Ditch method

3) Furrow methods

In furrow irrigation method water is applied only one fifth to one half of land surface which results in less evaporations.

This furrow methods is further classified as,
a) Graded furrow method
b) Contour furrow method
c) Level furrow method
d) Corrugation method.

4) Drip Irrigation

This type of irrigation is done by using small diameter plastic lateral lines called as drippers. It also called Trickle irrigation.

3) Overhead Irrigation

- In this method water is applied to the soil in the form of spray through a network of pipes and pumps. It is a kind of an artificial rain.
- There is uniform distribution of water. This method is suitable where land topography is irregular, where gradient is steep and soil is easily erodable.

Advantages

a) Uniform water distribution.
b) suitable for uneven land
c) saves water
d) Reduces soil erosion.

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## 2.5 Silting of Reservoir:

**Definition** → Silting is the deposition of sand, silt and soil particles carried by rivers into a reservoir.

- over time, these particles settle at the bottom of the reservoir and reduce its storage capacity.

### Rate of Sillting

The rate of silting is the amount of silt deposited in the reservoir per year.

It is generally expressed in:

- cubic metres per year ($m^3$/year)
- percentage loss of storage per year.

Higher rate of silting means.

- faster reduction in storage capacity.
- shorter life of reservoir.

### Factors Affecting Silting

The various factors which affect silting are:

1) Caltchment area: In case of fan shaped catchment the amount of deposition of finer soil fractions will be more as compared to fern shaped catchment.

2) Slope of Country: If the slope is steep more particles are deposited through runoff as velocity is more which carries silt and clay particles with it and high velocity may erode soil more.

3) Climatic condition: It also plays important role in silting, as climatic condition like dryness, rain, heat etc. helps in production of silt.

4) Nature of surface soil: If the soil is loose then silting is more as more particles will move along with runoff.

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i) Border strip method / border flooding
ii) Basin method
iii) Check method
iv) Ditch method

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## Effects of silting

1) Reduces reservoir storage
2) Reduces water supply.
3) Reduces irrigation capacity.
4) Reduces hydroelectric power generation.
5) Increases flood risk.
6) Shortens reservoir life.

## Control Measures of silting

1) Afforestation (Plan the more trees)
2) Construct check dams
3) Build silt traps
4) Practice contour farming.
5) Terrace farming on hilly areas.
6) Prevent soil erosion.
7) Desilt the reservoir reguarly.
8) proper watershed management.

## Methods to control silting

The following methods should be adopted in order to prevent silting of reservoirs.

1) Pre-constructing Methods.

The method adopted before and during construction of project are called as pre constructing methods which includes:

1) Selection of dam sites: Catchment area has been less erodable portion.

2) Constructing dam in stages: Height of dam should be kept low such that water storing capacity is less than annual runoff and when floods are cleared its height should be increased.

3) <u>Constructing check dam</u> : The small bunds called check dams are contructed along the tributaries which Contribute major sediment load arrest partially silt Particles.

4) <u>Providing vegetation</u>: vegetation growth is promoted in the catchment area.

5) Proper reservoir design causing silty water to escape.

2) <u>Post constructing methods</u>

The methods which are adopted after Construction of Project are called as post constructing methods which includes,

a) Removal of post flood water
b) Dredging
c) Mechanical stirring
d) soil conservation method.

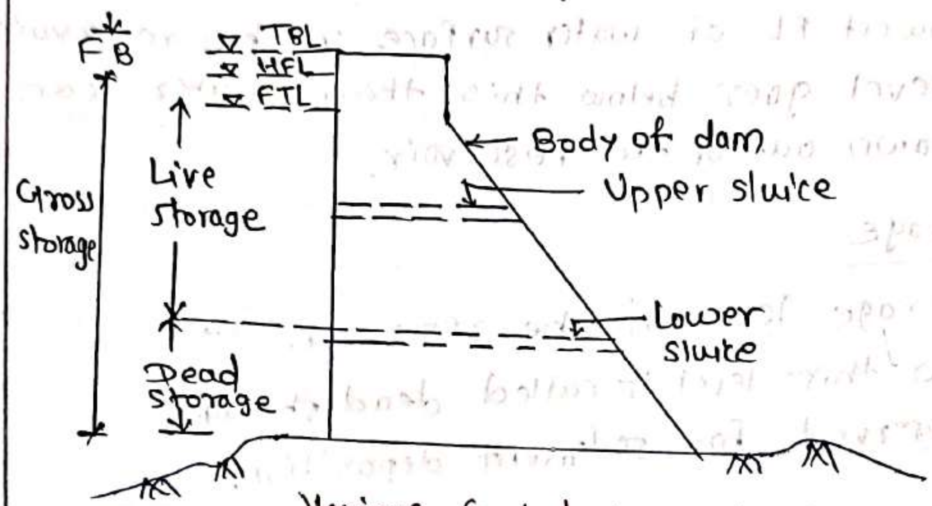
i) Dredging : Excavation under water and silt is excavated from bed of reservoir. It is costlier process.

