4. Surface irrigation methods

Introduction

- Surface irrigation is a method in which water is applied by gravity flow
- Irrigation systems generally consist of:

1. *Physical systems-to supply water* to cropped area
2. Social and organizational systems
3. Cropping system
4. Economic systems

Physical system of surface irrigation consist of:

a) The water supply subsystem

b) The water delivery subsystem

c) The water use subsystem

d) The water removal subsystem

Water supply sub –systems

- Diverts water from the source to conveyance /delivery system

Water delivery sub-system

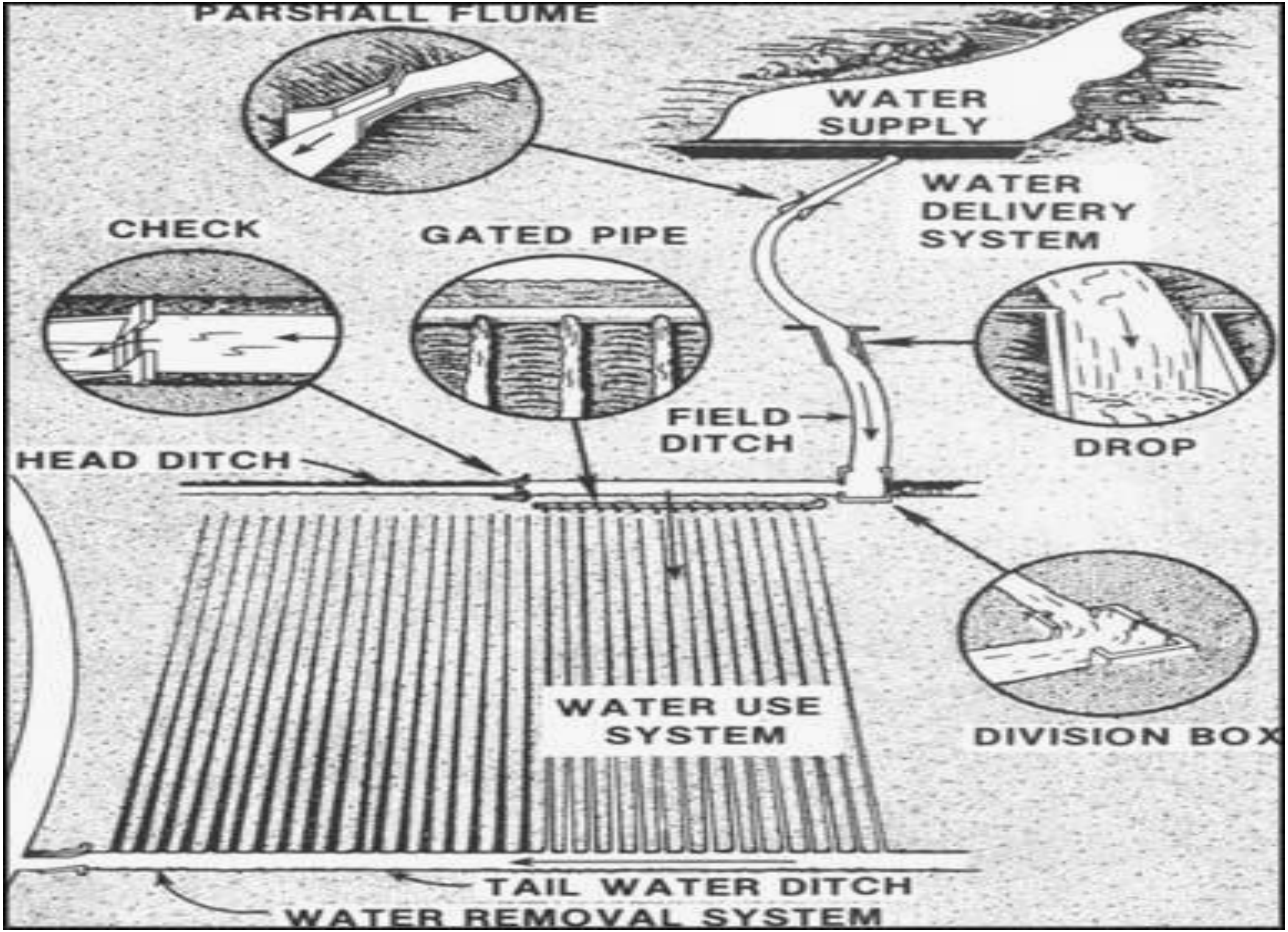
- Conveys water from the source to field through canals, distributaries, & channels at regulated rate

