Simple drainage design

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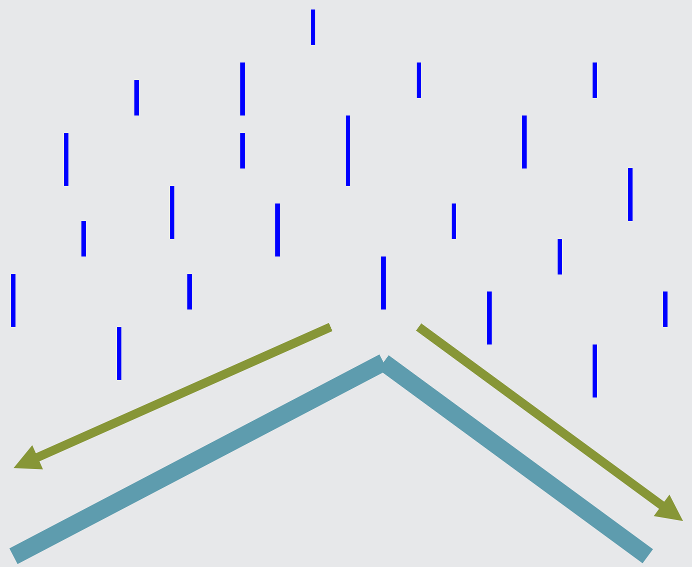
Transverse Slopes

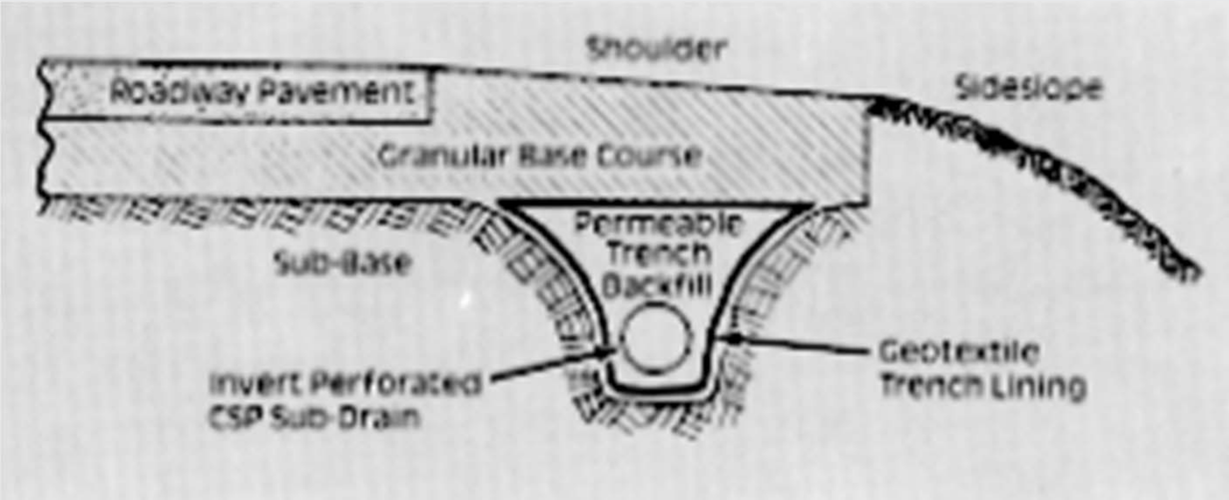
Removes water from pavement surfaces in shortest amount of time possible



Longitudinal Slopes

Gradient longitudinal direction of highway to facilitate movement of water along roadway

Collect surface water



A typical intercepting drain placed in the impervious zone

Drainage channels (ditches)

Design

- > Adequate capacity
- > Minimum hazard to traffic
- > Hydraulic efficiency
- > Ease of maintenance

Desirable design (for safety): flat slopes, broad bottom, and liberal rounding

Ditch shape

- Trapezoidal – generally preferred considering hydraulics, maintenance, and safety
- V-shaped – less desirable from safety point of view and maintenance

