

Culvert design on low and high gradient streams

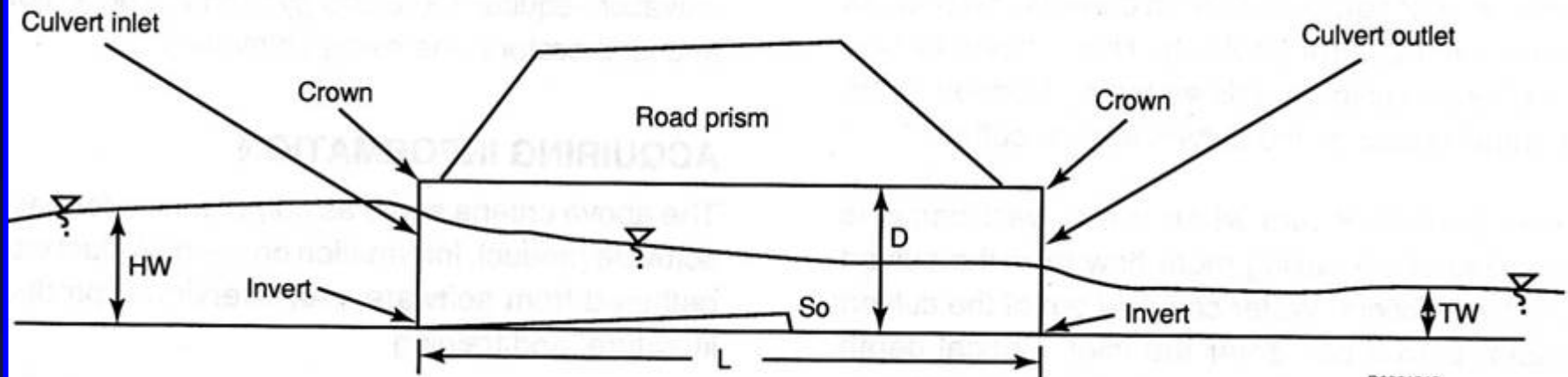


Mark Fedora and Dale Higgins, hydrologists, Ottawa
and Chequamegon-Nicolet National Forests, respectively

Overview

- Culvert Hydraulics
- Culvert Design Methods
 - Low Gradient
 - High Gradient
- Hydrology
- Site Assessment
- Alignment and Profile
- Bed and Banks
- Structure
- Sediment Mobility and Stability

Culvert hydraulics terms



HW - Headwater elevation
TW - Tailwater elevation
L - Barrel length
 S_o - Slope of culvert
D - Diameter of culvert barrel

- Invert, Headwater (HW), Tailwater (TW)
- Headwater/Depth Ratio (HW/D): $HW / \text{pipe diameter or depth}$
- Supercritical Flow: **high velocity, shallow water**
- Subcritical Flow: **low velocity, deep water**