Water use sub- system

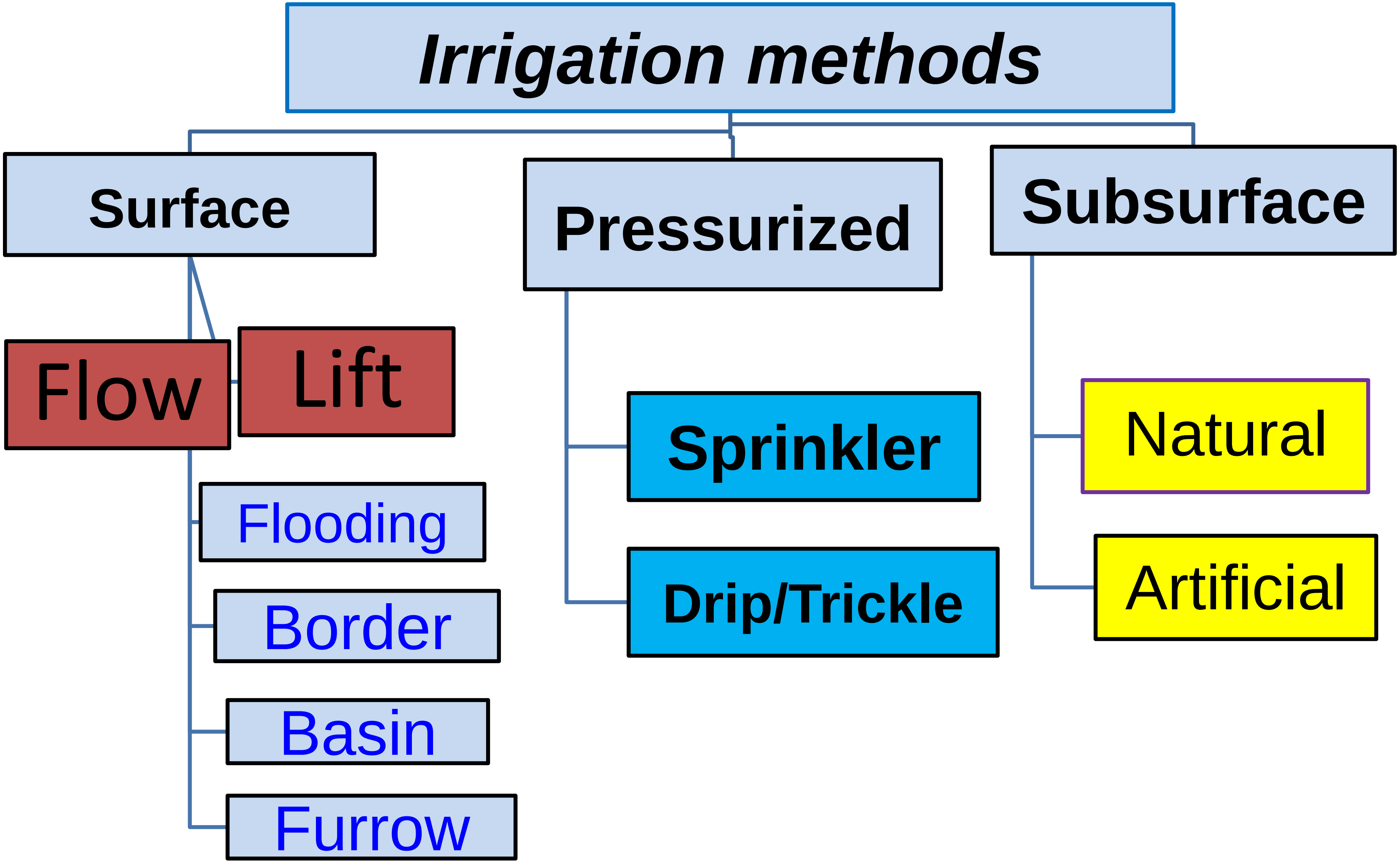
- Receives water from the water delivery & application sub–systems

Water removal sub –system

- Used for removal and disposal of excess surface and sub- surface water to improve aeration & salinity levels



Typical Physical systems of irrigation



Irrigation methods
Surface
Pressurized
Subsurface
Flow
Lift
Flooding
Border
Basin
Furrow
Sprinkler
Drip/Trickle
Natural
Artificial

Advantages of surface irrigation

- Gravity flow system is flexible, & relatively easily-managed. → More acceptable to farmers
- More acceptable to farmers as it appears easier to apply
- Can be developed at farm level with minimal cost. Expense is associated only with land grading
- Electrical power is not required
- less affected by climatic and water quality characteristics

Disadvantages

- The system experiences low efficiency (60-70%), water logging/salinity problems