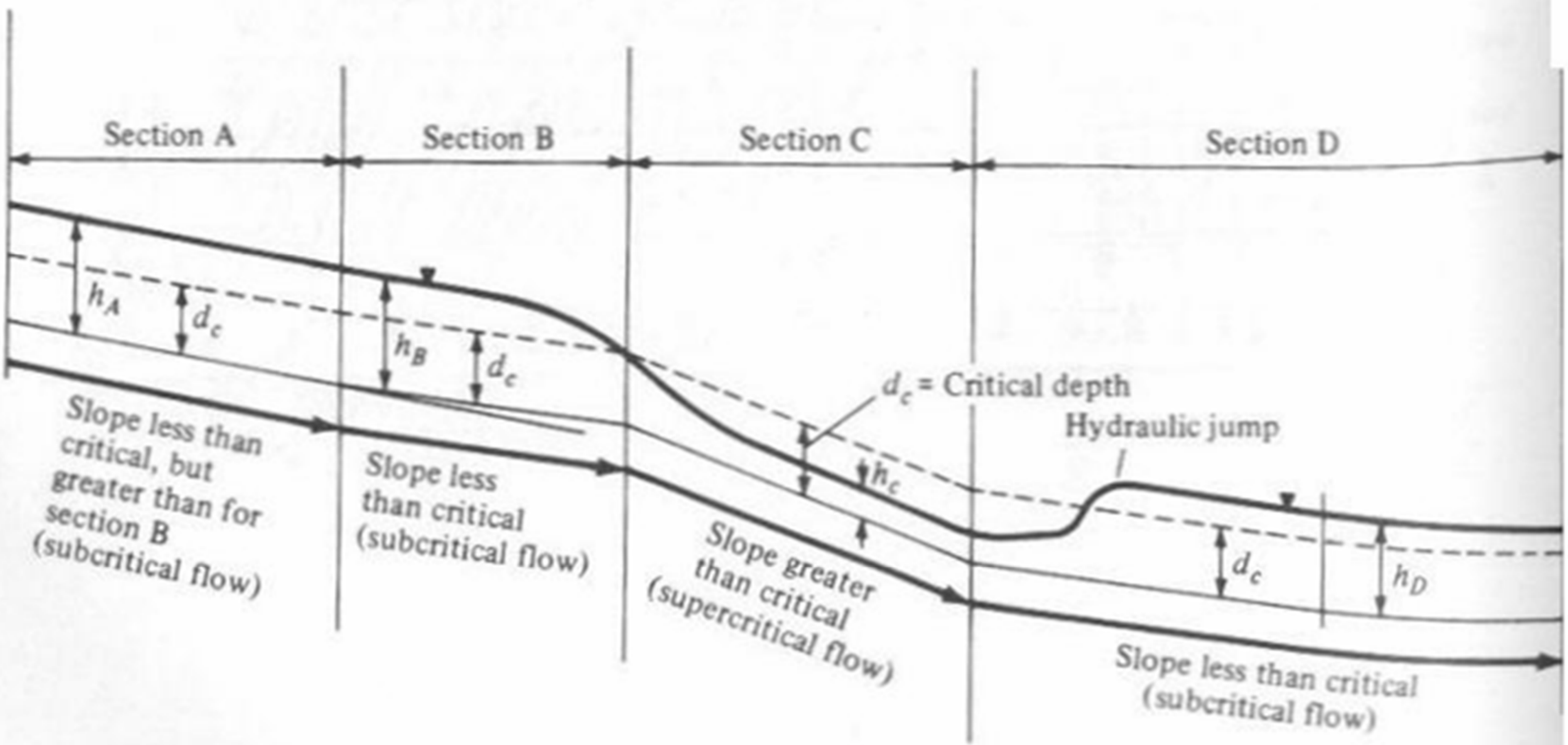


Figure 17.8 Schematic of the Effect of Critical Depth on Flow in Open Prismatic Channels

Flow velocity

- Depends on lining type
- Typically 1 to 5% slopes used
- Should be high enough to prevent deposit of transported material (sedimentation)

  - For most linings, problem if S < 1%

- Should be low enough to prevent erosion (scour)

  - For most types of linings, problem if S > 5%

Use spillway or chute if drop in elevation is large

Rip rap for drainage over high slope

Side ditch/Open channel design basics

Find expected Q at point of interest

Select a cross section for the slope, and any erosion control needed

Manning's formula used for design

Assume steady flow in a uniform channel

Manning's formula

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

Where:

V is the mean velocity (m/s)

R is the hydraulic radius (m) = area of the cross section of flow (m^2) divided by wetted perimeter (m)

S is the slope of channel (m/m)

n is the Manning's roughness coefficient

Side ditch/Open channel design basics

$Q = VA$

Q = discharge (m^3/s)

A = area of flow cross section (m^2)

US Federal Highways Agency has developed charts to solve Manning’s equation for different cross sections