ii) Mechanical means : Silt is kept in disturb condition by mechanical means it is pushed through sluices and thus soil particle passes towards downstream side.

iii) Soil conservation:
soil conservation adopted on upstream side of reservoir such as excavation of ditches, crop rotation etc.

## 2.6 Control levels in Reservoir

Definition → Control levels are the important water levels fixed in a reservoir for proper operation and safety.
They help in storing water, supplying water and protecting the dam during floods.




Various Control levels in dam

The following are the control levels of dam:
1) Top bund level (TBL)
2) High flood level (HFL)
3) Full tank level (FTL)
4) Lowest water level (LWL)

1) Top bund level (TBL)

This is reduced level of top of bund or dam which depend on capacity, storage flood lift and free board. The height of dam at any section is difference between TBL and GL (Ground level). The length of dam is measured at this level.

2) High flood level (HFL)

It is the maximum RL upto which water can Rise in the reservoir. It depends on flood lift and FTL (Full tank level).

3) Full tank level (FTL)

It is the RL where Gross storage capacity is available and it is also level upto which water will be stored.

in that reservoir. The crest of spillway is kept at this RL. The spread of water in the area within the contour of FTL is called as submergence.

It is also called as full reservoir level.

4) Lowest Water level (LWL)

It is the lowest RL of water surface in the reservoir. If water level goes below this then water can not be drawn out of the reservoir.

5) Dead storage

- Lowest storage level of the reservoir.
- Water below this level is called dead storage.
- Mainly reserved for sediment deposition.

6) Live Storage

Water between MDDL and FRL; available for use.

Live storage = Irrigation requirement + Tank losses.

7) Gross Storage

It is the storage of FTL in the reservoir generally.

Gross storage = Dead storage + Live storage

8) Free Board

It is the vertical distance between TBL and HFL. It is clear margin kept as a measure of safety so that wave form should not cross over dam.

9) Parent stream

It is the river across which dam is constructed.

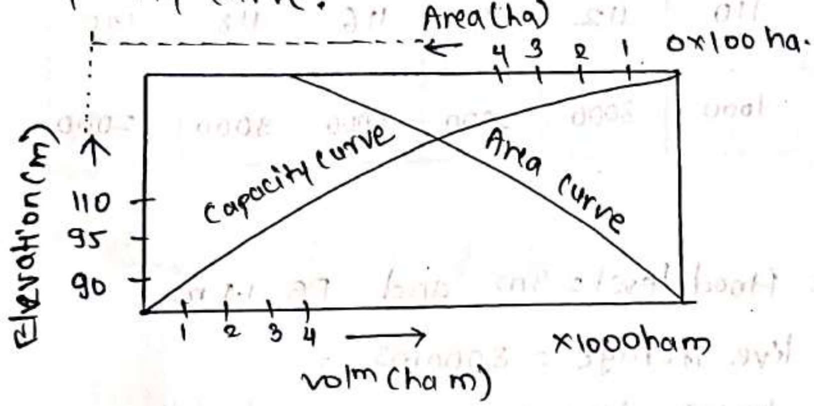
# Area Elevation/Area capacity curve

The Area capacity curve is a graph that shows the relationship between the water surface area of a reservoir and the volume (capacity) of water stored at different water levels.

It helps engineers know how much water is stored in the reservoir at any particular water level.

## What is an Area Capacity curve?

- As the water level in a reservoir rises, the water spreads over a larger area.
- At the same time, the volume of water stored also increases.
- The graph showing this relationship is called the area capacity curve.




Area elevation/capacity curve

The area capacity curve is useful in,

1. Deciding capacity of reservoir.
2. Water spread of reservoir.
3. Elevation of water at any point can be calculated.
4. This curve will also useful in determining control level of dam.

1. Trapezoidal Formula

$$V = h\left(\frac{A_1 + A_n}{2} + A_2 + A_3 \cdots + A_{n-1}\right)$$

2. Prismoidal Formula

$$V = [(A_1 + A_n) + 4(A_2 + A_4 + A_6) + 2(A_3 + A_5 + A_7 \ldots)]$$

where; V = volume or capacity of the reservoir,

h = Height of interval.