A. Surface irrigation methods

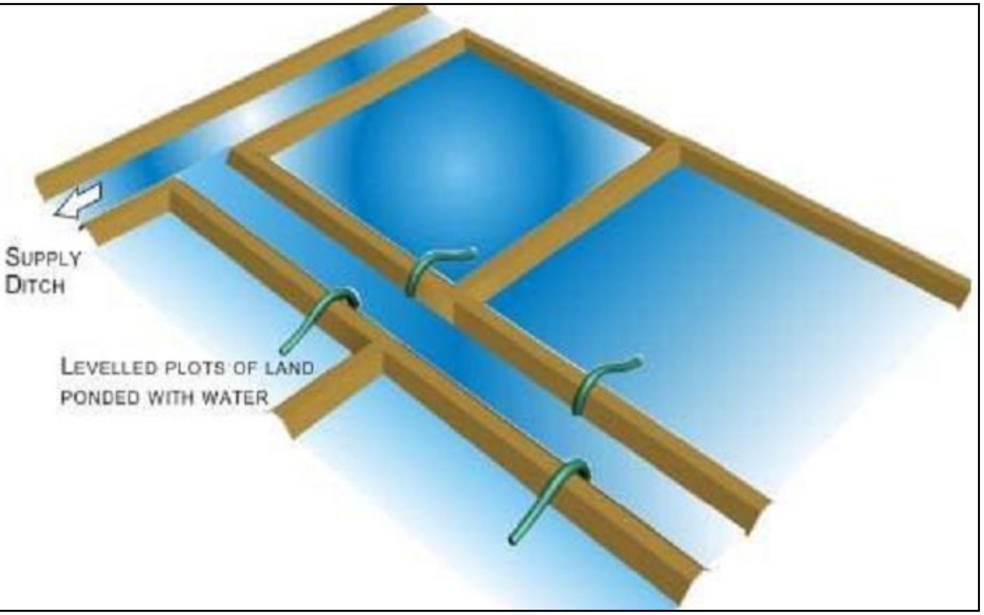
1. Wild flooding

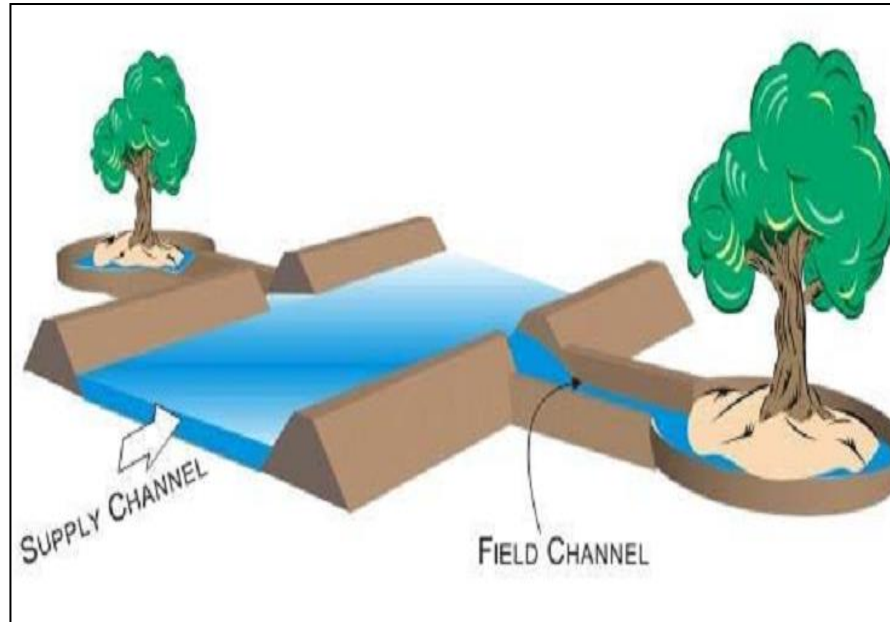
- Since movement of water is not restricted, it is called uncontrolled, wild or 'free' flooding
- Water is applied to the crop land without land preparation, can be used on land that have irregular topography
- No levees to guide or restrict the flow on the field

- Most suitable to close growing crops
- Results in excess irrigation at the inlet of field & insufficient at the outlet of field
- Application efficiency is low due to deep percolation or excess runoff
- Recommended only when no water scarcity, land surface is irregular, crops are not affected by water logging

2. Basin irrigation

- Basins are flat areas of land, surrounded by low bunds/levees
- The dykes/levees/bunds prevent runoff from basin, and also undirected flow onto the basin
- Frequently used to irrigate trees & orchards
- Suited to medium to heavy soils with low intake rate
- Most efficient among surface irrigation methods
- Most expensive *develop and maintain* *but* least expensive to *operate and manage*





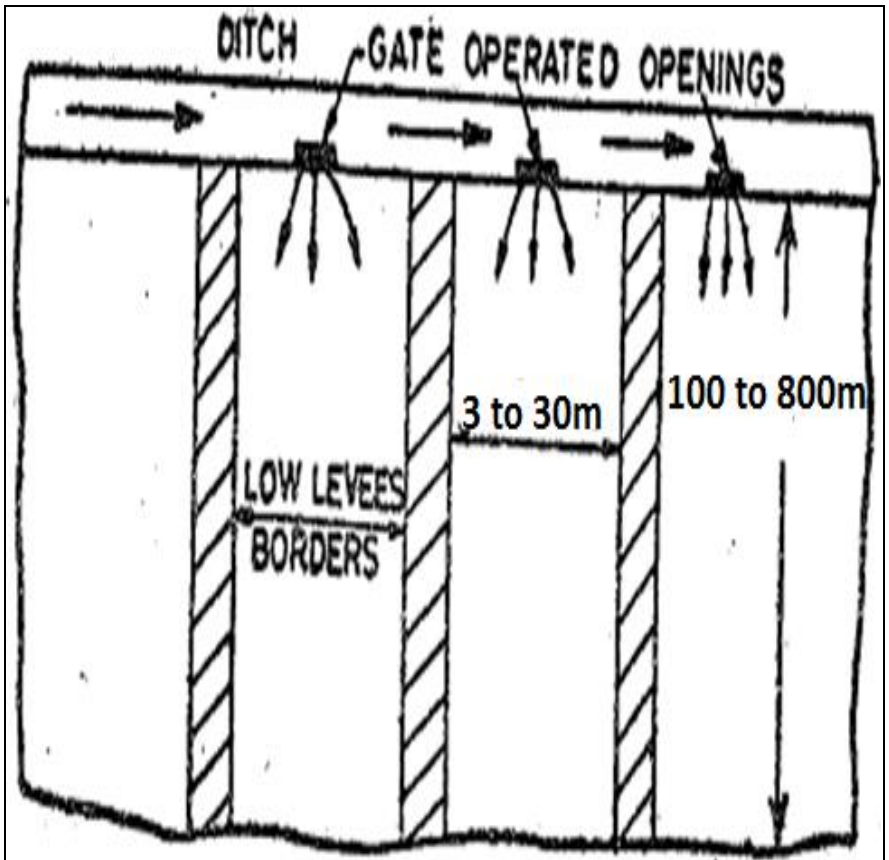
a) Check- basin

b) Ring-basin

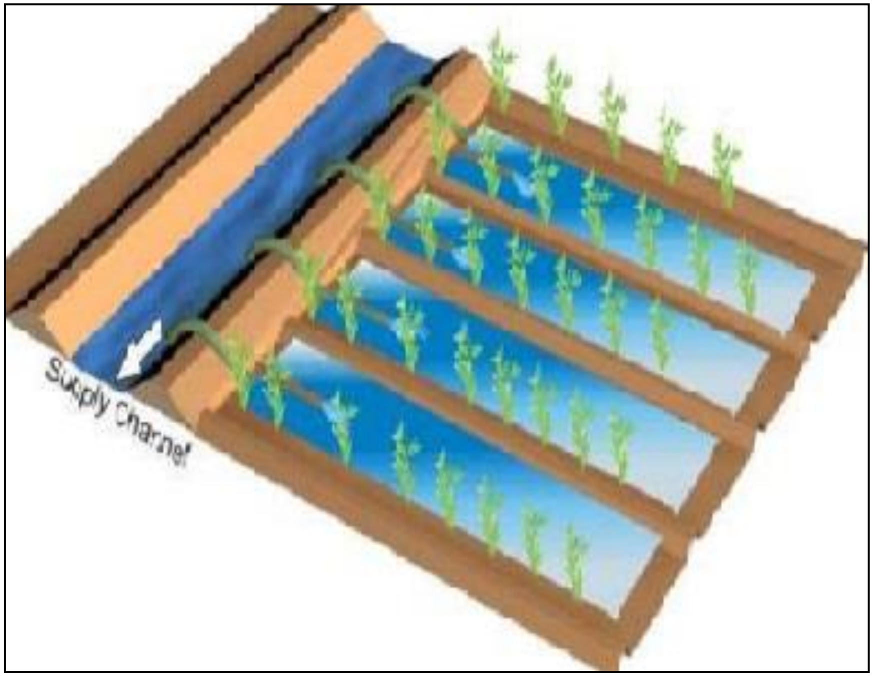
- Basin size depends on slope, soil type & flow size to the basins

