How to Create Stream Smart Crossings

The Golden Rule:
Let the stream act like a stream

Stream Smart Options

1) **Avoid** creating a crossing
2) **Remove** the crossing
3) **Open bottom** structure that spans or exceeds channel
   - Abutments for temporary bridge
   - Bridge or 3-sided box culvert
   - Arch culvert
4) **Embedded** culvert
5) **Hydraulic designs**

Open bottom structures

Temporary Bridge Deck

Bridge

Bottomless Box Culvert

Arch Culvert

Embedded pipes

Embedded box culvert

Liners don’t achieve Stream Smart outcomes!

Rules of Thumb (4 S's)

<u>Span the stream</u>

Set elevation right

Slope and skew match stream

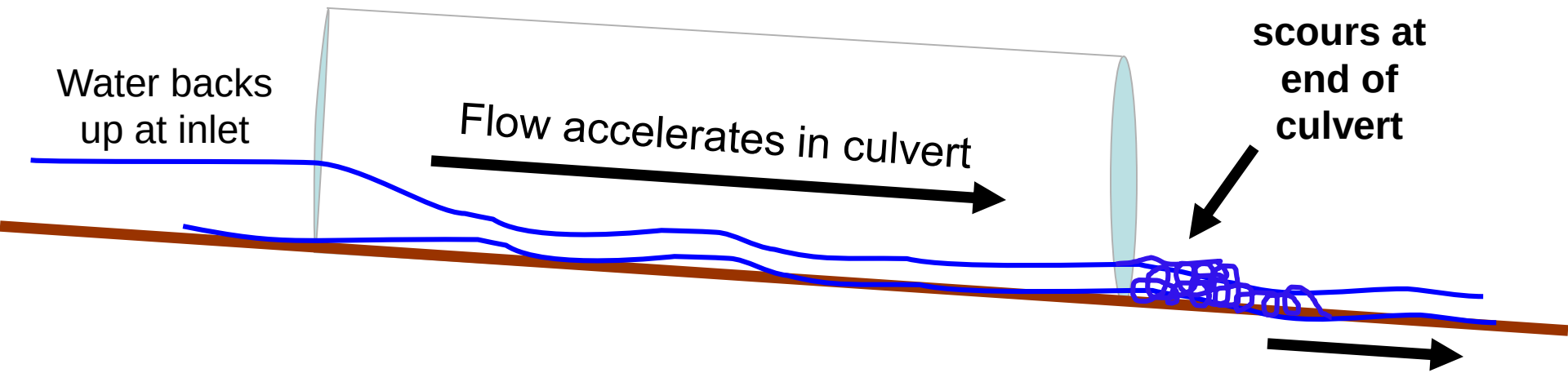
Substrate in the crossing

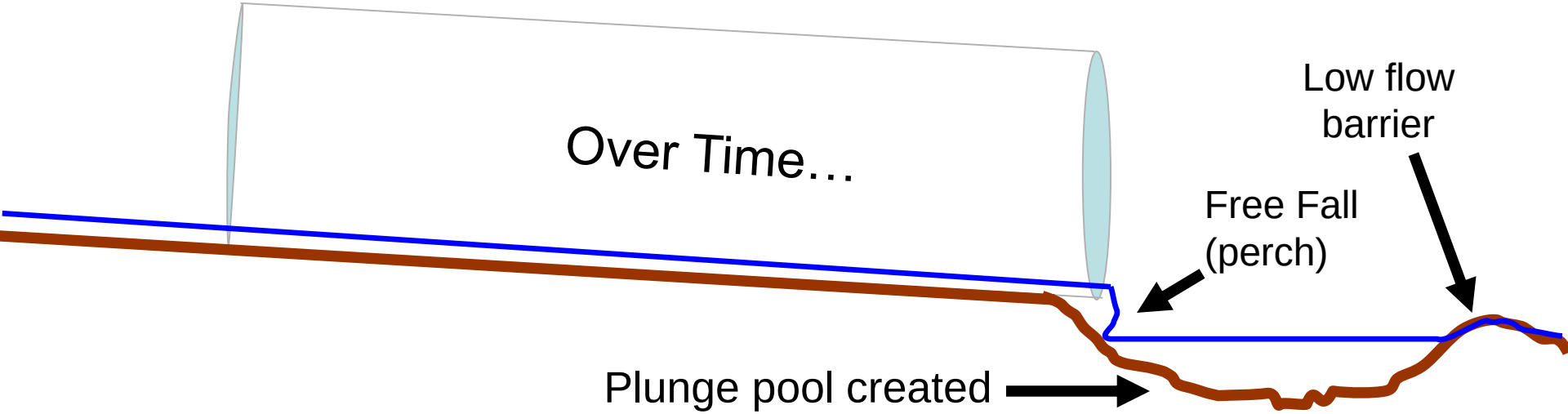
Don’t pinch the stream

Span the stream
(and exceed it where possible)

How undersized culverts constrict stream flow and become perched

Culvert that does not span the channel set at stream grade





Real World – Blanchard

2008

2010

Rules of Thumb (4 S's)

Span the stream

<u>Set elevation right</u>

<u>Slope and skew match stream</u>

Substrate in the crossing

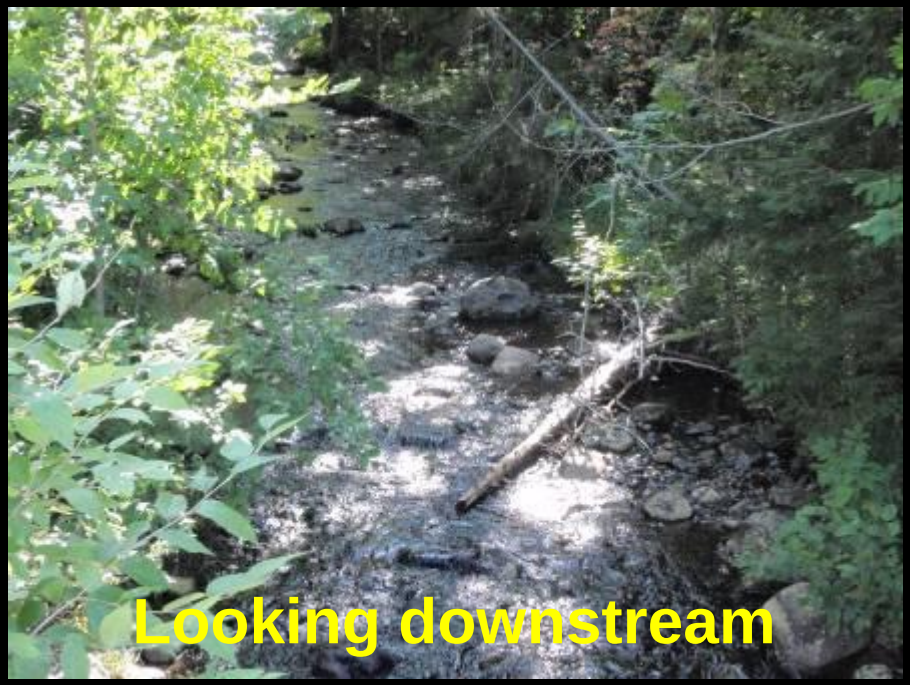
Set elevation right

Upstream

Indicators of elevation problems

A stream channel rediscovered!