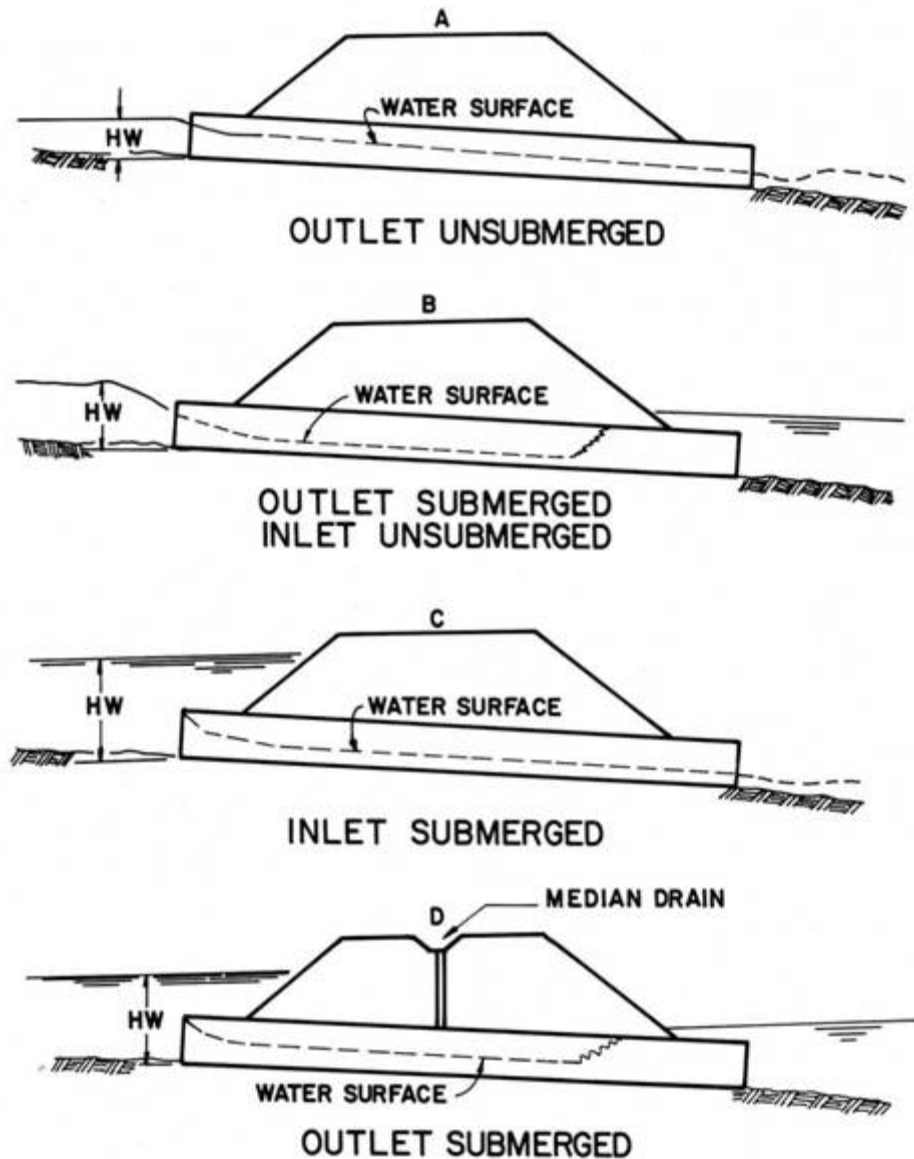
Inlet control



Culvert geometry at inlet controls flow

- Flow determined by HW elev and inlet characteristics
- Flow in culvert is supercritical
- Culvert can convey more flow than inlet will accept