3. ***Border strip irrigation***

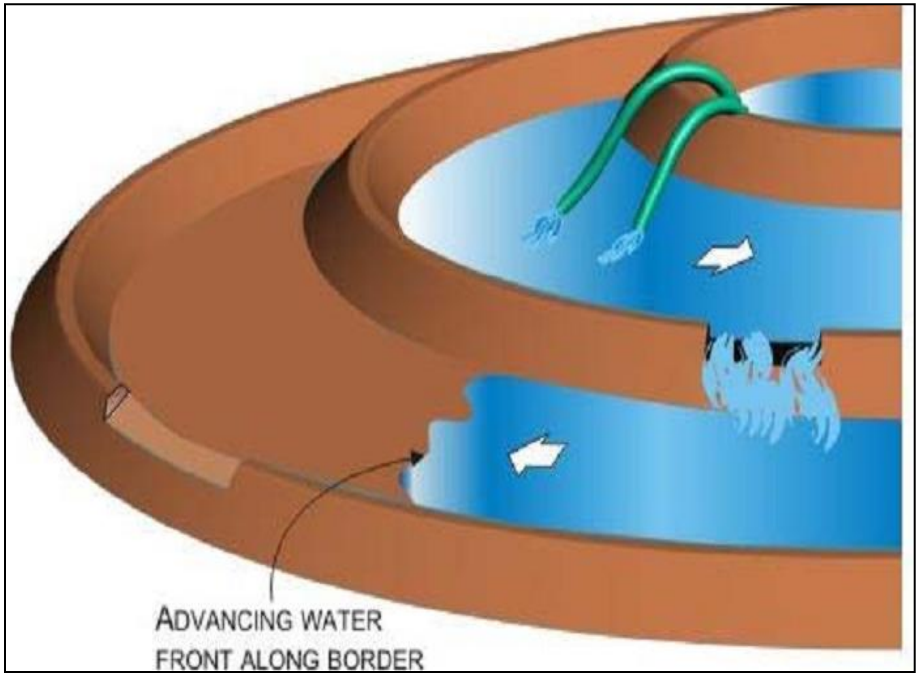
- Border strips are usually uniformly graded strips of land separated by small earth bunds (low ridges/ levees)



- The farm is divided into a number of strips (3-30m wide & 100-800m long
- The strips are level between levees but sloped along the flow path
- Each strip is irrigated independently by turning on a stream at upper end
- When the advancing water reaches the lower end of the border, the stream is turned off



Straight border



Contour border

Flow supply system of borders can be:

a) Fixed *flow*

- a system in which the inlet flow rate remains constant throughout the duration of irrigation.
- It is simple but generally of low efficiency.

b) Cutback flow

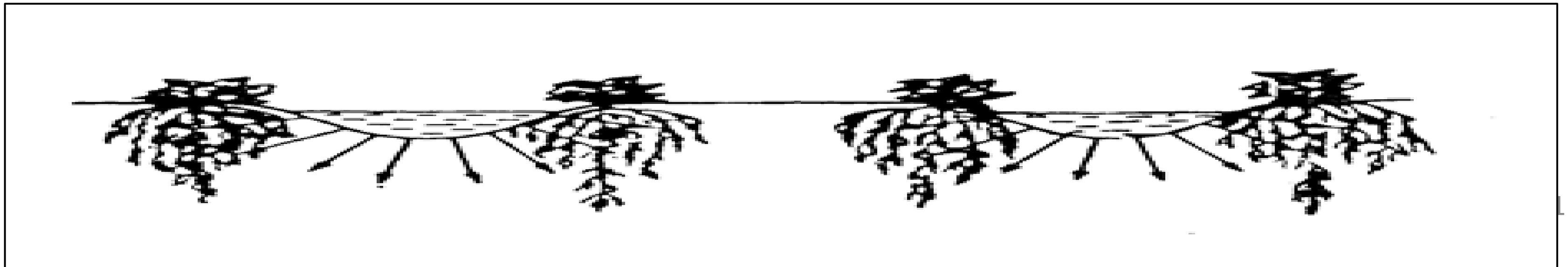
- A system in which irrigation begins with nearly maximum *non erosive inlet flow rate*, for part of irrigation period & reduced for part of a period
- Efficient than fixed flow system