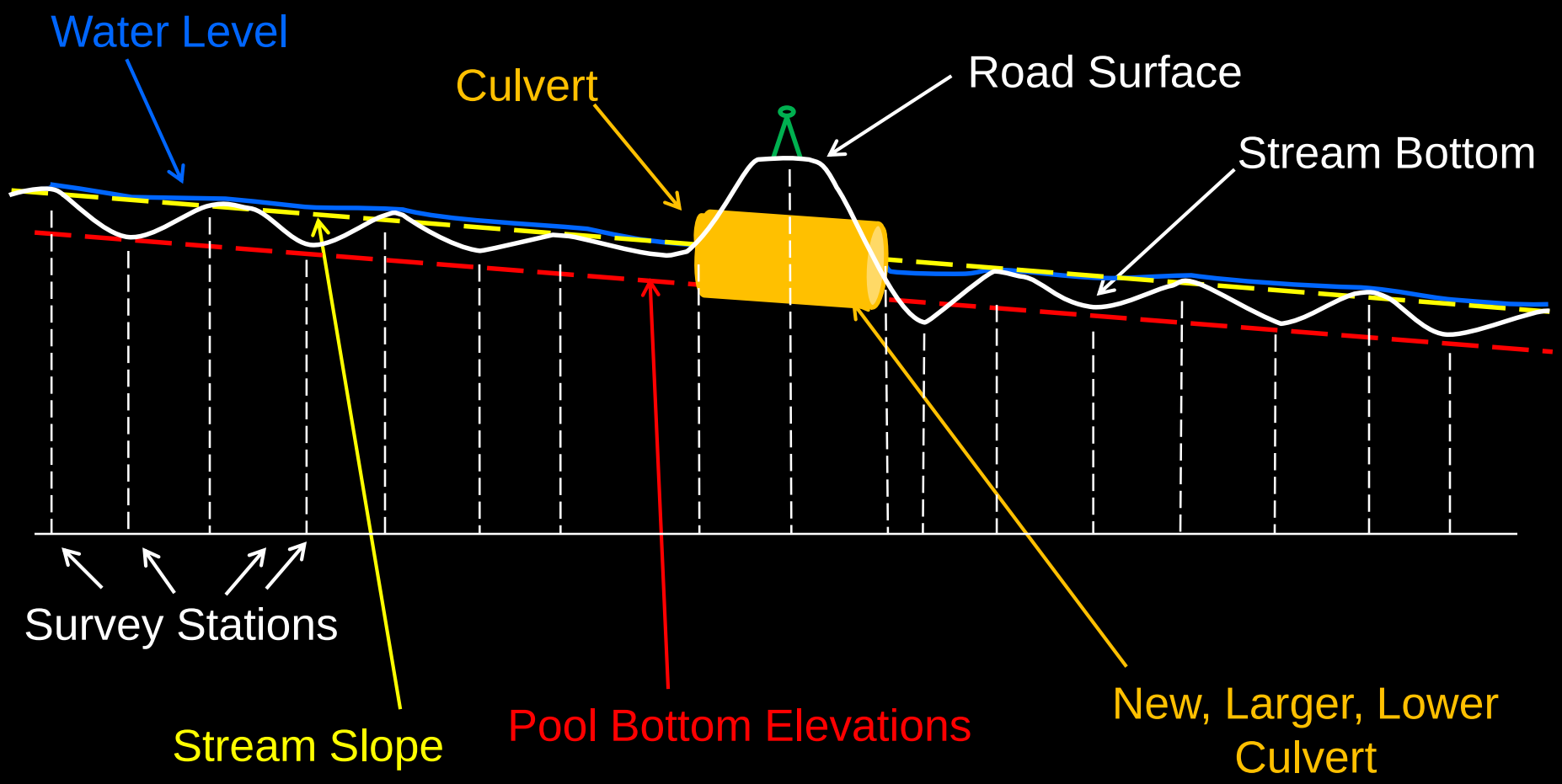
Indicators of correct elevation



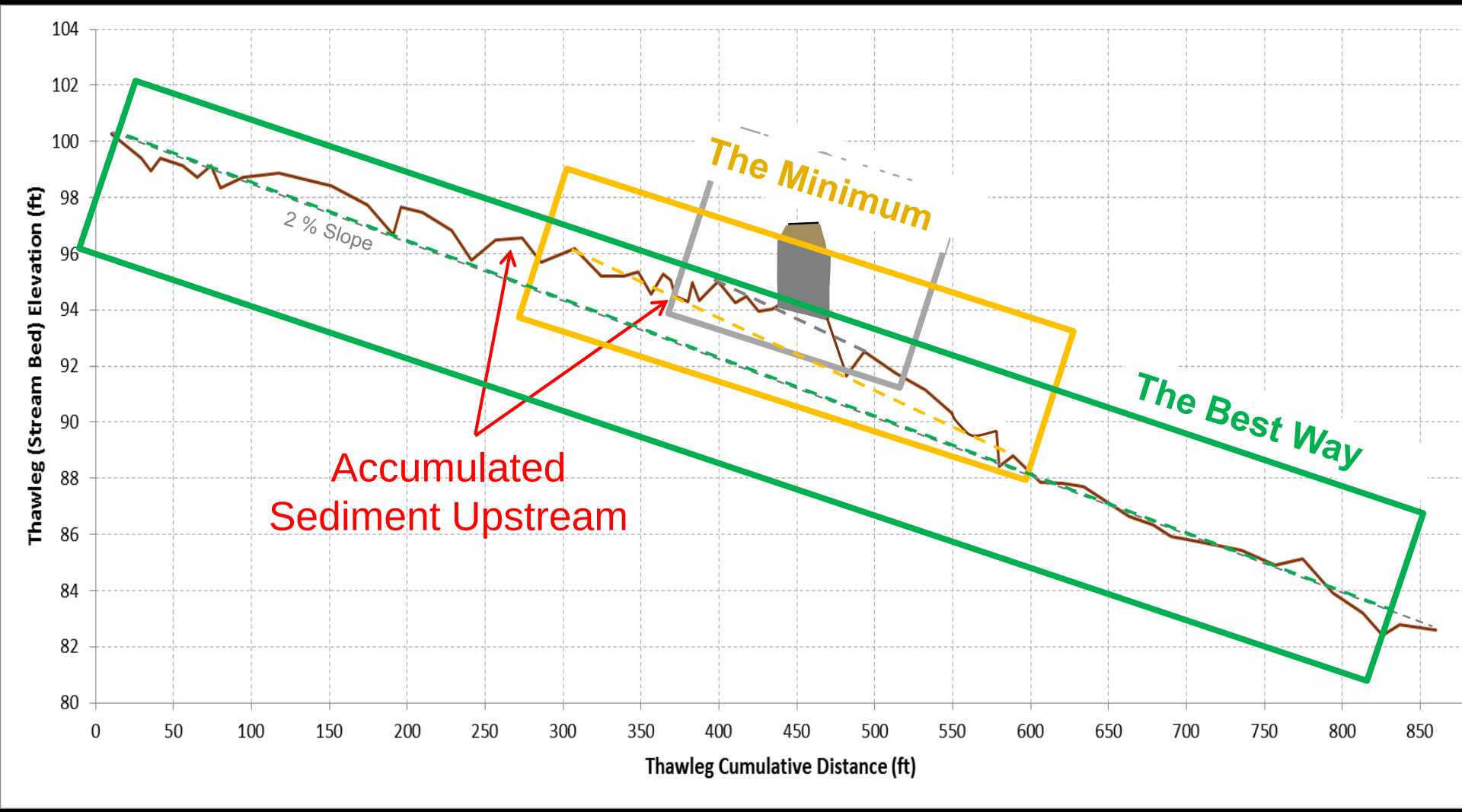
Seamless inlets and outlets

Stream Profile

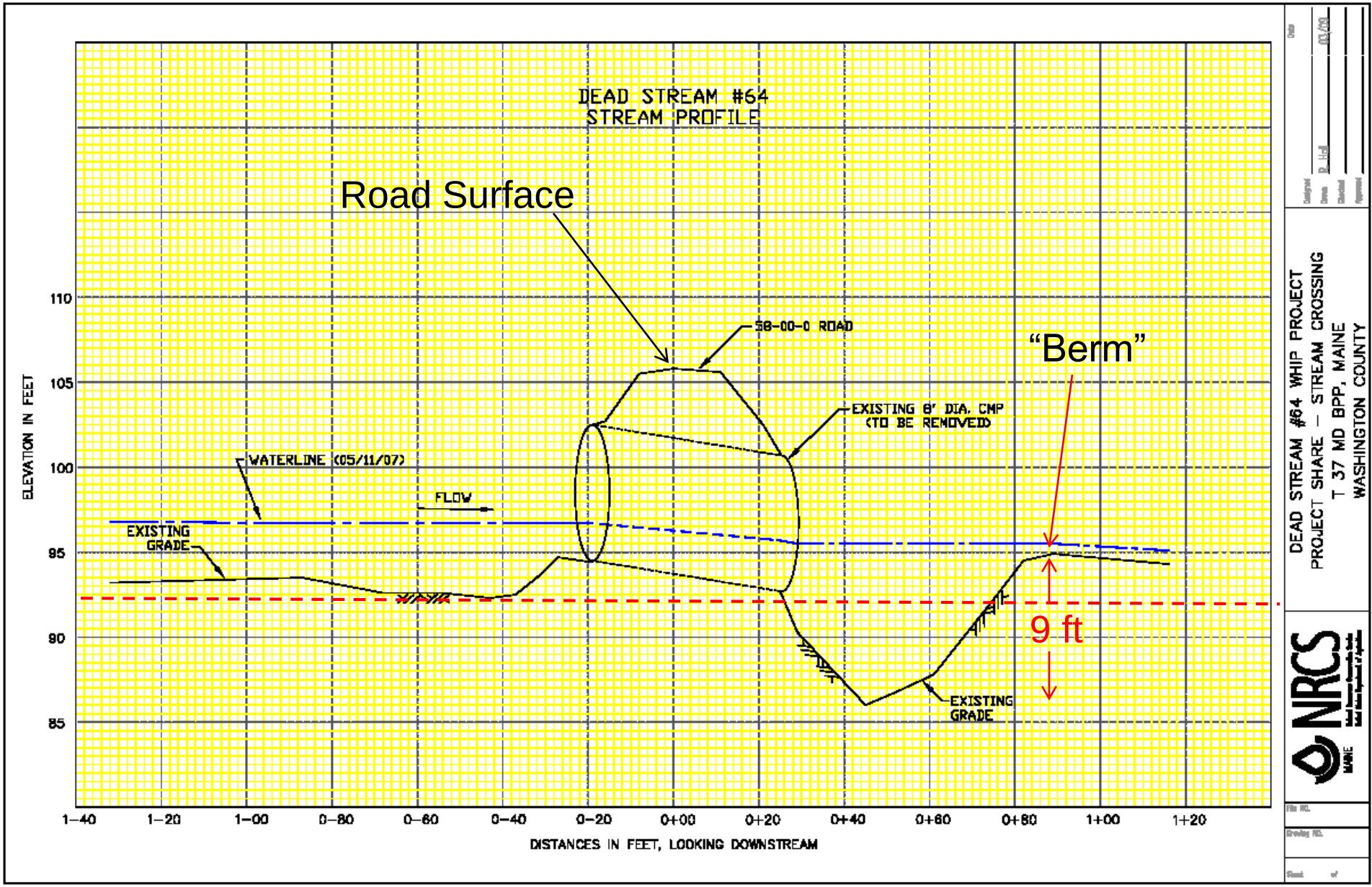
Used to find correct elevation and slope