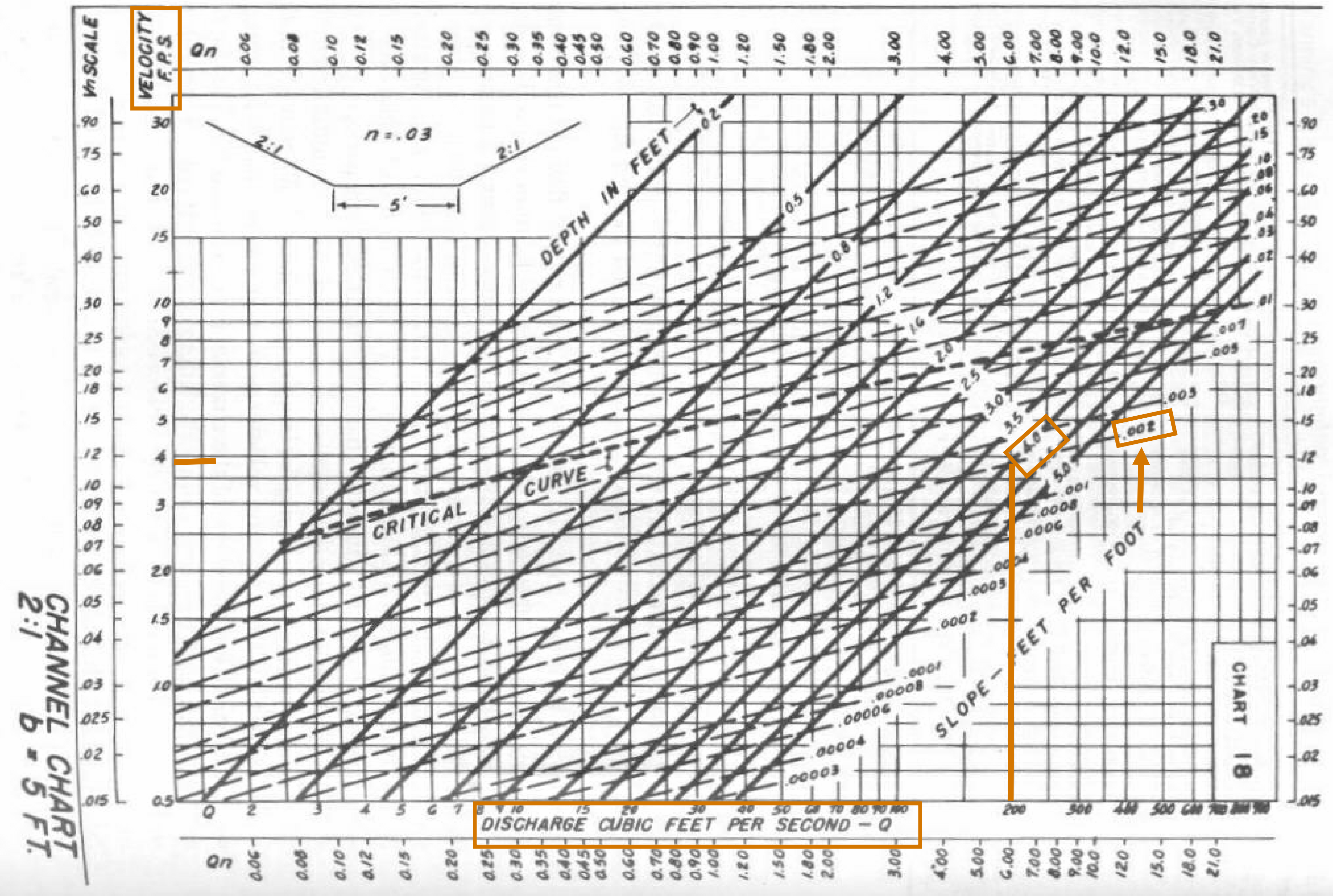


Figure 17.6 Graphical Solution of Manning's Equation for a 2:1 Side Slope Trapezoidal Channel

Open channel - Example

Runoff = 10 m^3/sec (Q)