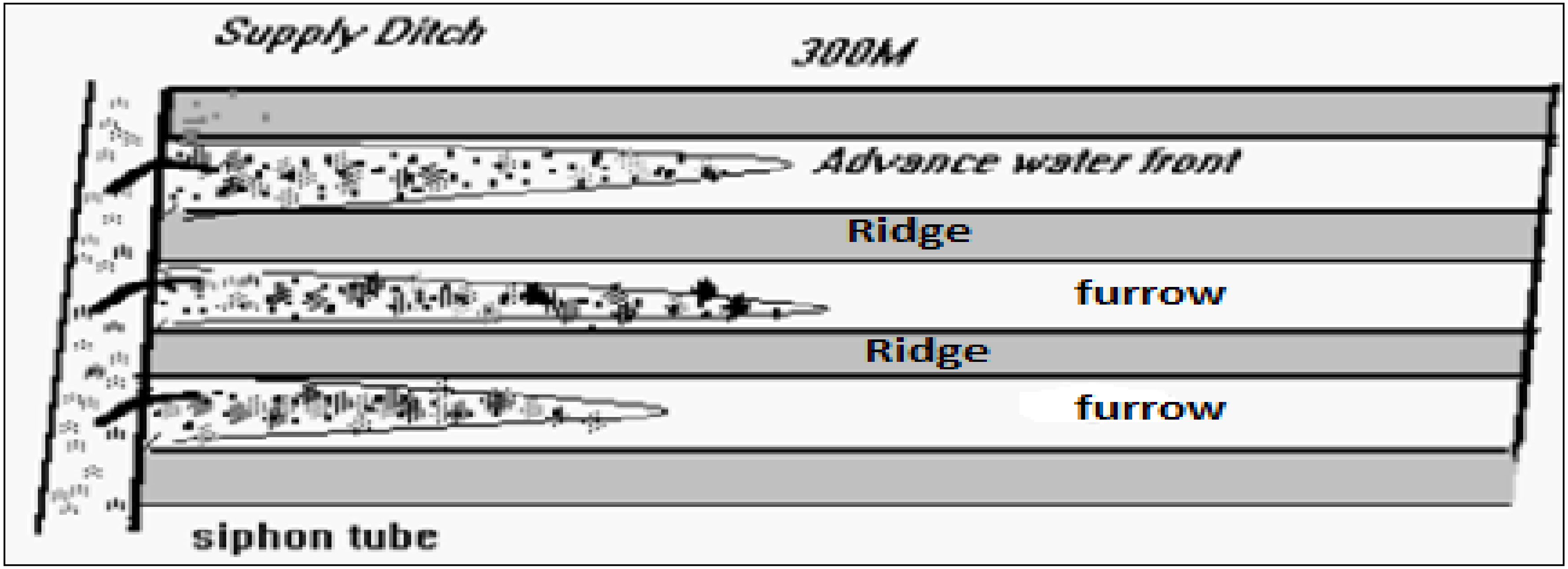
c) Tail water *reuse*:

- A system in which excess surface runoff from the downstream end is collected & then pumped back into the same field to irrigate another border.

4. ***Furrow irrigation***

- Furrows are small channels, which carry water down the land slope between crop rows.
- Water is discharged and runs down small sloping channels (called *'furrows', 'creases' or corrugations*)
- Water infiltrates into the soil laterally & vertically as it moves along the slope (infiltration is two dimensional)
- The crop is usually grown on ridges between the furrows
- Suitable for all **row crops**
- Suited to medium to fine textured soils
- Flow supply can be **fixed**, **cut-back** or **tail water reuse**




Supply Ditch
300M
Advance water front
Ridge
furrow
Ridge
furrow
siphon tube

- Water from supply channel may be applied to furrows by:

a) Flexible **siphon tubes** to extract water from supply channel

b) Temporary **breaches** on supply channel as shown below

Runoff from crop irrigation can cause sediment, nutrients and pesticides to flow into surface waters, degrading their quality. Above, a furrow-irrigated dry bean field in Chico was used to evaluate various methods of runoff mitigation to improve water quality.

c) **Fixed pipe** outlets from supply channel

Advantages of furrow method

- Least expensive to develop and maintain because of minimal land levelling requirement than basins
- Undulations in slope have less impact on efficiency & uniformity than in basin or border
- Provide better on-farm water management
- A smaller wetted area reduces evaporation losses

Disadvantages of furrow method

- Risk of erosion is higher than in either basin or border
- Possibility of increased salinity between furrows
- Tail water losses unless ***end dikes*** are used
- Difficulty in moving farm equipment ***across*** furrows
- High requirement of *labor* than any other methods
- Difficult with regard to regulating equal discharge in each furrow unless equal sized siphon tubes or pipes are used

Criteria for selection of surface irrigation methods

1. **Natural circumstances** (slope, soil type),

- Border>furrow>basin, in slope

2. **Type of crop**

- Basins for trees, orchards, rice
- Furrows for row crops, borders for close growing crops

3. **Required depth of application**,

- Basin >border >furrow if other factors are constant

4. **Level of technology**,
5. **Required labour input**,
6. Previous experiences with irrigation and
7. Existing farming operations

Summarized characteristics of surface irrigation methods

ITEM	BASIN	BORDER	FURROW
Main slope	**Usually zero slope or nearly zero attained**	**Up to 2-5 % (min. 0.05%)**	**< 1 % (min. 0.05%)**
Soils	**medium to fine textured soils**	**moderately low to moderately high intake rate soils**	**best suited to soils with moderate to low intake rates.**
Infiltration	**one dimensional and vertically downward**	**same as basin**	**two dimensional**
Field size	**all size**	**large**	**Large**
Geometry shape of farm	**all shape**	**regular**	**Regular**
Sediment load	**not problematic**	**not problematic**	**not problematic**
Biological quality	**not problematic**	**not problematic**	**not problematic**
Salinity	**not problematic**	**slightly problematic**	**problem if very high salt**
Crops variety	**all crops but best for ponded water crops**	**best for close growing crops**	**best for row crops**
Farming machinery	**difficult to use**	**easy to apply**	**adapted to mechanized farming**
Labor input	**least labor compared to other surface irrigation systems**	**high**	**High**
Application efficiency	**65 –80 %**	**60- 70 %**	**60- 70%**
Level of technology requirements	**simplest**	**highest**	**lower than border**
Initial cost	**higher**	**lower**	**low to medium**

System Variables

Channel/border length (L)

- The length of a basin/border/a furrow should be determined based on soil type & method of irrigation

Flow rate (Q)

- Discharge diverted into a furrow, a border or a basin should not cause erosion & should be enough

Cut-off time (t_{co})

- Time b/n the onset of irrigation & supply is stopped

Cut-back time (t_{cb})

- *T*ime b/n flow is reduced to some level from the initial discharge & supply is terminated