Stream Profile Example 1



Stream Profile Example 2



Rules of Thumb (4 S's)

Span the stream

Set elevation right

Slope and skew match stream

<u>Substrate in the crossing</u>

Substrate in the crossing

Stream Smart Sizing

Step 1: Field Assessment

- Stream profile
- Stream cross-section

Step 2: Project Design

- Structure Choice
- Elevations
- Hydrology
- Hydraulics

Step 1: Field Assessment

What volume of flow are we allowing for?

50-, 100- or 500-year storm event?

What species are we concerned about?

Fish, amphibians, mammals, invertebrates?

Step 1: Field Assessment

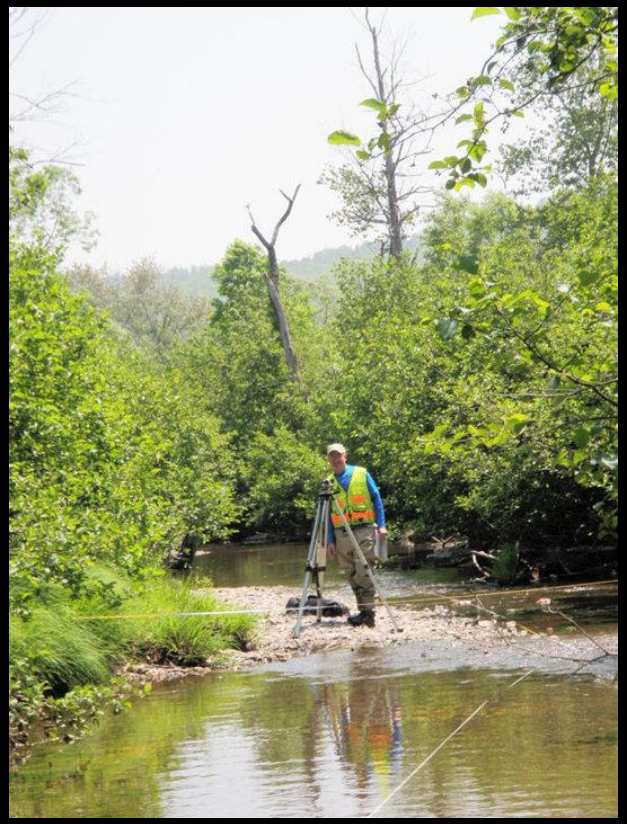
- Geomorphic Map
- Stream Profile
  - Bed elevation
  - Slope
  - Scour potential
  - Footer depth
  - Road /structure height
- Cross Section
  - Structure span width
- Bed characterization
  - Stream bed material size
  - Bank material size

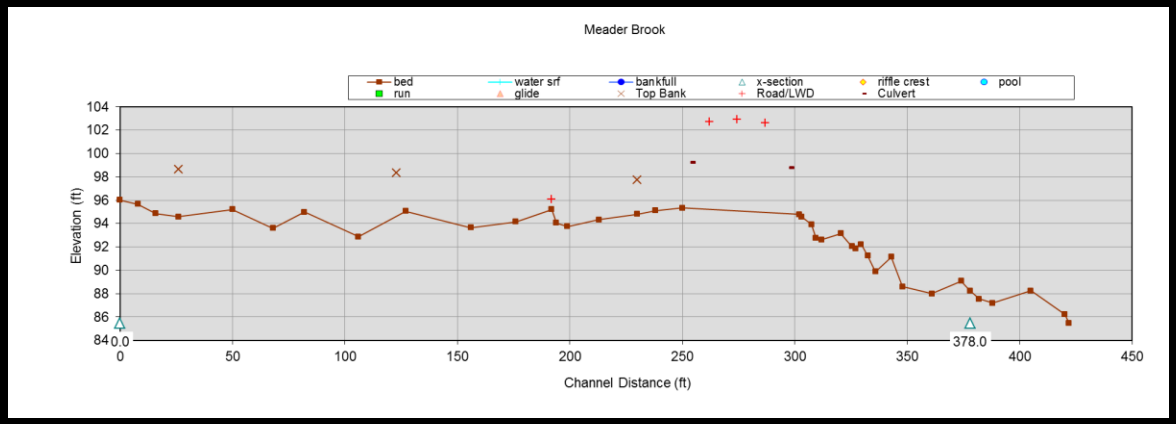
Grace Levergood / NHDES

Step 1: Field Assessment

Determine the stream profile

to determine elevation and slope

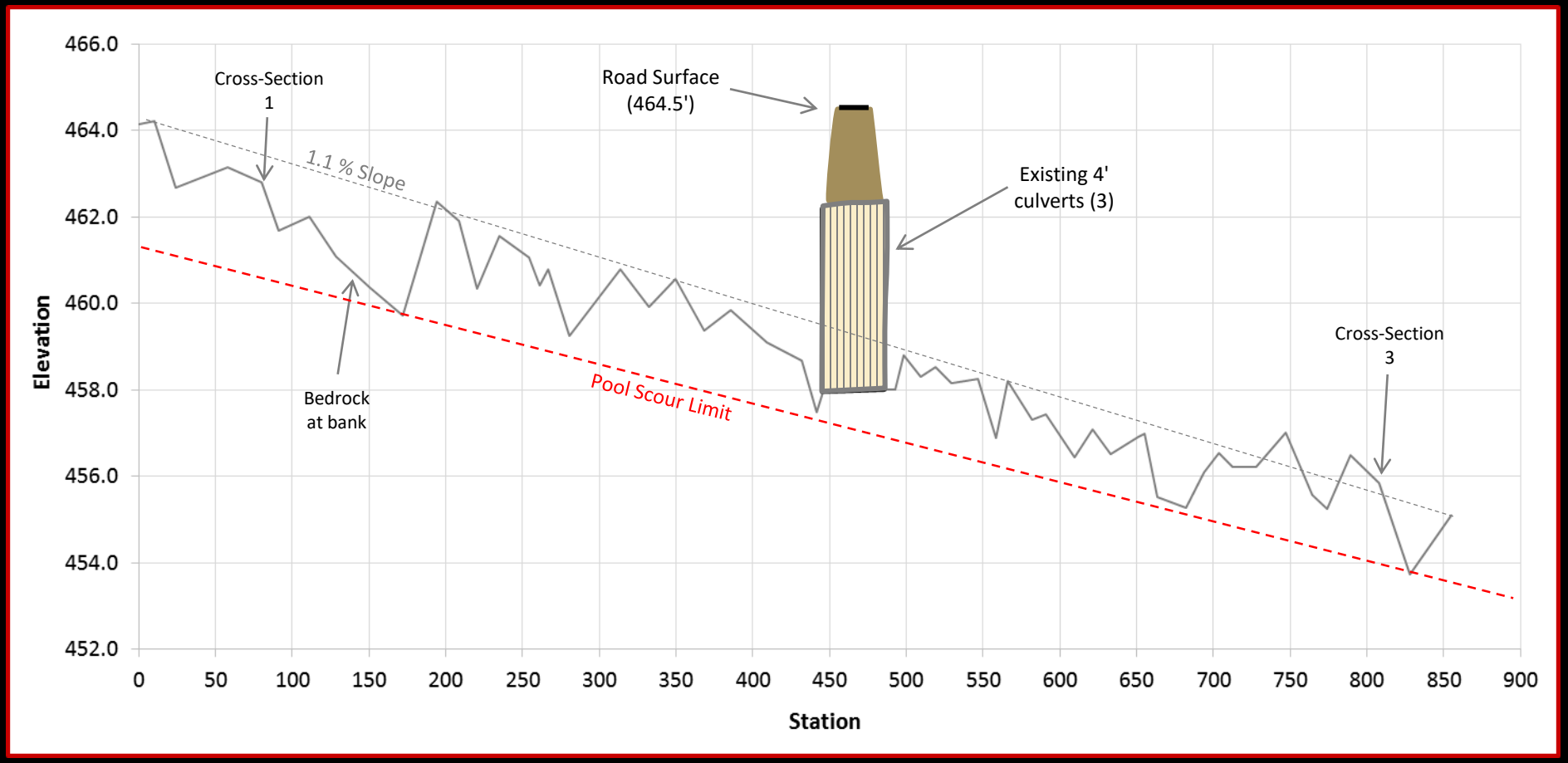




Measure ***well upstream and downstream*** from existing crossing structure - 20-30 times the width of the stream in distance

