MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

Bridges and Culverts Permitting Considerations

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Presentation Outline

- MESBOAC
- Bankfull Width
  - Undersized Culverts
  - Bankfull Indicators
  - Measuring Bankfull
  - Regional Curves
- Roadway Slopes
- Matching Culvert Slopes to Streams
- How to Embed Culverts
- Offsetting Multiple Culverts
- Culvert Alignment
- Stream Headcuts

EGLE

Federal Highway Administration (FHWA) Guidance Based on the Clean Water Act

If aquatic life is a designated use, culvert installation, operation, and maintenance should not cause **physical**, **chemical**, or **biological** degradation or otherwise alter fish species composition, demographics, and habitat.

The discharge should not impede the movement of:

- fish
- prey and forage
- symbiotic and commensal species

Fundamental Stream and Culvert Interactions

- Fish and other aquatic organisms live and travel primarily along the channel margins.
- This is the environment under which they evolved and developed their swimming capabilities: 0 - 3 feet/sec
- When culverts less than the bankfull width restrict flow at a road prism, exit velocities from the culvert easily reach 5 feet/sec
- DNR has measured some up to 14 feet/sec

What is MESBOAC?

M – Match culvert width to bankfull stream width

E – Extend culvert length through toe of side slope

S – Set culvert slope the same as stream slope

B – Bury culvert 1/6th bankfull stream width

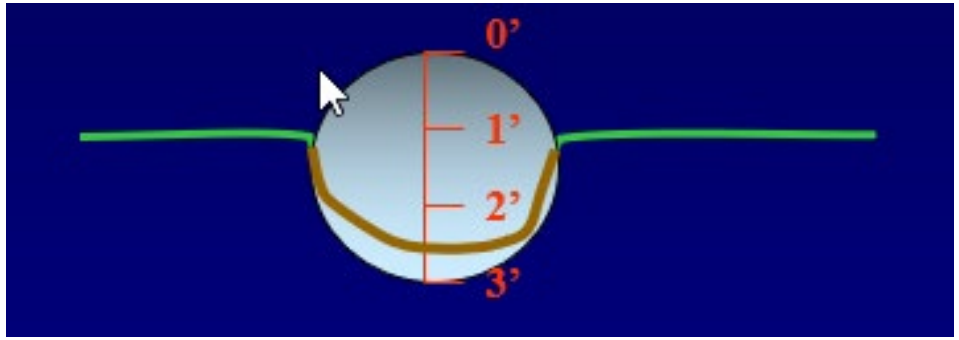
O – Offset multiple culverts (for additional capacity)

A – Align culvert with natural stream meanders

C – Consider headcuts and cut-offs

EGLE

M - Match Bankfull Width

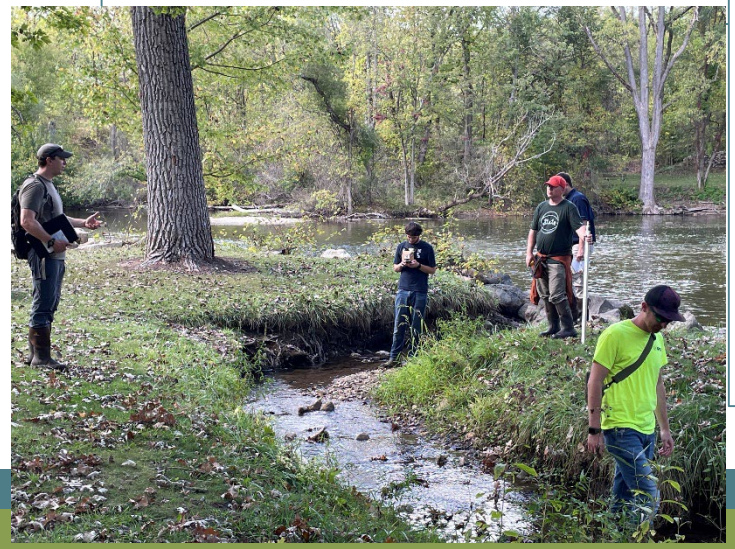


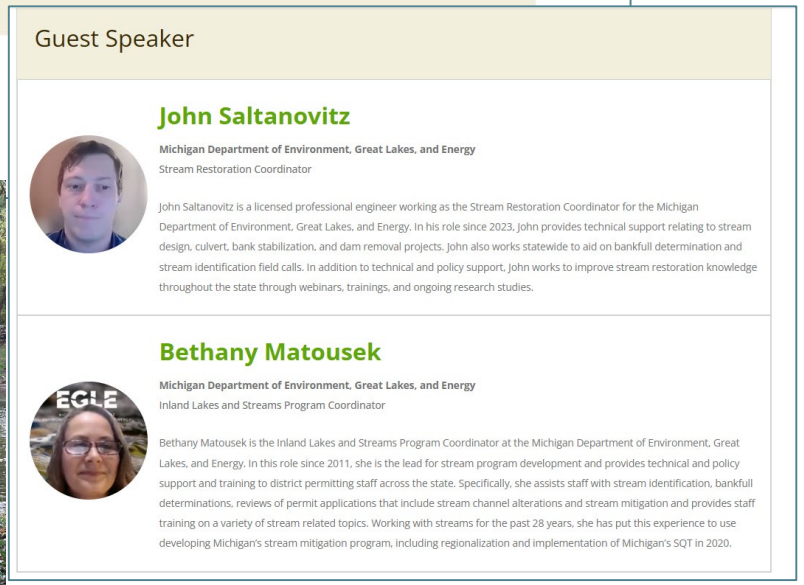
This is the size of the channel that will remain stable while carrying the water, sediment, and debris of the watershed.