- **Net depth (d_{net})** of application as a function of inflow rate (Q) and field geometry is given as:

$$\boldsymbol{d_{net} = \frac{Q*T}{A}} = \boldsymbol{\frac{Q*T}{W*L}}$$ if flow is constant for irrigation period, T

Where: T=time of application, A=area

W= furrow/border/basin width;

L= furrow/ border/ basin length

If Q varies with time, then:

- $\boldsymbol{d_{net1} = \frac{Q1*t1}{W*L}}$, **where Q1= initial flow rate**

  t1= time b/n onset of irr. & flow reduction

- $\boldsymbol{d_{net2} = \frac{Q2*t2}{W*L}}$ **, where: Q1= initial flow rate**

  t_2= cut back time

- $\boldsymbol{d_{total} = d_{net1} + dnet_2}$

Example:

Q. Furrows 90 m long and spaced 75 cm apart are irrigated by an initial stream of 2 lit/sec. The initial stream reached the lower end of the field in 50 minutes. The size of the stream was then reduced to 0.5 lit/sec. The cut back stream continued for 1 hour. Estimate the total depth of irrigation.

- **d1=(Q1*t1)/(W*L)**= $\frac{\frac{2lit}{sec} * 50\ \min}{75cm * 90m} = \frac{2*360*50}{0.75*90*60} = 8.88cm$
- **d2==(Q2*t2)/(W*L)=** $\left(\mathbf{0.5}\,\frac{\boldsymbol{lit}}{\boldsymbol{sec}} * \frac{\mathbf{1}\boldsymbol{hr}}{\boldsymbol{w*L}} = \frac{\mathbf{0.5*360*1}}{\mathbf{0.75*90}}\right) = \mathbf{2.66}\boldsymbol{cm},$
- Total dt=d1+d2=8.88+2.66**= <u>11.54cm</u>**

B. Pressurized irrigation methods

- ✓ Water moves through the pipes under pressure
- ✓ Energy is required in order to develop enough head to overcome frictional resistances in pipes and pump sections

Major components of pressurized system

- Water sources
- Energy sources
- Distribution Network-pipe system & emission devices

1. Sprinkler irrigation

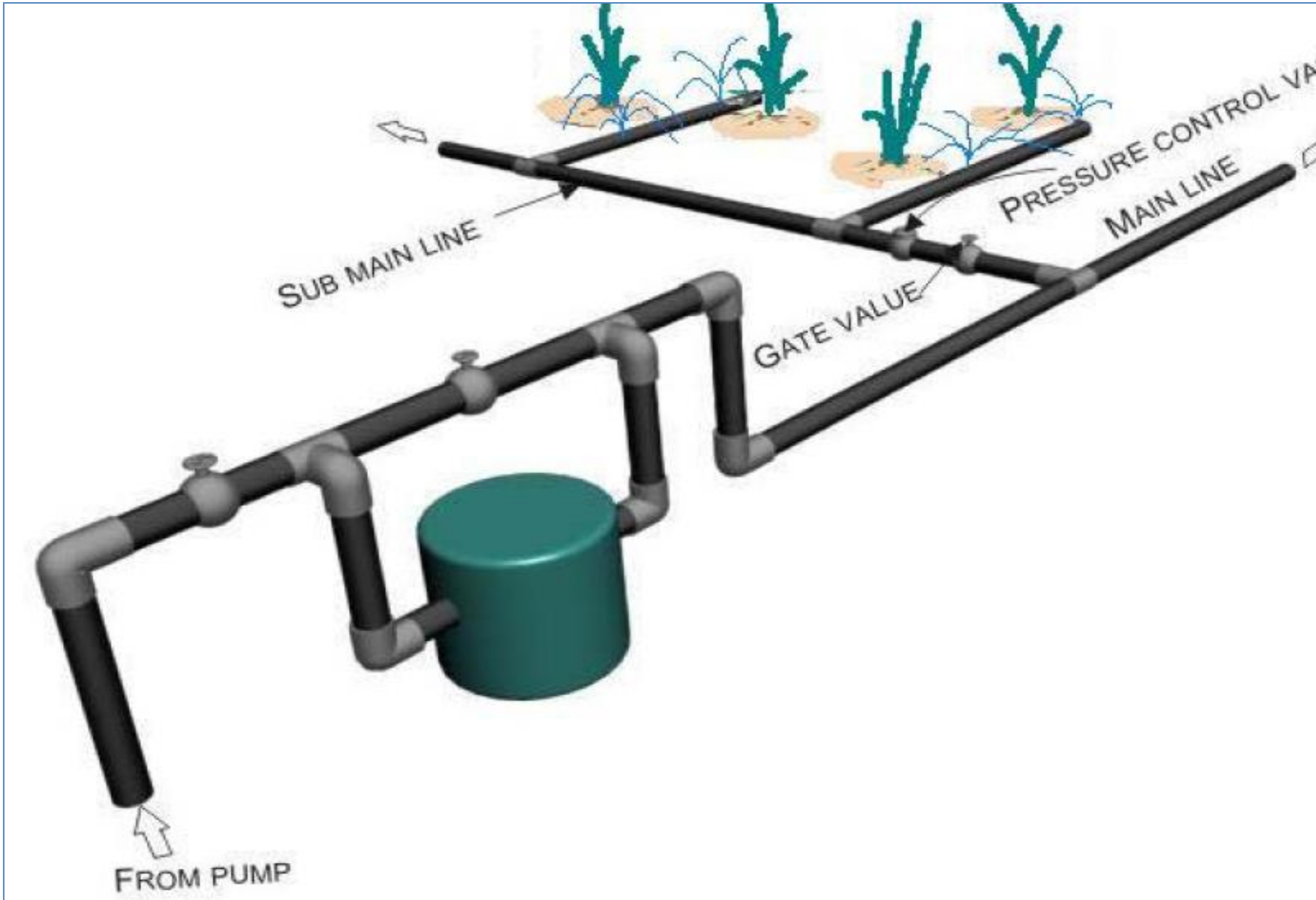
- A method of applying irrigation water to the surface of soil in the form of a spray (artificial rain) @ a rate less than infiltration rate of the soil
- Water is distributed through a system of pipes usually by pumping. Water should be clean
- Suitable to **most crops, any slope, sandy soils**