Inlet control

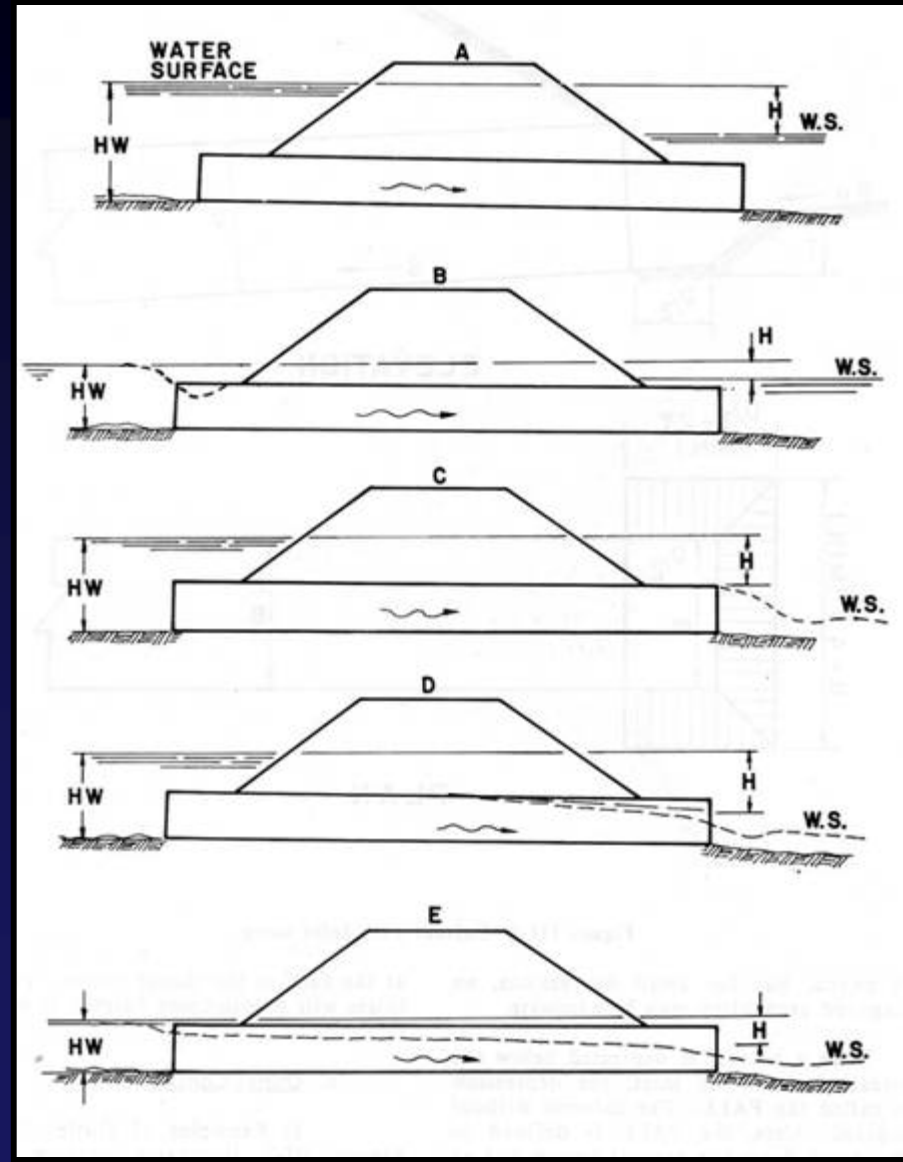


Outlet control



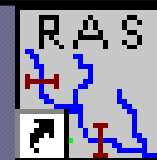
- Tailwater, culvert inlet and barrel characteristics (slope, length, roughness) control flow
- Flow in culvert is subcritical or under pressure
- Culvert inlet can convey more flow than barrel

Outlet control



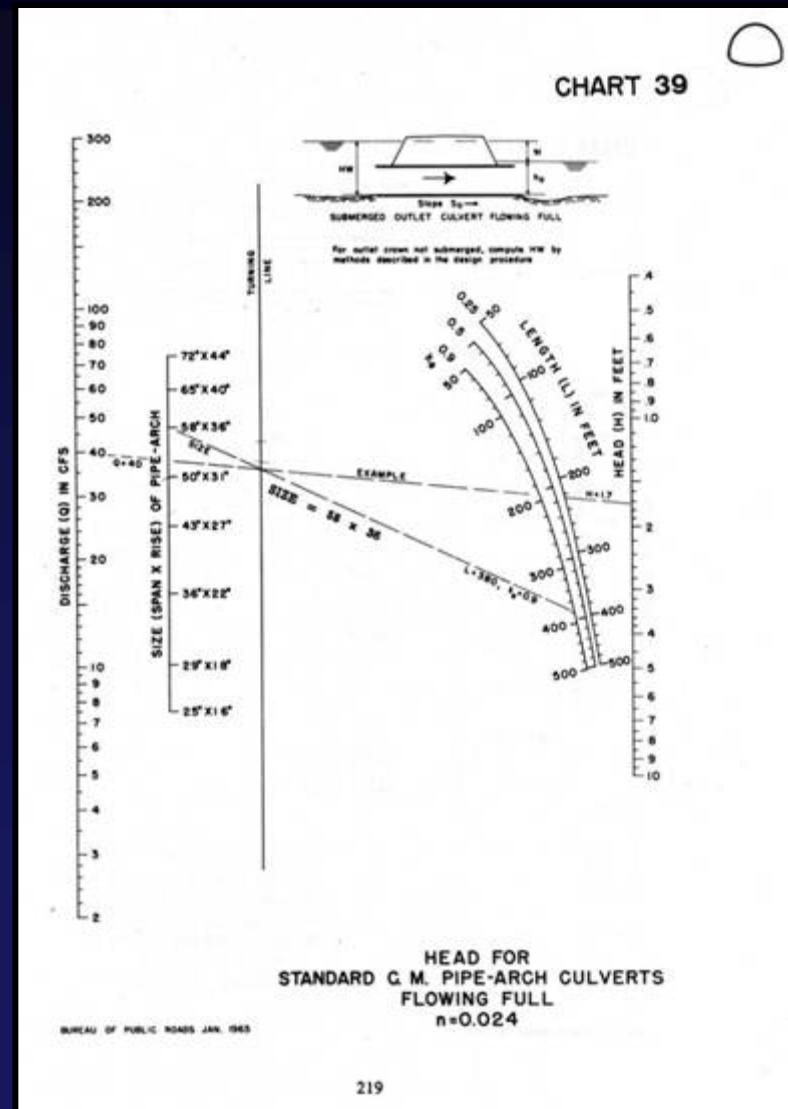
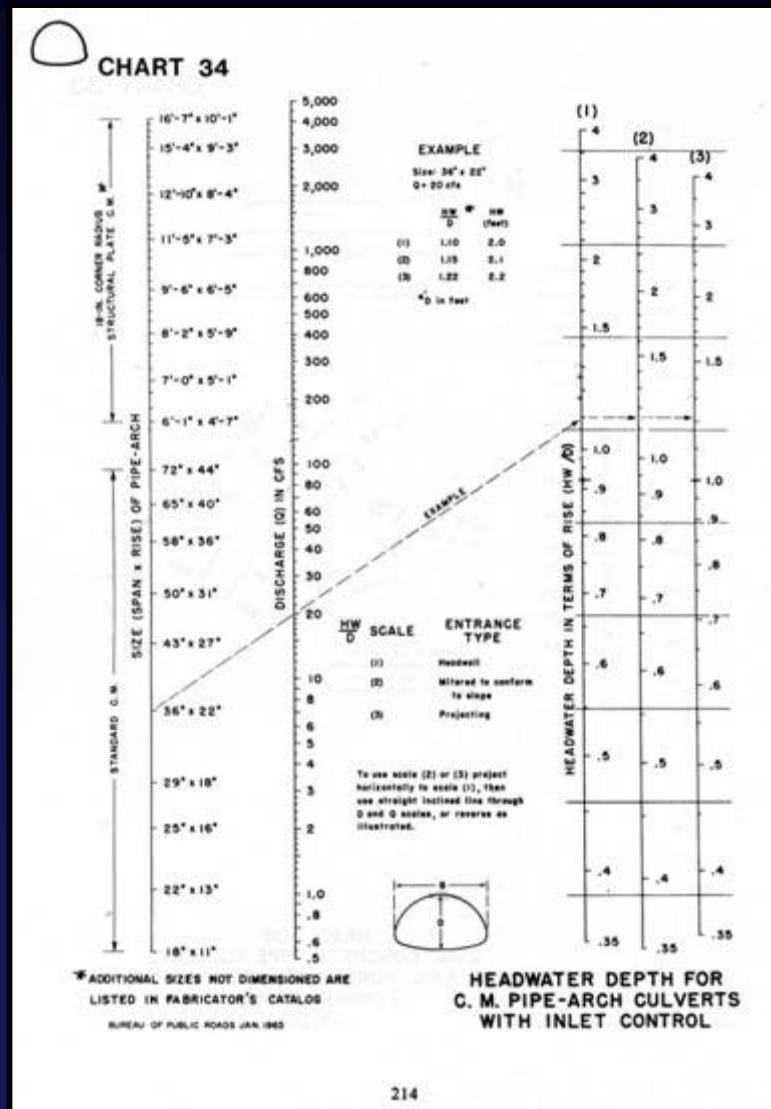
Hydraulic analyses for culverts