Step 1: Field Assessment

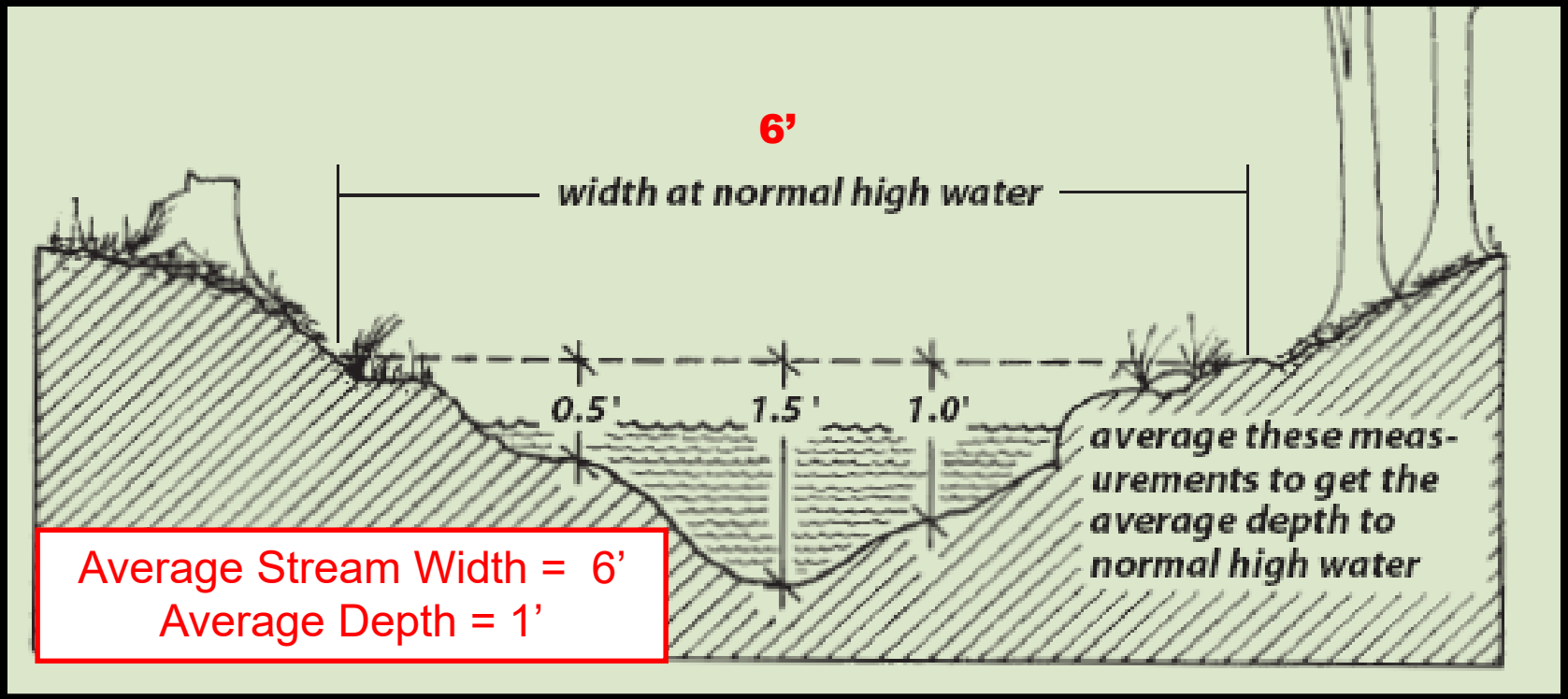
Stream Profile



Step 1: Field Assessment

Determine the stream cross-section to set the opening area of the crossing

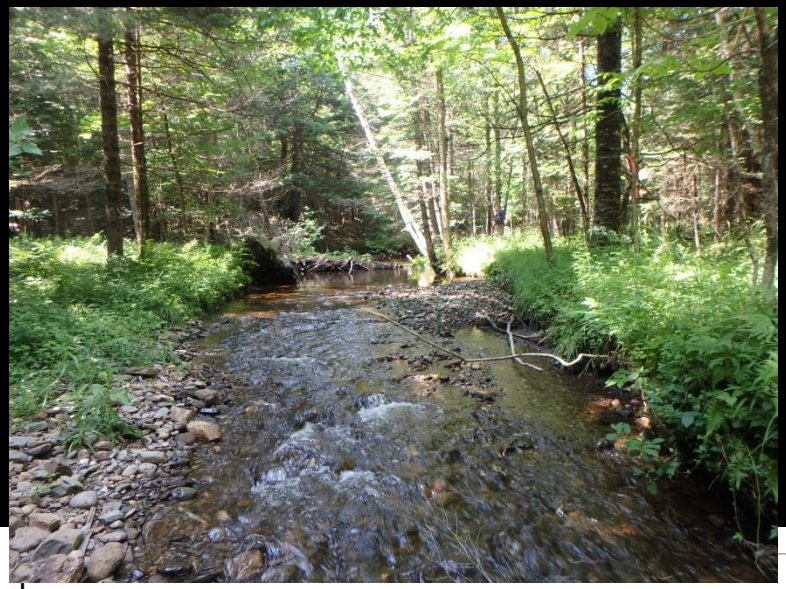
Measure both upstream and downstream of crossing in an undisturbed location, and average measurements

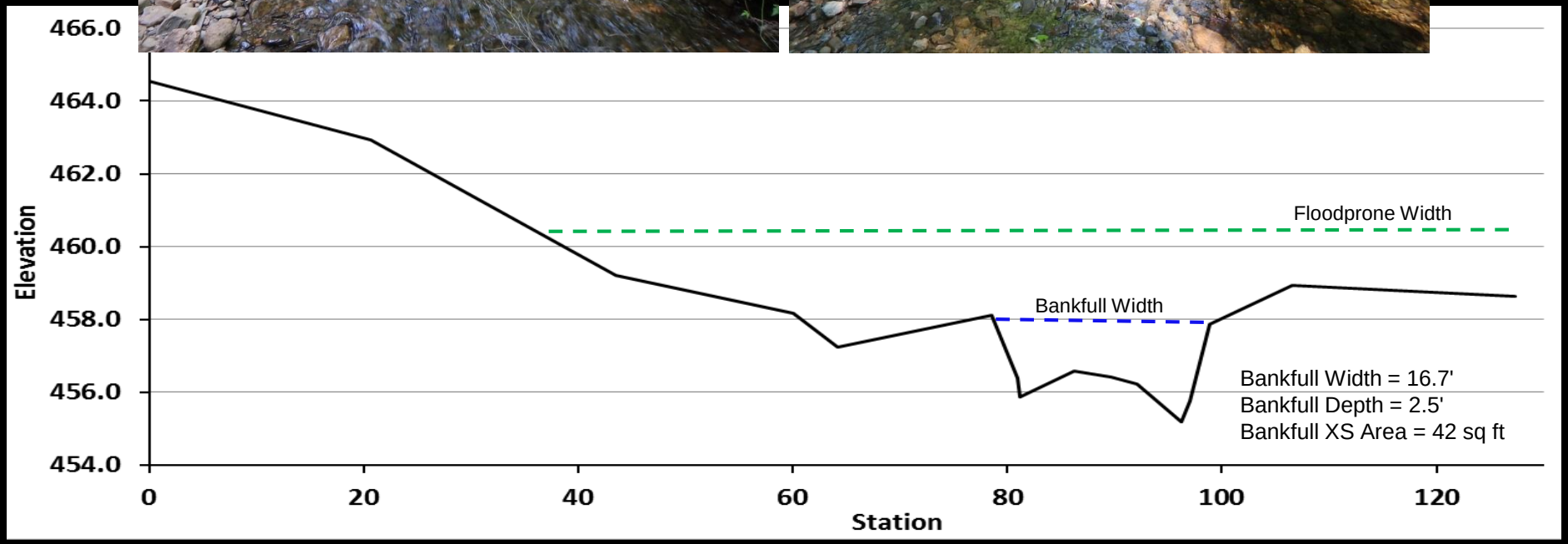


Average Stream Width = 6'
Average Depth = 1'