- Based on arrangement for spraying, sprinklers can be:
- Fixed nozzle, Perforated or rotating type

Rotating type sprinkler

Components of sprinkler system:

- Pressure generating units (Pump unit)
- Water carrier units (Mainlines , sub mainlines, Laterals)
- Water delivery units (riser pipes and Sprinkler nozzle)
- Quality improvement sub units (Screens , Desilting basins)
- Ancillary units (Fertilizer and other chemical applicator)



Components of sprinkler system

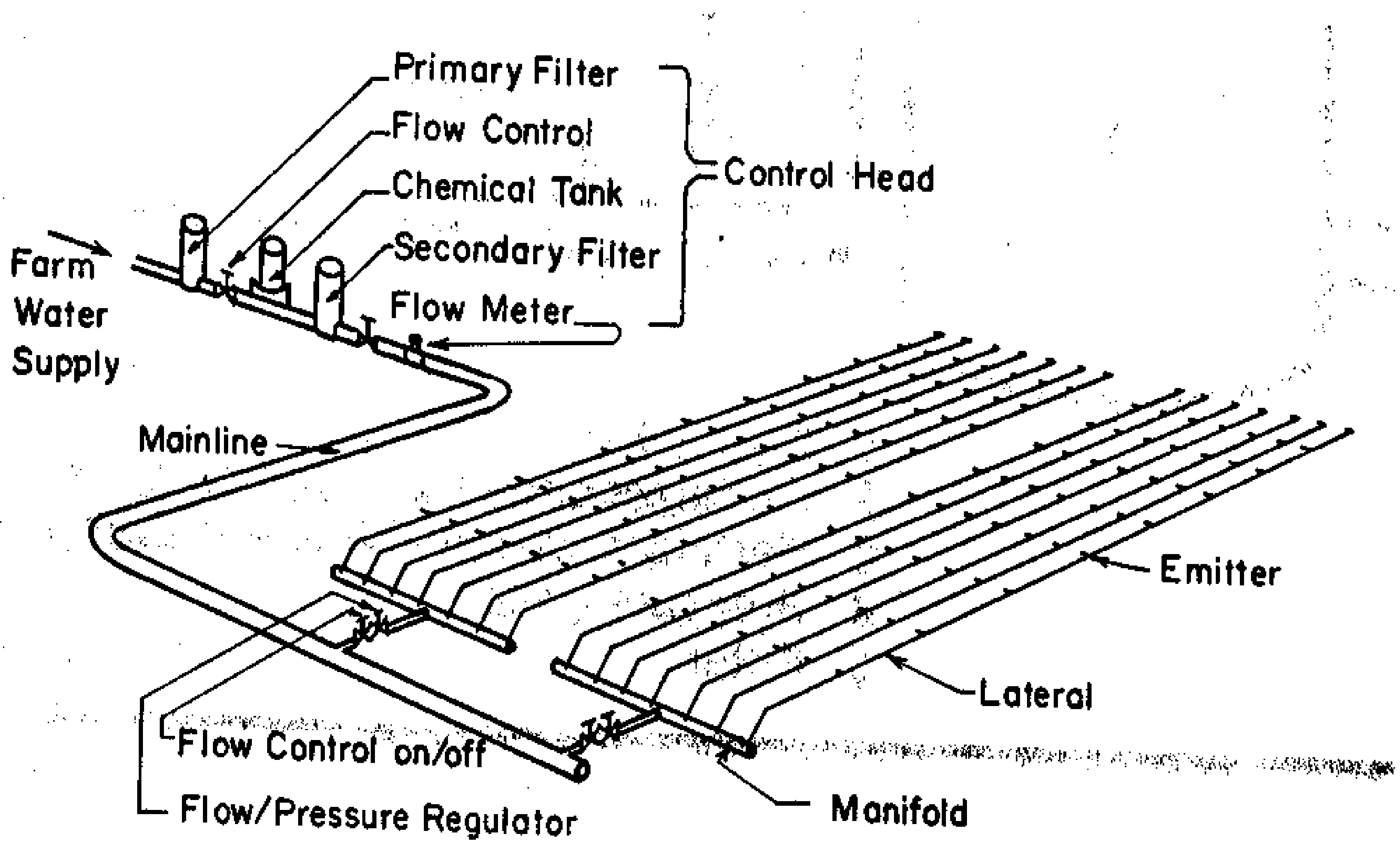
Limitation of sprinkler Irrigation:

- Wind distorts sprinkler pattern and causes uneven distribution of water
- Ripened soft fruits may be affected by spraying water.
- Water must be clean and free of sand, & debris. If not, nozzle blockage may happen.
- High initial investment as compared to surface irrigation.
- High power requirements
- Fine textured soils with slow infiltration rate can not be irrigated efficiently.

2. Drip irrigation

- It is sometimes called trickle irrigation
- Involves dripping water onto the soil at very low rates through *emitters or drippers*
- Water is applied slowly close to the plant roots
- Water spreads laterally and vertically
- Most efficient but most expensive method and hence applicable in water scarce areas.
- Water with sediment impurities should not be used for drip as it may cause *clogging of emitters*
- It is more economical for *orchards* & unsuitable for closely planted crops like wheat & barely

- The system consists head, main, sub-main, laterals & drop nozzles/emitters



Advantages of drip irrigation

- High application efficiency (90%). Hence, saves water
- Requires lower line pressure compared to sprinkler- Saves energy requirement
- Fertilizer application with high precision
- Elimination of the need for Drainage
- Possible to irrigate marginal soils

Limitations of drip irrigation

- High initial investment
- Requires clearer water
- Salt accumulation at the periphery- no continuous leaching
- Pipes are liable to mechanical damages
- Limited root development- localized to the wetted area.

