Module 7: Distribution Systems in Irrigation

1. Canal Systems & Alignment

Types of Canals

- **Main Canal:** Carries entire system's water from the headwork; no direct irrigation.
- **Branch Canal:** Takes off from main canal, >5 cumec capacity, no direct irrigation.
- **Distributary Canals:** Supply water to minor distributaries/water courses; for direct irrigation.
- **Water Courses/Field Channels:** Deliver water directly to fields; maintained by farmers [1].

Canal Alignment

- **Watershed (ridge) Canal:** Aligned along the highest ground between catchments; supplies both sides, avoids cross-drainage, most efficient alignment [2] [3].
- **Contour Canal:** Follows land contours; irrigates one side only, used where ridge alignment not feasible.
- **Side-Slope Canal:** Aligned transverse to contours, steeper bed slope, requires careful design.

Key Considerations

- Shortest length
- Minimum cross-drainage works
- Avoids inhabited, alkaline, and waterlogged areas
- Runs through the center of the command area [1] [3].

2. Canal Losses & Estimation of Design Discharge

Types of Canal Losses

- **Seepage:** Loss through bed and sides; largest contributor.
- **Evaporation:** From free surface, minor compared to seepage.
- **Transpiration:** From vegetation along canal.
- **Absorption:** Initial soil moisture absorption, short-lived.
- **Operational Losses:** Due to faulty regulation or leakage [4] [5].

Methods of Loss Estimation

- **Empirical Formulae:** Use established equations (e.g., Davis-Wilson, Kostiakov).
- **Field Methods:** Ponding test, inflow-outflow method, and tracer techniques for in-situ measurement [5] [6] [7] [8].

Design Discharge Calculation

- Determined based on command area, crop water requirements, irrigation intensity, and conveyance losses.
- The discharge at a specific point equals water delivered plus anticipated losses up to that section [1] [9].

3. Design of Channels

(A) Rigid Boundary Channels

- Made of non-erodible material (concrete, masonry, rock).
- **Design:** Use Manning's equation for uniform flow,

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

  where Q=discharge, A=area, R=hydraulic radius, S=slope, n=Manning's coefficient [10] [11].
- Select dimensions to avoid velocities causing either deposition or erosion.

(B) Alluvial Channels

Kennedy's Theory

- Focuses on "critical velocity" concept; velocity sufficient to keep silt in suspension but not so high as to cause scouring.
- Critical velocity, $V_0 = CD^n$, usually $V_0 = 0.55mD^{0.64}$ where m=critical velocity ratio [12] [13].
- Channel designed so mean velocity approximates this critical value.

Lacey's Theory ("Regime" Channels)

- Based on "regime" concept: channel achieves stable dimensions for given discharge and silt load.
- Lacey's equations relate area, velocity, slope, perimeter, and silt factor.
- Emphasizes relationships such as:

$$P = 4.75\sqrt{Q}$$
$$V = \sqrt{\frac{Qf}{140}}$$

  Where P=wetted perimeter, Q=discharge, V=velocity, f=silt factor [12] [13].

4. Canal Outlets

Classification

Type	Discharge Depends On	Example	Usefulness	
Non-modular	Head difference between canal and watercourse	Submerged pipe outlet, open sluice	For low head, controlled by shutter	
Semi-modular	Canal water level only (not watercourse)	Pipe outlet, venturi flume	Equitable distribution	
Modular	Neither canal nor watercourse level (discharge constant)	Rigid modules (e.g., Gibb's)	Highly dependable	[14] [15] [16] [17] [18] [19]

5. Water Logging

Causes

- Over-irrigation
- Seepage from canals/reservoirs
- Obstruction of natural drainage
- Inadequate surface/subsurface drainage
- High permeability sub-soils, overlying impermeable strata [20] [21] [22].

Effects

- Poor soil aeration; inhibits root and microbial activity
- Lowered soil temperature and pH changes
- Decreased fertility and nutrient loss
- Stunted plant growth
- Increased disease and weed proliferation [21] [23] [22].

Remedial Measures

- Provision of surface and subsurface (tile) drains
- Restriction and improved scheduling of irrigation
- Canal lining to reduce seepage
- Deepening/protecting natural drains
- Conjunctive use of shallow tube wells [22] [20] [23] [24].

6. Lining of Canals

Purpose

- Reduce seepage losses (save 60–80% more water than unlined canals)
- Improve flow efficiency
- Reduce maintenance and weed growth
- Prevent water logging and channel erosion [25] [26] [27].

Types

Type	Description	Use/Advantages	Disadvantages	
Cement Concrete	Most common, durable, impermeable	Both small and high-flow canals	Costly, prone to cracking	
Brick/Tile	Bricks set in cement/soil mortar	Cheaper, moderate durability	Shorter life, not for high-velocity	
Compacted Earth	Earth compacted to reduce seepage	Inexpensive, local material	Prone to erosion	
Soil-Cement	Mix of soil and cement, hardens like concrete	Fast construction, moderate impermeability	Needs protection from weather	
Plastic/Geoplastic	Polyethylene/PVC sheets	Fast to install, flexible	Susceptible to UV, punctures	
Boulder/Stone	Dressed stone blocks or boulders	Good for specific localities	High resistance, costly transport	
Asphalt/Prefabricated	Flexible, easier to lay	For curves, variable surfaces	Asphalt less durable, higher initial cost	[25] [26] [27]

7. Drainage of Irrigated Lands

Necessity

- Prevents or remedies water logging and soil salinity
- Allows crops to thrive by keeping root zones aerated
- Facilitates mechanized farming and efficient land use [28] [29] [30].

Methods

Method	Description	Suitability	
Surface Drainage	Shallow open ditches or field leveling	Most common, low-cost	

Method	Description	Suitability	
Subsurface (Tile) Drainage	Perforated pipes laid below soil surface	For fields with high water table or poor permeability	
Vertical (Tube wells)	Groundwater withdrawn via tube wells	Salinity/water table control where groundwater is suitable	
Land Grading	Slope modification to guide water to drains	Works in combination	
Mole Drainage	Underground unlined channels for temporary drainage	Heavy clay soils	[28] [31] [32]

Key Takeaways:

- Proper design and alignment of canals, selection of outlets, and loss minimization are crucial for efficient irrigation distribution.
- Channel design must ensure stability (avoiding both silting and scouring), using empirically developed theories such as those of Kennedy and Lacey for alluvial regimes.
- Canal outlets are chosen for local conditions—modularity ensures discharge reliability.
- Water logging is a severe hazard in irrigation; remedial action primarily revolves around drainage and management reforms.
- Canal lining, while a significant investment, offers both short- and long-term benefits in water saving and system sustainability.
- Drainage of irrigated lands is essential for sustained productivity and land reclamation[1] [3] [4] [5] [25] [28] [31].

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