- HDS-5 Nomographs
- Computer Models:
 - HEC-RAS
 - HY-8 FHA
 - Culvertmaster



HEC-RAS 3.1.3.Ink

Hydraulic analyses for culverts



Hydraulic analyses for culverts

HEC-RAS 4.0

File Edit Run View Options Help

Project: Brookside Cr at Brookside Road C:\...\brookside_cr_brookside_rd\HEC-RAS\BrooksideCratBro.prj

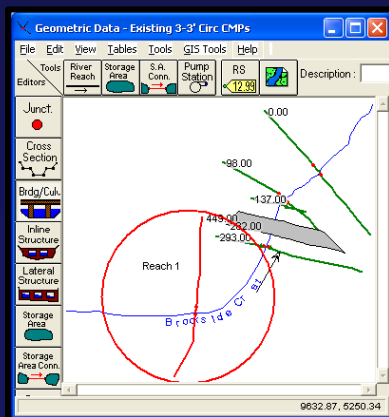
Plan: Existing 3-3' Circ CMPs C:\...\brookside_cr_brookside_rd\HEC-RAS\BrooksideCratBro.p01

Geometry: Existing 3-3' Circ CMPs C:\...\brookside_cr_brookside_rd\HEC-RAS\BrooksideCratBro.g01

Steady Flow: 500-yr, 100-yr, 1.5-yr, Hfpf, Lfpf C:\...\brookside_cr_brookside_rd\HEC-RAS\BrooksideCratBro.f01

Unsteady Flow:

Description: US Customary Units



Steady Flow Data - 500-yr, 100-yr, 1.5-yr, Hfpf, Lfpf

Enter/Edit Number of Profiles (25000 max): 5 Reach Boundary Conditions... Apply Data

River: Brookside Cr at Add Multiple...

Reach: Reach 1 River Sta.: 449.00 Add A Flow Change Location

Flow Change Location		Profile Names and Flow Rates					
River	Reach	RS	500-yr (449 cfs)	100-yr (381 cfs)	1.5-yr (78 cfs)	Hfpf (13.7 cfs)	Lfpf (0.2 cfs)
1	Brookside Cr at Reach 1	449.00	474	381	78	19.6	0.2

Edit Steady flow data for the profiles (cfs)

Steady Flow Analysis

Plan: Existing 3-3' Circ CMPs Short ID: Existing 3-3' Cir

Geometry File: Existing 3-3' Circ CMPs

Steady Flow File: 500-yr, 100-yr, 1.5-yr, Hfpf, Lfpf

Flow Regime:
 Subcritical
 Supercritical
 Mixed

Plan Description:

COMPUTE

Enter to compute water surface profiles