EGLE

Bankfull Identification Resources

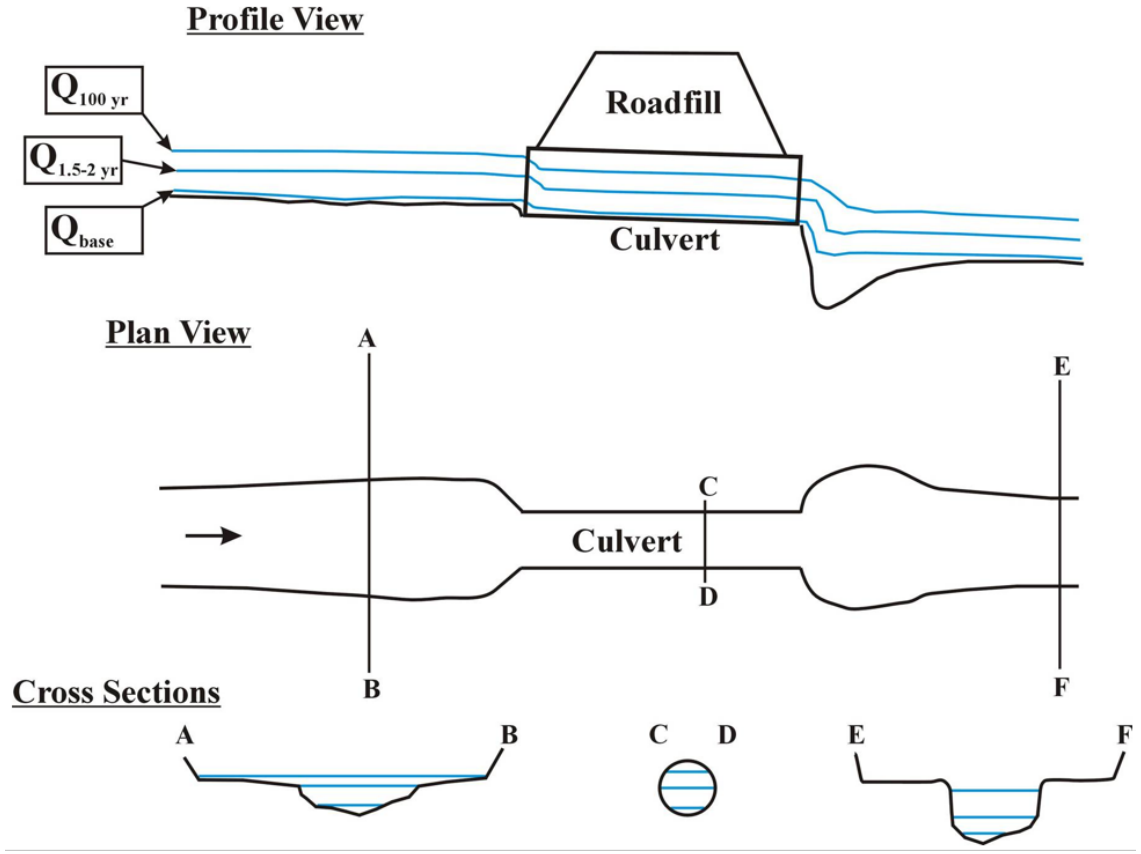
- Michigan Wetlands Association
  - miwetlands.org
- Webinars
  - Past Webinars
  - Bankfull Identification Webinar
- Google MWA Bankfull Webinar





Undersized Culverts

- Enhance erosion of channel sides
- Cause backwater conditions upstream – increasing inlet head and thus exit velocities
- Scour the outlet pool



Bankfull Definitions

- Bankfull flow is the flow responsible for moving the most sediment and maintaining channel form (Dunne and Leopold 1978).
  - Considered the most **effective** or **channel forming** flow.
- That is why bankfull flow width is the minimum structure width required for simulating and maintaining form and functions through a crossing.
- The Bankfull Discharge (flow) on average is a 1.5-year storm event.