## Numericals

Q 1) Fix the F.R.L and T.B.L from the given data.

i) D.S.L = 110.00m ii) Effective live storage = 8000 $m^3$

iii) Tank losses = 1500 $m^3$ iv) Max flood discharge = 400 $m^3$/sec

v) Length of waste weir = 100m

vi) Francis formula $Q = 1/8\ LH^{3/2}$

vii) Free Board = 1.5 m

| Contour RL | 110 | 112 | 114 | 116 | 118 | 120 |
|---|---|---|---|---|---|---|
| Capacity in $m^3$ | 1000 | 3000 | 5000 | 6000 | 9000 | 12000 |

Solution

Assume FL = Flood level = 3m and FB = 1.5 m.

Effective live storage = 8000 $m^3$

Tank losses = 1500 $m^3$

Total = 9500 $m^3$

Dead storage = 1000 $m^3$ (corresponds to RL 110)

Gross storage = Total + dead storage

Gross storage = 10,500 $m^3$

∴ RL corresponds to Gross storage = $\frac{(10,500 - 9000)}{(12000 - 9000)} \times (120 - 118)$

above mention interpolation method, because it lies in $\boxed{RL = 118 - 120}$

$\boxed{\text{RL corresponds to gross storage} = 1m}$

$FRL = 118 + 1$

$FRL = 119 m$

$HFL = FRL + FL = 119 + 3 m$

$HFL = 122 m$

$TBL = HFL + FB = 122 + 1.5$

$\boxed{TBL = 123.5 m}$

W-25, S-22

Q 2) Fix the FRL, TDL and HFL from following data.

i) D.S.L = 210.00m

ii) Effective live storage = 8500 m3

iii) Max. flood discharge = 500m3

iv) Tank losses = 450 m3/sec.

v) Length of waste weir = 100m

vi) Free board = 2.5m

vii) $Q = 1.8 L H^{3/2}$ (Francis formula)

| Contour R.L (m) | 210 | 212 | 214 | 216 | 218 | 220 |
|---|---|---|---|---|---|---|
| Capacity (m3) | 1500 | 3200 | 5000 | 6500 | 9000 | 12000 |

Solution →

Free board = 2.5m

Flood level = 3m

Effective live storage = $8500 m^3$

Tank losses = $450 m^3$

Total = Effective live storage + Tank losses

= 8500 + 450

$\boxed{Total = 8950 m^3}$

Dead storage = $1100 m^3$

Gross storage = Total + dead storage

= 8950 + 1100

$\boxed{Gross\ storage = 10,050 m^3}$

RL corresponds to, $101050 m^3$

is in between RL 218 220

9000 12000

Using interpolation,

$$FRL = \frac{(10,050 - 9000)}{(12000 - 9000)} \times (220 - 218)$$

$\boxed{RL = 0.65 m}$

$FRL = 218 + 0.65$

$\boxed{FRL = 218.65 \approx 218.7 m}$

High flood level = FRL + FL

$= 218.7 + 3$

$\boxed{HFL = 221.7 m}$

TDL = HFL + FB

$= 221.7 + 2.5$

$\boxed{TDL = 224.2 m}$

By Francis formula,

$$q = 1.8 L H^{3/2}$$

$$500 = 1.8 \times 100 \times H^{3/2}$$

$\boxed{H = 0.598 m}$

High flood level,

HFL = FRL + H

$= 218.7 + 0.598$

$\boxed{HFL = 219.298}$

Top of dam level,

TDL = HFL + FB = 219.298 + 2.5

$\boxed{TDL = 221.798 m}$

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Q 3) Determine LSL, FL, MRL and TBL from the data given below.

Effective storage required for crops = 5200 ha-m

Tank losses = 15% of effective storage.

Carry over allowance = 10% of effective storage.