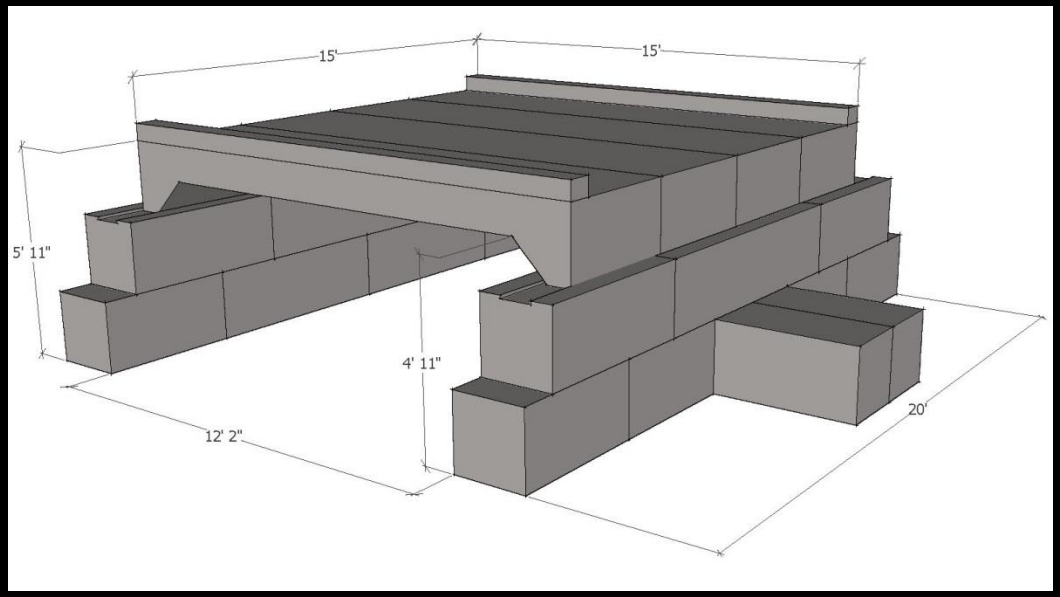
Step 1: Field Assessment

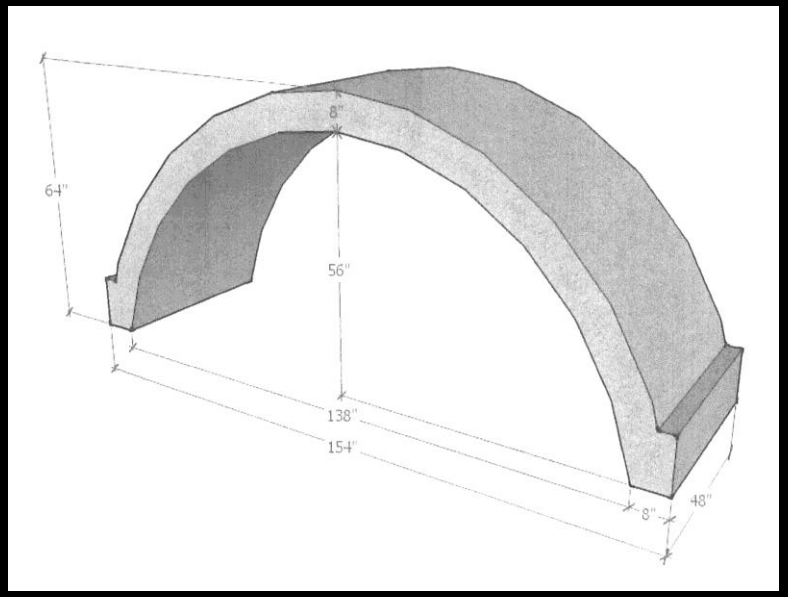
Cross-section

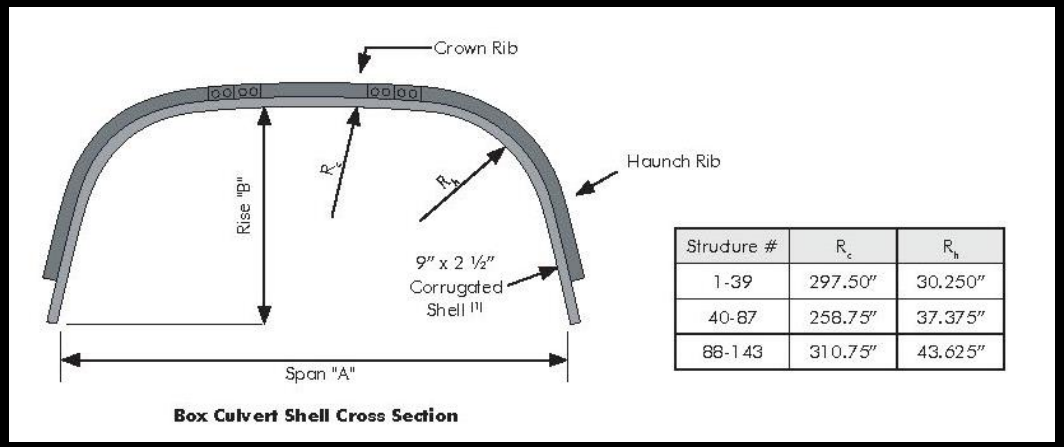




Step 2: Structure Choice

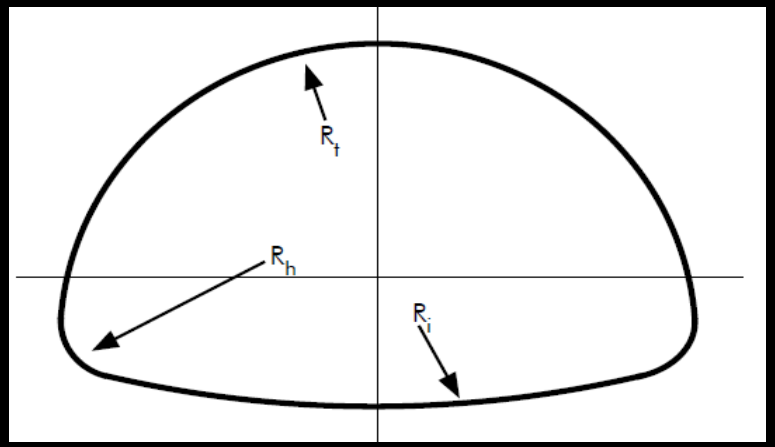






Strudure #	R_c	R_h
1-39	297.50"	30.250"
40-87	258.75"	37.375"
88-143	310.75"	43.625"

Box Culvert Shell Cross Section



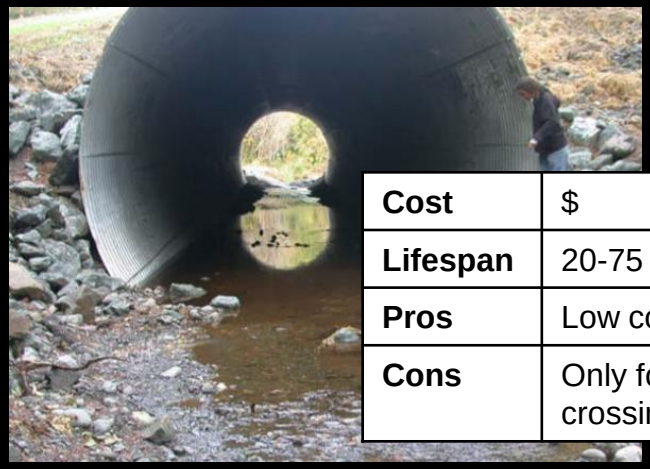
Comparison of Stream Crossing Structures