LAND GRADING/LEVELLING

- Land grading is reshaping of the field surface to a planned grade
- It involves site clearing, removal of abrupt irregularities, filling of depressions & *moving large quantity of earth* over considerable distance
- It is necessary:

- to control the flow of water,
- to check soil erosion
- to provide surface drainage
- to have uniform distribution of water

- When uneven land is irrigated, the *high spots are watered too little* and the low spots too much



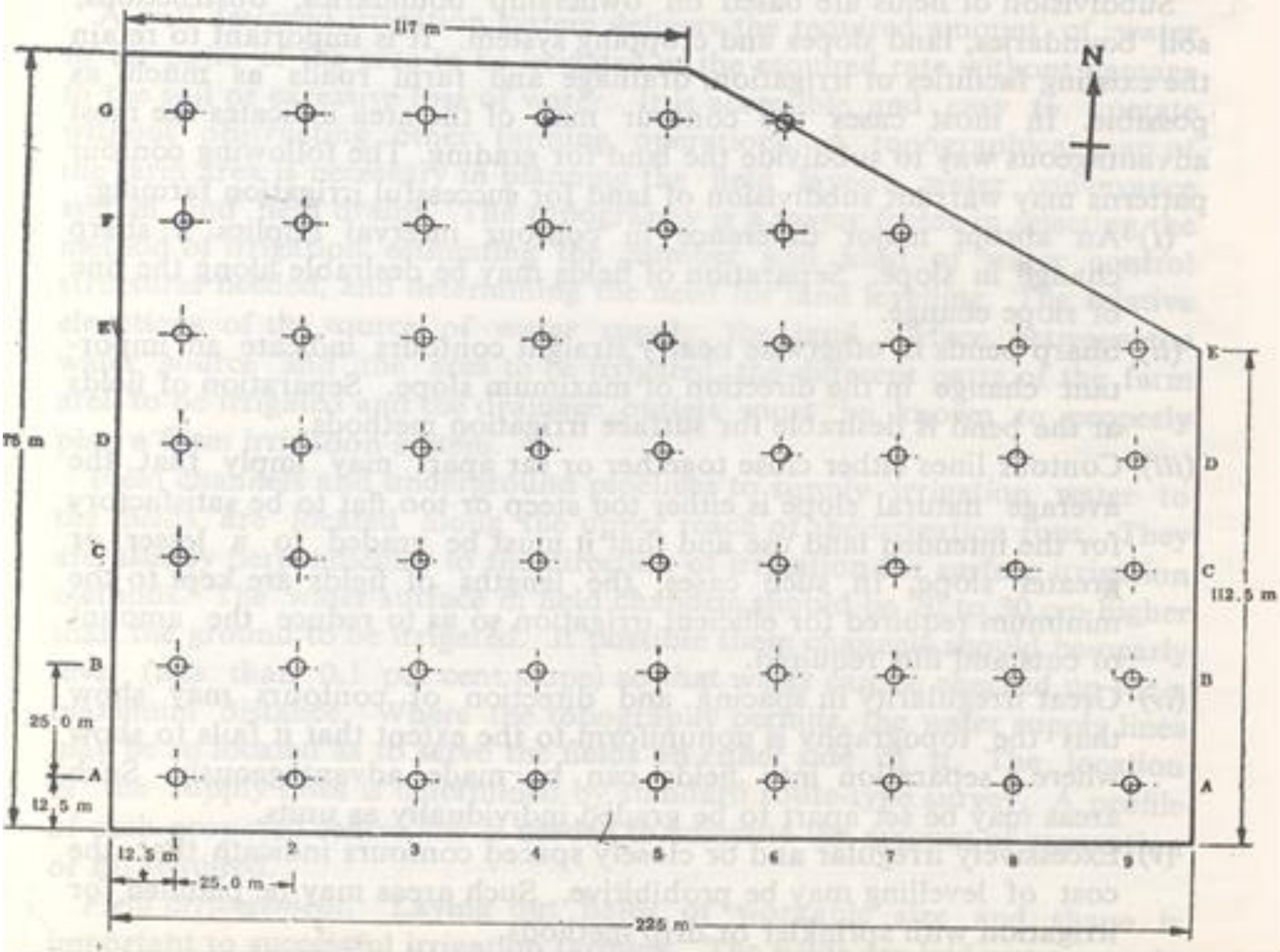

Land grading survey and design

- Prior to leveling design, the following points should be known
- the location of the field boundaries,
- irrigation water supply system,
- drainage systems and the farm roads
- After field boundaries are established, a grid system is established and sticks at the grid points are set
- The usual grid space is 25m*25m, but 30 * 30m, 20 * 20m, and 15 * 15m are also used
- For convenience, the **row lines** are *lettered* and the **column lines** are numbered
- The **plane method** is the most commonly used method of land leveling design

The procedure for land leveling design

A. Determination of the centroid of the filed

- The centroid of a rectangular field is located at the point of intersection of its diagonals.
- The centroid of a triangular field is located at the intersection of the lines drawn form its corners to the mid-points of the opposite sides.
- The centroids of irregular fields is equal to the sum of the products of the distances of each line from the reference (x or y) line times no. of stakes on that line divided by the total no. of stakes.



117 m
N
G
F
E
D
C
B
A
75 m
112.5 m
25.0 m
12.5 m
1
2
3
4
5
6
7
8
9
12.5 m
25.0 m
225 m

B. *Determination of average elevation of the field*

- This is obtained by *summing the elevations of all* grid points in the field and dividing by the *total number of points*

C. Computation of slope of the plane of best fit

- Best fit slope may be as **play ground** (zero slope) or **sloped downfield**

D. *Computation of formation levels (new elevations), cut or fill depths or volumes*

E. Determination of cut & fill ratio