Dead storage = 10% of gross storage.

| Contour R.L (m) | 51 | 54 | 57 | .... | 110 | 113 | 116 |
|---|---|---|---|---|---|---|---|
| storage (mm3) | 3.0 | 5.5 | 7.5 | .... | 50.0 | 70.0 | 90.0 |

Solution → Gross storage,

= Effective storage + Tank losses + carry over allowance

= 5200 + 15% 5200 + 10% of 5200

$= 5200 + \left[\left(\frac{15}{100}\right) \times 5200\right] + \left[\left(\frac{10}{100}\right) \times 5200\right]$

= 5200 + 780 + 520

= 6500 Ham

$\boxed{\text{Gross storage} = 65\ mm^3}$

Storage, $65\ mm^3$ lies, – 50 to 70

So, 110 ? 113

50.0 65 70.0

$RL = \frac{(113-110)}{(70-50)} \times (65-50)$

$\boxed{RL = 2.25\ m}$

FRL = RL + Previous RL

= 2.25 + 110

$\boxed{FRL = 112.25\ m}$

Dead storage = 10% of gross storage

$= \frac{10}{100} \times 65$

$= 6.5\ mm^3$

which lies, storage 6.5 mm³,

54 & 57

5.5 6.5 7.5

$$DSL = 54 + \left[ \frac{(57-54)}{(7.5-5.5)} \times (6.5-5.5) \right]$$

$$= 54 + 1.5$$

~~DSL = 55.5 m~~

$$\boxed{DSL = 55.5 m}$$

HFL = FRL + Flood lift

HFL = 112.25 + 2 = 114.25 m

TBL = HFL + FB

TBL = 114.25 + 3

$$\boxed{TBL = 117.25 m}$$

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# ASSIGNMENT QUESTIONS

1. Define base period and crop period.
2. Derive relation between Duty, Delta, and Base period.
3. Draw a layout of lift irrigation scheme. Explain its function with component parts.
4. Differentiate between sprinkler irrigation and drip irrigation.
5. 

Find the designed discharge of a canal having following details.

i) Transit losses = 18%

ii) Time factor = 0.7

iii) Capacity factor = 0.8

| Sr No | Name of Crop | Area under irrigation (Ha) | Duty at field in Ha/cumec. |
|---|---|---|---|
| 1 | Sugarcane | 350 | 700 |
| 2 | Rice (Kharif) | 150 | 600 |
| 3 | Bajari (Kharif) | 600 | 1500 |
| 4 | Wheat (Rabbi) | 1200 | 1800 |
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6. 

Fix the F.R.L., TDL and HFL from data.

i) D.S.L. = 210.00 m

ii) Effective Live storage = 8500 $m^3$

iii) Max. flood discharge = 500 $m^3$

iv) Tank losses = 450 $m^3/sec$

v) Length of waste weir = 100 m

vi) Free board = 2.5 m

vii) $Q = 1.8\ L.H.^{3/2}$ (Francis formula)

| Contour R.L. (m) | 210 | 212 | 214 | 216 | 218 | 220 |
|---|---|---|---|---|---|---|
| Capacity ($m^3$) | 1500 | 3200 | 5000 | 6500 | 9000 | 12000 |

7. State ill effects of irrigation.

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8.

Fix the control levels DSL, FRL, HFL and TBL from given data.

i) Effective storage required for crops 3000 Ha.m

ii) Carry over allowance and tank losses 25%

iii) Dead storage - 10% of gross storage

| R.L(m) | 580 | 582 | 584 | 610 | 612 | 614 |
|---|---|---|---|---|---|---|
| Storage ($mm^3$) | 3.0 | 4.5 | 6.0 | 30 | 40 | 50 |

Assume flood lift as 1.5 m and free board as 2.5 m.

9. Enlist factors affecting the Duty.
10. Explain the meaning of
    i) Time Factor ii) iii) Capacity Factor iv)Command Area Irrigation Command Area

11.

Determine LSL, FL, MRL & TBL from the data Given below. Effective storage required for crops = 5000 ha.m. Tank losses = 15% of effective storage, carry over allowance = 10% of effective storage, Dead storage = 8% of gross storage.

| Contour$_m$RL | 51 | 54 | 57 | 110 | 113 | 116 |
|---|---|---|---|---|---|---|
| Storage $mm^3$ | 3.0 | 5.5 | 7.5 | 50 | 70 | 90 |

12. Explain the Drip irrigation with neat sketch and describe components of each.
13.

Fix control levels of medium size reservoir from given data –

Effective storage required for crops = 30 Ha.m

Tank losses = 20% of effective storage

Carry over allowance = 10% of effective storage

Dead storage = 10% of gross storages

| Contour (RL) (m) | 250 | 253 | 256 | 278 | 281 | 284 |
|---|---|---|---|---|---|---|
| Storage ($Mm^3$) | 3.20 | 4.10 | 5.25 | 42.65 | 47.30 | 55.12 |

Assume flood lift = 3 m and free board = 3 m.

14. Discuss sprinkler irrigation system w.r.t. merits, demerits, sketch and trouble shooting of it.
15. State any two silt control measures of a reservoir.
16. Describe in brief with neat sketch area capacity curve.