Crossing Structure Type	Material	Cost	Life Span (years)	Advantages	Disadvantages
Bridge A	Steel-reinforced concrete abutments (poured in-place) and decking on steel I-beam stringers	$$$	50-75	Natural bottom, durability, snow-plowable	High cost
Bridge B	Precast concrete block abutments with steel I-beam stringers and timber deck (possibly paved or alternate decking)	$	50-75; timber redeck 5-10	Natural bottom, low cost; simplicity	Limited abutment height and deck life; snow plowing may be limited
Bridge C (3-Sided Box Culvert)	Steel-reinforced concrete, galvanized steel or aluminum	$$	50-75	Natural bottom, simplicity	Span/weight of sections can limit installation options; assembly required for metal plate structures
Open Bottom Arch	Galvanized Steel, aluminum, steel-reinforced concrete	$$	50-75	Natural bottom, ease of transport, can be low profile	Care must be taken to install and protect footings, assembly required for metal plate structures
Embedded Box Culvert	Steel-reinforced concrete, galvanized steel, aluminum	$$	50-75	Natural bottom; variety of configurations	Must span stream and be set below stream elevation to avoid outlet perch; limited by bedrock
Embedded Pipe Arch	Galvanized steel, aluminum	$ - $$	20-50	Natural bottom; wide for given volume; low cost of steel	Short life (steel); not for use with ledge; limited sizes
Embedded Round Pipe	Galvanized steel, aluminum, plastic, steel-reinforced concrete	$	20-75	Natural bottom; lowest cost	Limited to smaller sizes; not for use with ledge
Round Pipe (at stream grade) *Not Recommended*	Galvanized steel, aluminum, plastic, steel-reinforced concrete	$	20-75	Lowest cost	Rarely adequate for fish passage (develops outlet perch); limited to smaller sizes

Structure Comparison

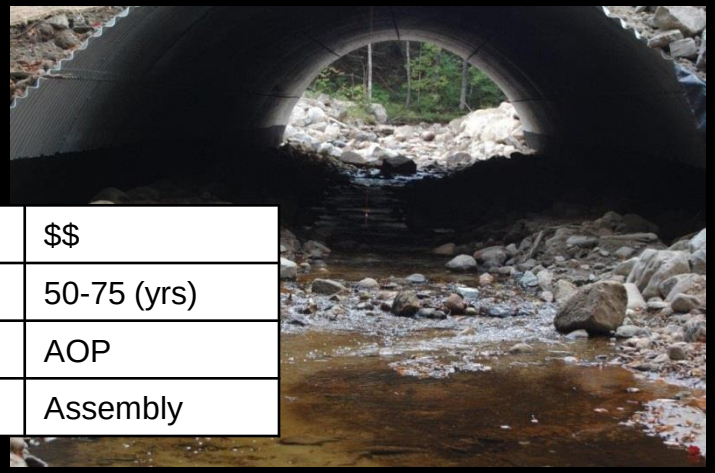
Cost	$$$
Lifespan	50-75 (yrs)
Pros	AOP, Durable
Cons	High cost

Bridge



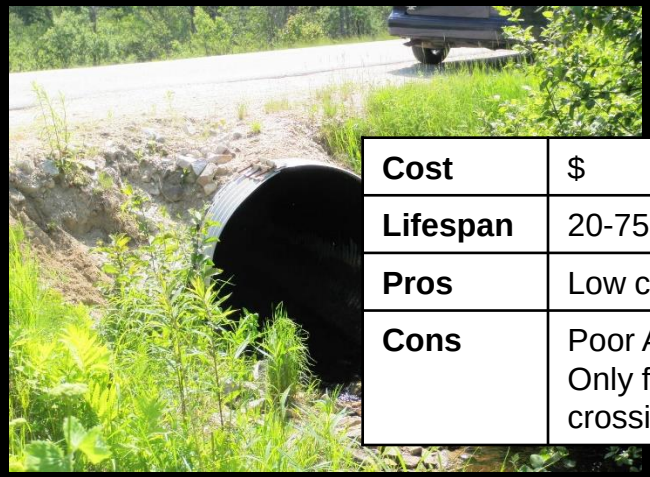
Cost	$
Lifespan	20-75 (yrs)
Pros	Low cost
Cons	Only for small crossings

Embedded Pipe



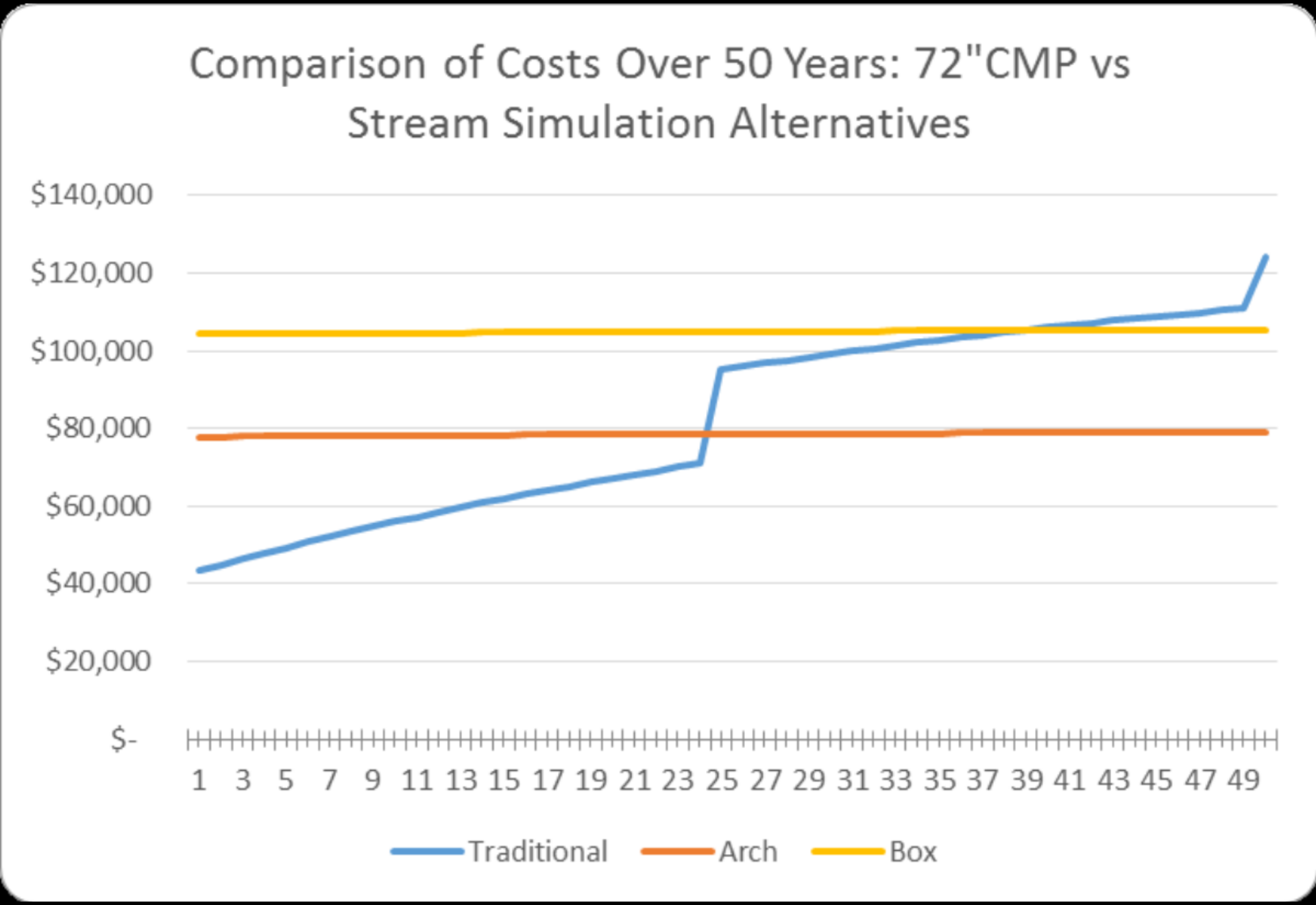
Cost	$$
Lifespan	50-75 (yrs)
Pros	AOP
Cons	Assembly

Open Bottom Arch



Cost	$
Lifespan	20-75 (yrs)
Pros	Low cost
Cons	Poor AOP Only for small crossings

Traditional Pipe


Comparison of Costs Over 50 Years: 72"CMP vs Stream Simulation Alternatives
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$-
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49
Traditional
Arch
Box