Slope = 1%

Manning's number = 0.015

Determine necessary cross-section to handle estimated runoff

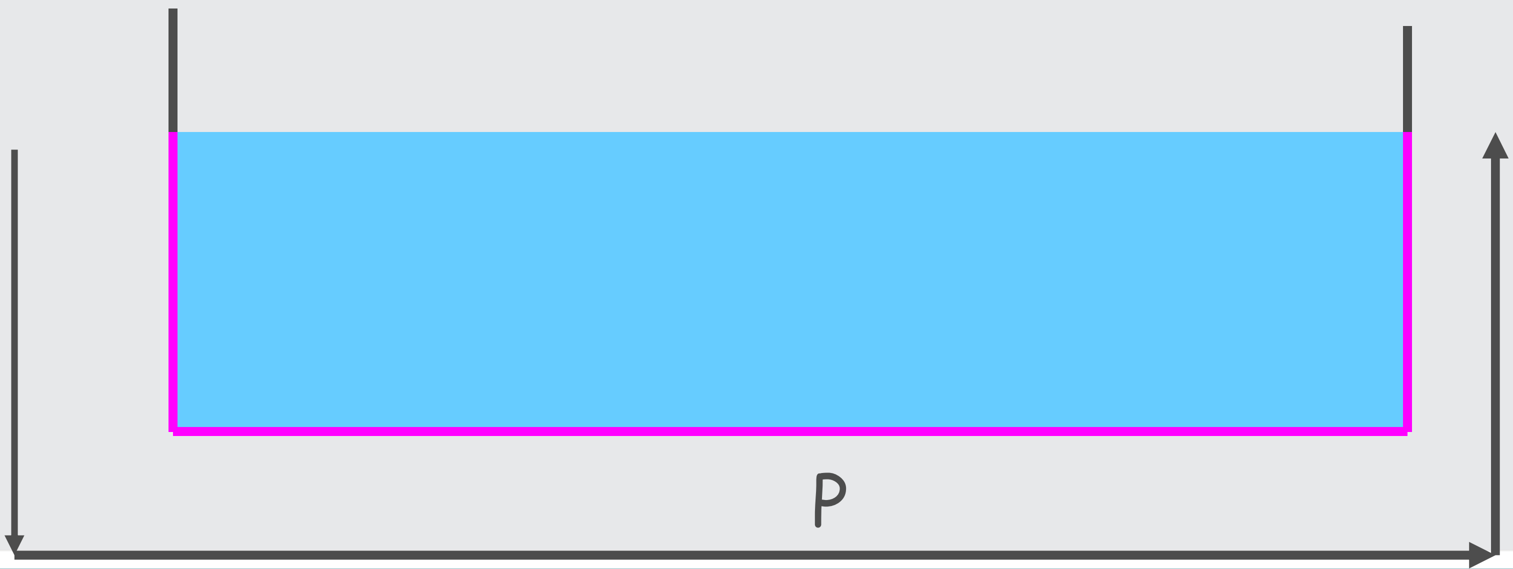
Use rectangular channel 2 m wide

Open Channel Example

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

Hydraulic radius, R = a/P

a = area, P = wetted perimeter

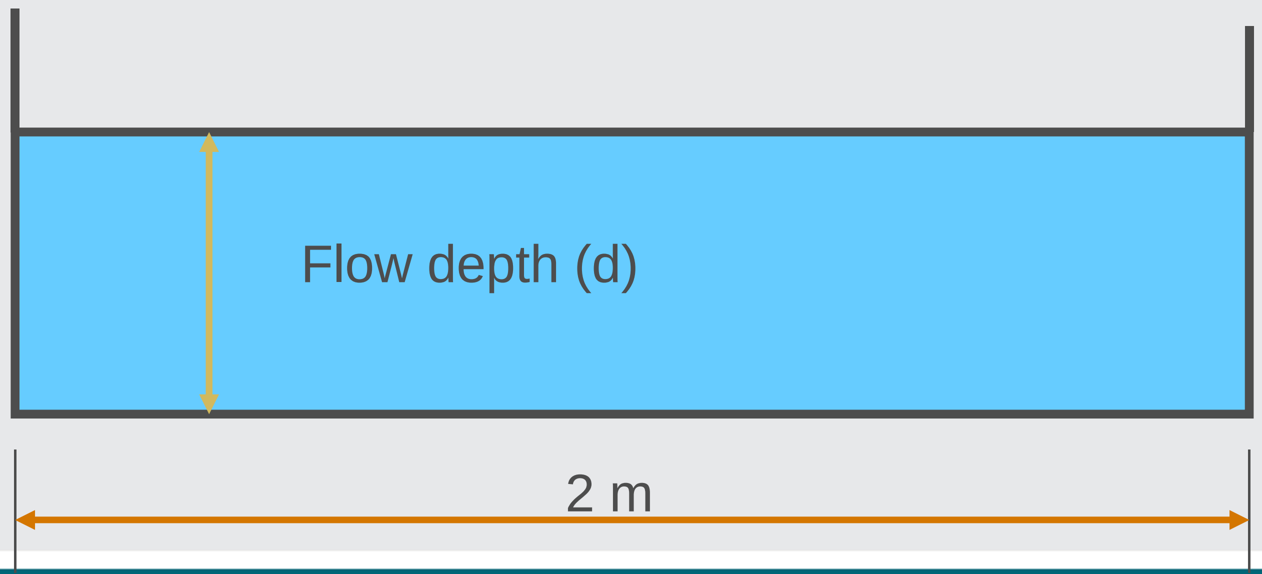


Open Channel Example

Flow depth = d

Area = 6 m x d

Wetted perimeter = 6 + 2d



Example (continued)

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

?

$d \approx 1.2$ m

<u>Channel area needs to be at least 1.2 m x 2 m</u>

Example (continued)

Find flow velocities?

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Working with water

Hydrologic and economic considerations

Alignment and grade of culvert (with respect to roadway) are important

Similar to open channel

Design flow rate based on storm with acceptable return period (frequency)

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Any questions?

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