Stream-Smart: Open Arch

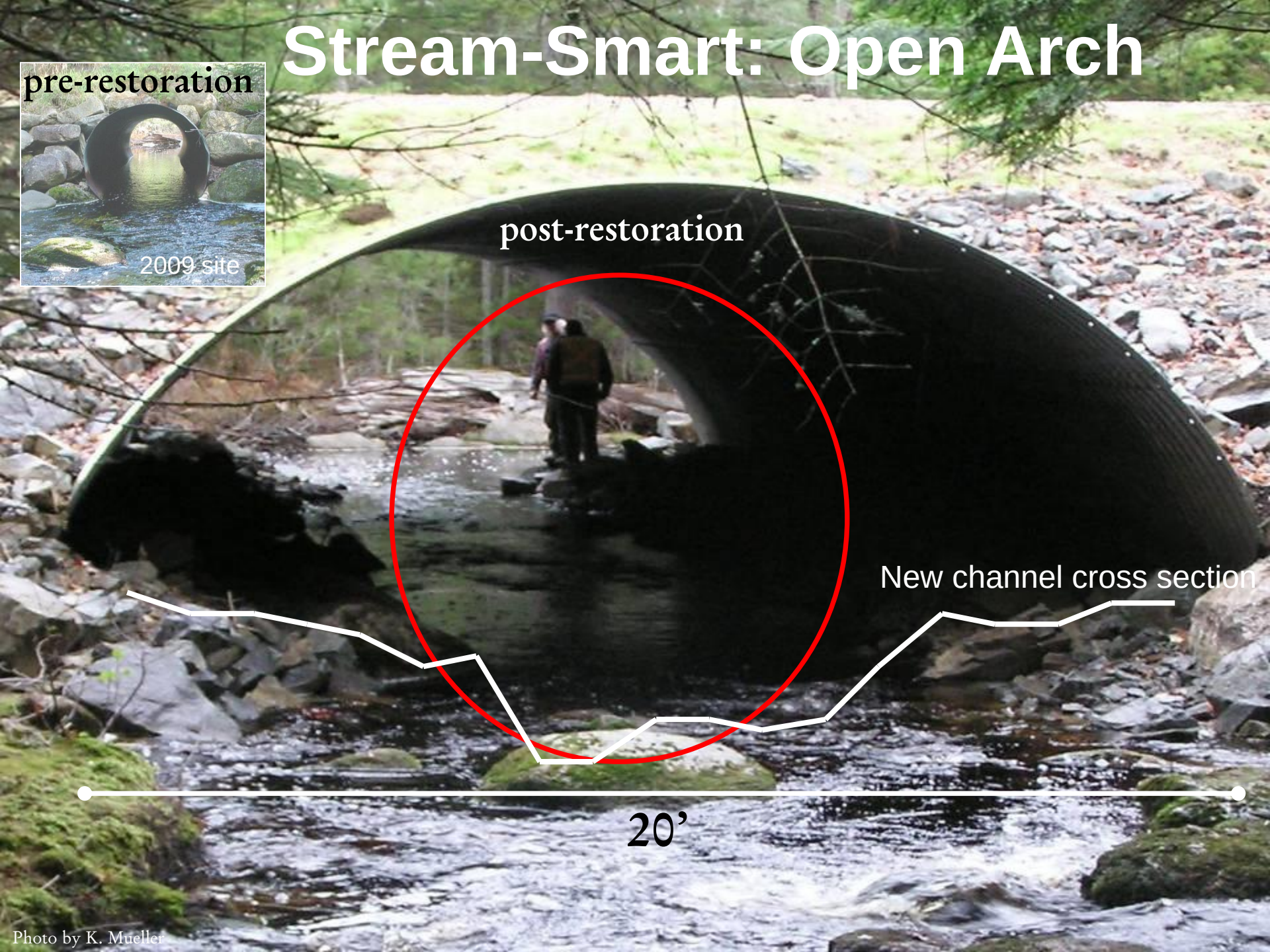


Photo by K. Mueller

Stream-Smart:
Small bridge on low volume road

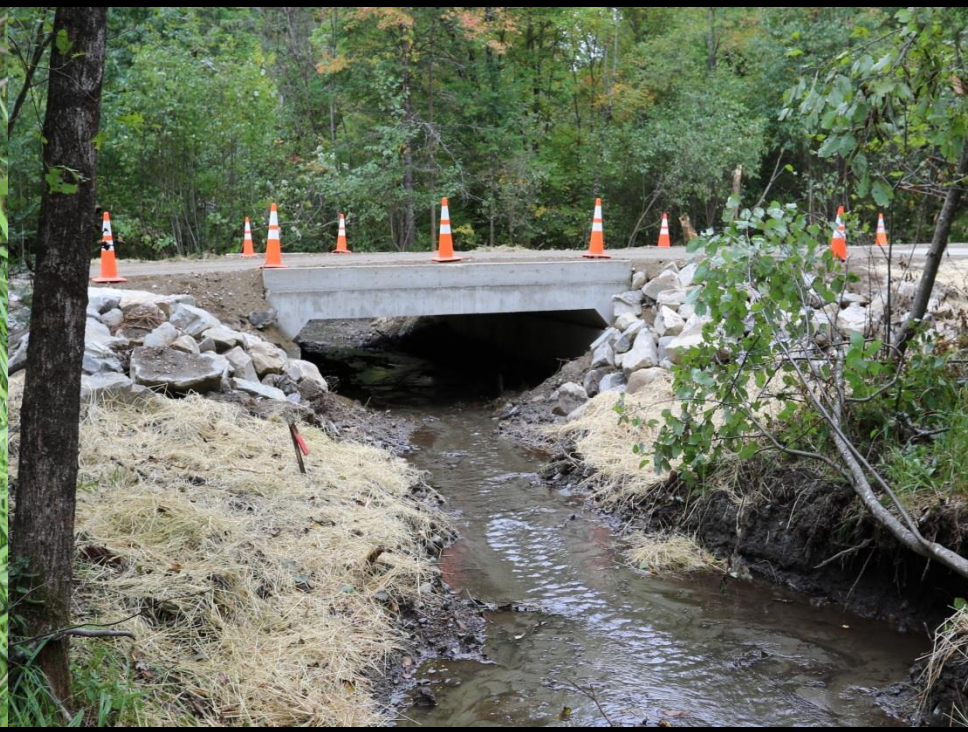
Stream-Smart:
Embedded Box Culvert

Before

After

Stream-Smart:
3-Sided Box Culvert

Before



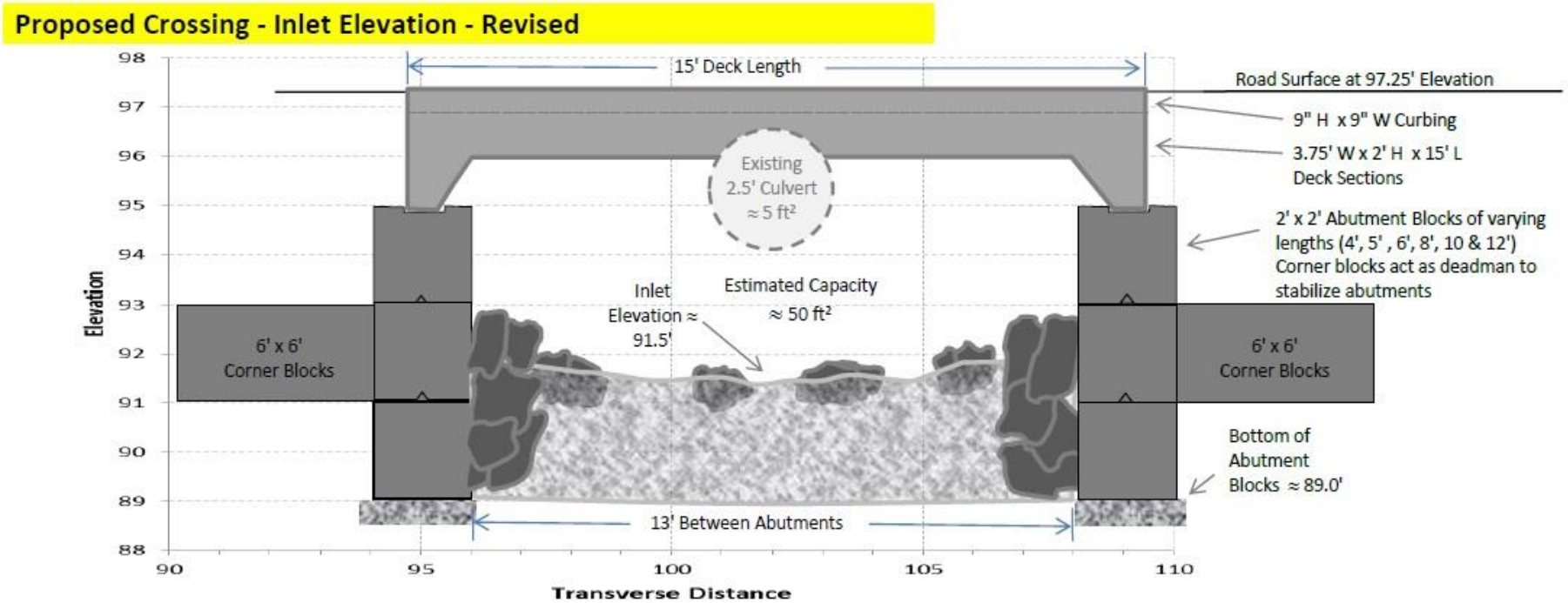
After

Stream-Smart:
Concrete Arch Culvert

Before

After

Step 2: Elevations



Note: Proposed road elevation assumes paving over bridge deck.

Step 2: Hydrology

USGS StreamStats

Hydrology & Hydraulic Analysis

Attribute	Value	Units	Definition
Drainage Area	0.41	sq. miles	Area that drains to crossing
Wetlands	0.0	percent	Percentage of NWI storage
Elevation	600	feet	Mean basin elevation
Precipitation	45.9	inches	Mean annual precipitation
Aquifer	0.0	percent	Percentage of land underlain by sand & gravel aquifers
X-coordinate	421595	UTM	Basin centroid E/W location
Y-coordinate	4957950	UTM	Basin centroid N/S location

Return T (yr)	Peak Q_T (ft^3/s)
1.1	14.8
2	31.4
5	49.9
10	63.9
25	83.2
50	98.7
100	115.3
500	157.7

References:

Hodgkins, G., 1999.
Estimating the magnitude of peak flows for streams in Maine for selected recurrence intervals
Water-Resources Investigations Report 99-4008
US Geological Survey, Augusta, Maine

Lombard, P. & Hodgkins, G., 2015
Peak Flow Regression Equations for Small, Ungaged Streams in Maine: Comparing Map-Based to Field-Based Variables
Water-Resources Investigations Report 2015-5049
US Geological Survey, Augusta, Maine

Porter Crossing 10405 - West Branch Tenmile Brook at Sarah Bridge Road

Crossings
- Barrier
- Potential Barrier
- No Barrier
- Unknown

Drainage Area Boundary
Known Brook Trout Habitat

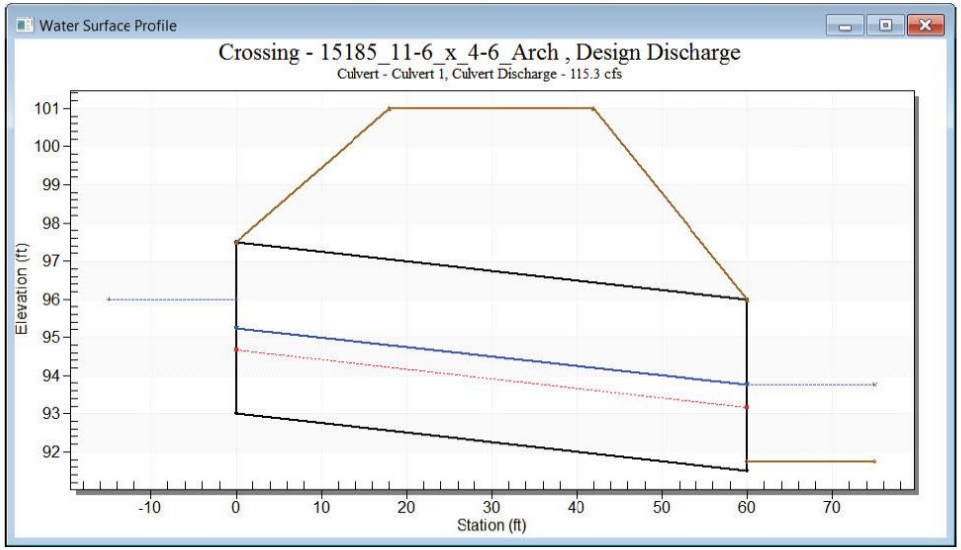
N

0 0.25 0.5 Miles

Map created by A. Abbott 1/10/17

Step 2: Hydraulics

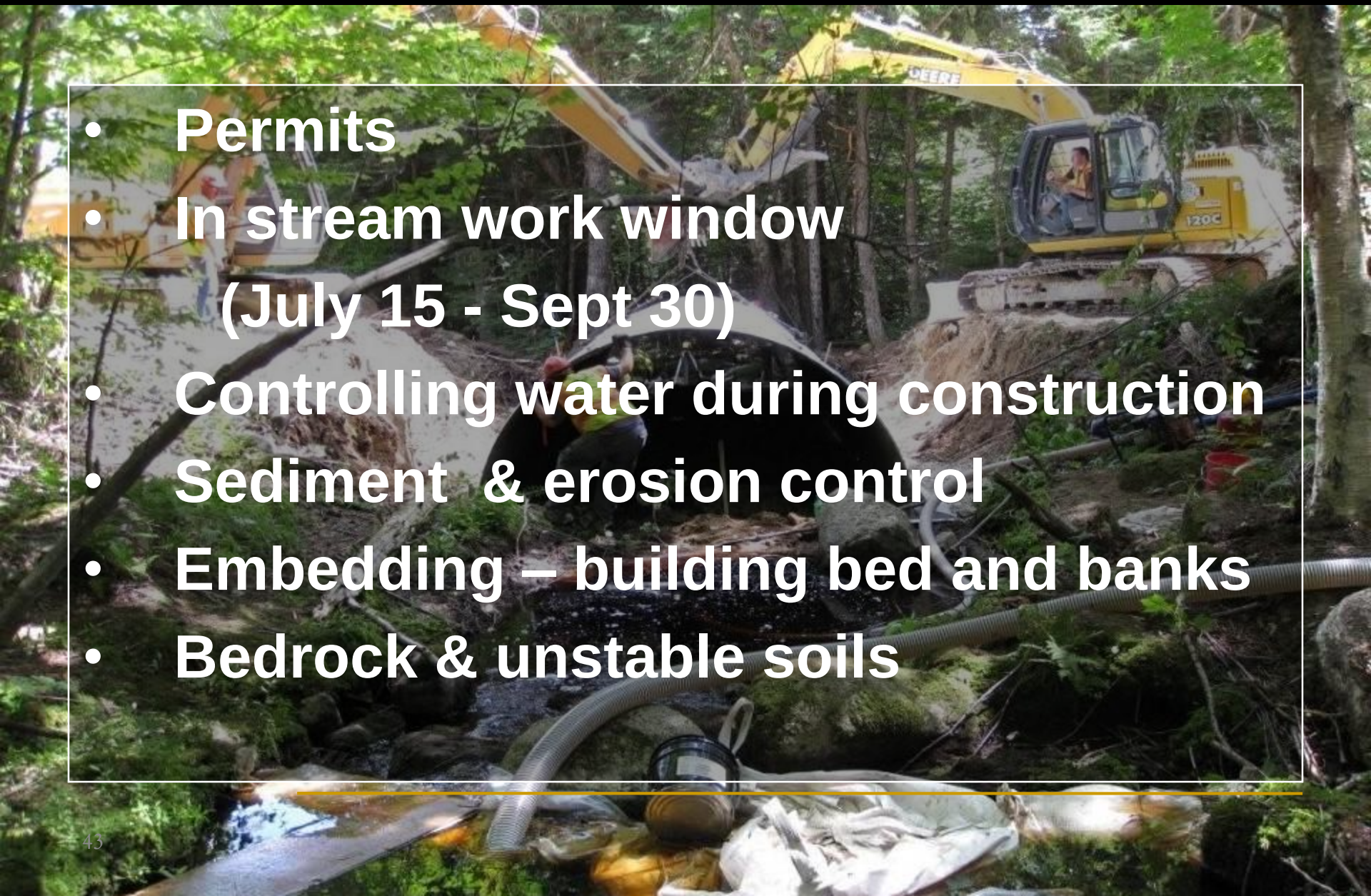
HY-8 Hydraulic Analysis Program of the U.S. Federal Highway Administration provides results for the above peak flow estimates for the proposed crossing design, and indicates that the crossing as proposed will successfully pass the expected 100-year storm event.



Discharge Names	Culvert Discharge	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Outlet Depth (ft)	Outlet Velocity (ft/s)
1 year	14.80	93.90	0.62	0.90	3-M1t	0.91	1.71
2 year	31.40	94.44	1.15	1.44	3-M1t	1.23	2.66
5 year	49.90	94.56	1.56~	0.00	3-M1t	1.51	3.36
10 year	63.90	94.81	1.81~	0.00	3-M1t	1.74	3.66
25 year	83.20	95.12	2.12~	0.00	3-M1t	1.98	4.13
50 year	98.70	95.71	2.37	2.71	3-M1t	2.12	4.57
100 year	115.30	95.99	2.67	2.99	3-M1t	2.25	5.01
500 year	157.70	96.70	3.42	3.70	3-M2t	2.56	6.04

Note that prediction errors are quite large when using regression equations to estimate flows and bankfull widths based on drainage area. It is best to account for potentially larger flows at these return intervals.

Design & Installation Considerations



- Permits
- In stream work window
  (July 15 - Sept 30)
- Controlling water during construction
- Sediment & erosion control
- Embedding – building bed and banks
- Bedrock & unstable soils

Controlling Water

When might you seek help?

- Complicated legacy effects
- When you can’t find natural channel
- Tidal streams
- Safety or traffic issues

Rules of Thumb (4 S's)

Span the stream

Set elevation right

Slope and skew match stream

Substrate in the crossing

The Golden Rule:
Let the stream act like a stream