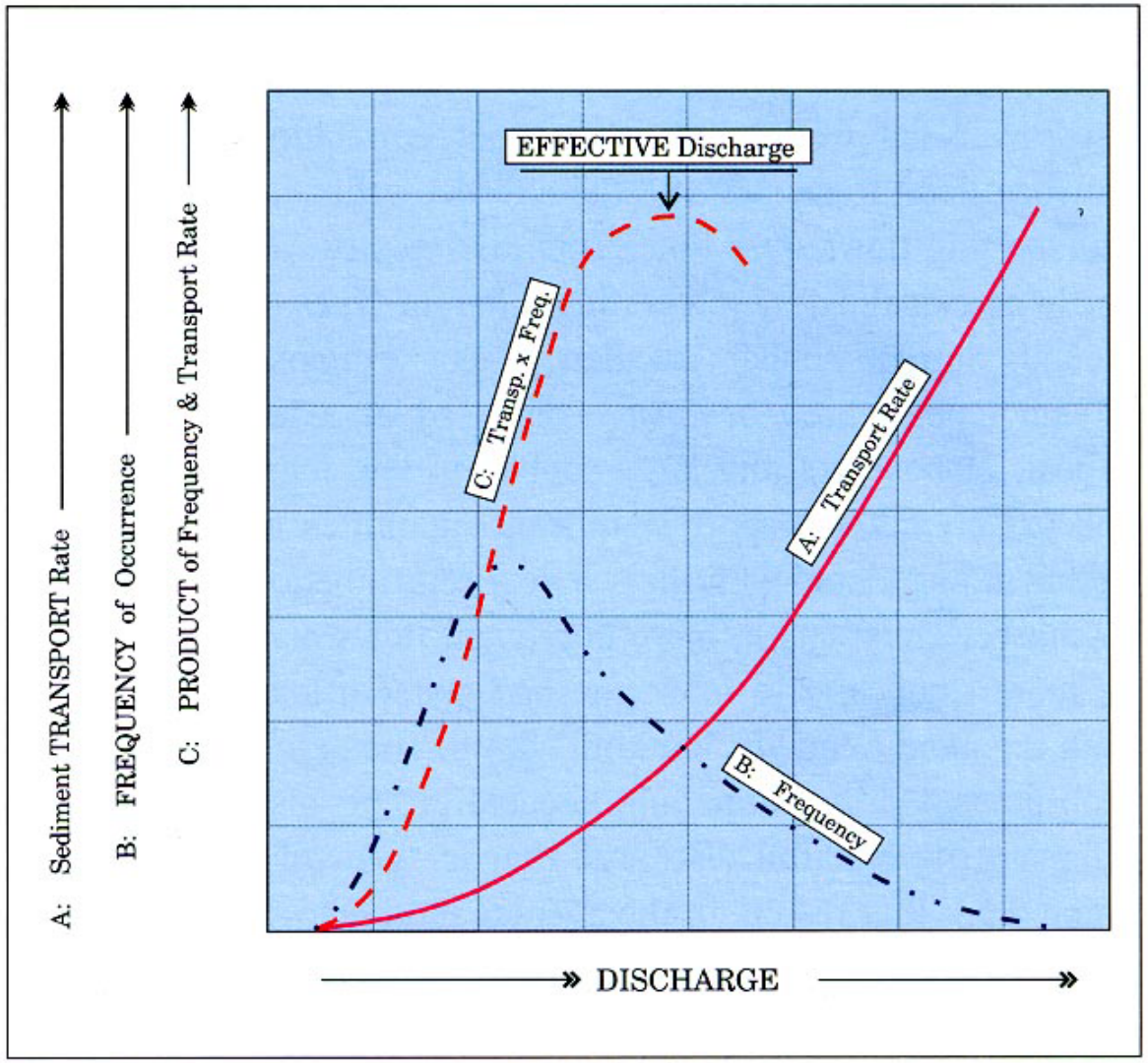


FIGURE 2-2. Relations between DISCHARGE, Sediment TRANSPORT Rate, FREQUENCY of Occurrence, and the PRODUCT of Frequency and Transport Rate. *(After Wolman and Miller, 1960)*

The most effective sediment discharge, over time, occurs, at the bankfull flow rate which is between the 1-to-2-year recurrence interval.

At the bankfull flow, the stream bottom picks up and moves, then redistributes itself in the same pool & riffle patterns existing prior to the bankfull discharge.

Taken from Rosgen, 1996

Bankfull Determination Preference

- 1. Bankfull: For the purposes of these categories, bankfull should be determined through the following methods, in order of preference, and the application must include supporting documentation (e.g., photographs of measurements, calculations, etc.).

  a) Determine bankfull using onsite field indicators. Bankfull widths should be measured at riffles that are located outside the influence of any existing road stream crossings.

  b) Where field indicators are not present (e.g., highly altered or incised channels) and to verify measurements from field indicators, estimate bankfull width using the drainage area at the project location and the regional hydraulic geometry curves for Michigan.

  c) Where field indicators are not present and regional curves are not available, calculate the 1.5-year flow using hydrologic analyses or request this flow from EGLE. Then determine the natural, stable channel dimensions (bankfull width, depth, and cross-sectional area) that will accommodate the calculated flow. Natural, stable channel dimensions (i.e., the ratio of bankfull width to bankfull mean depth) should be similar to reference stream conditions (e.g., channel type B: width/depth (W/D) ratio = 16; C = 13; and E = 9).

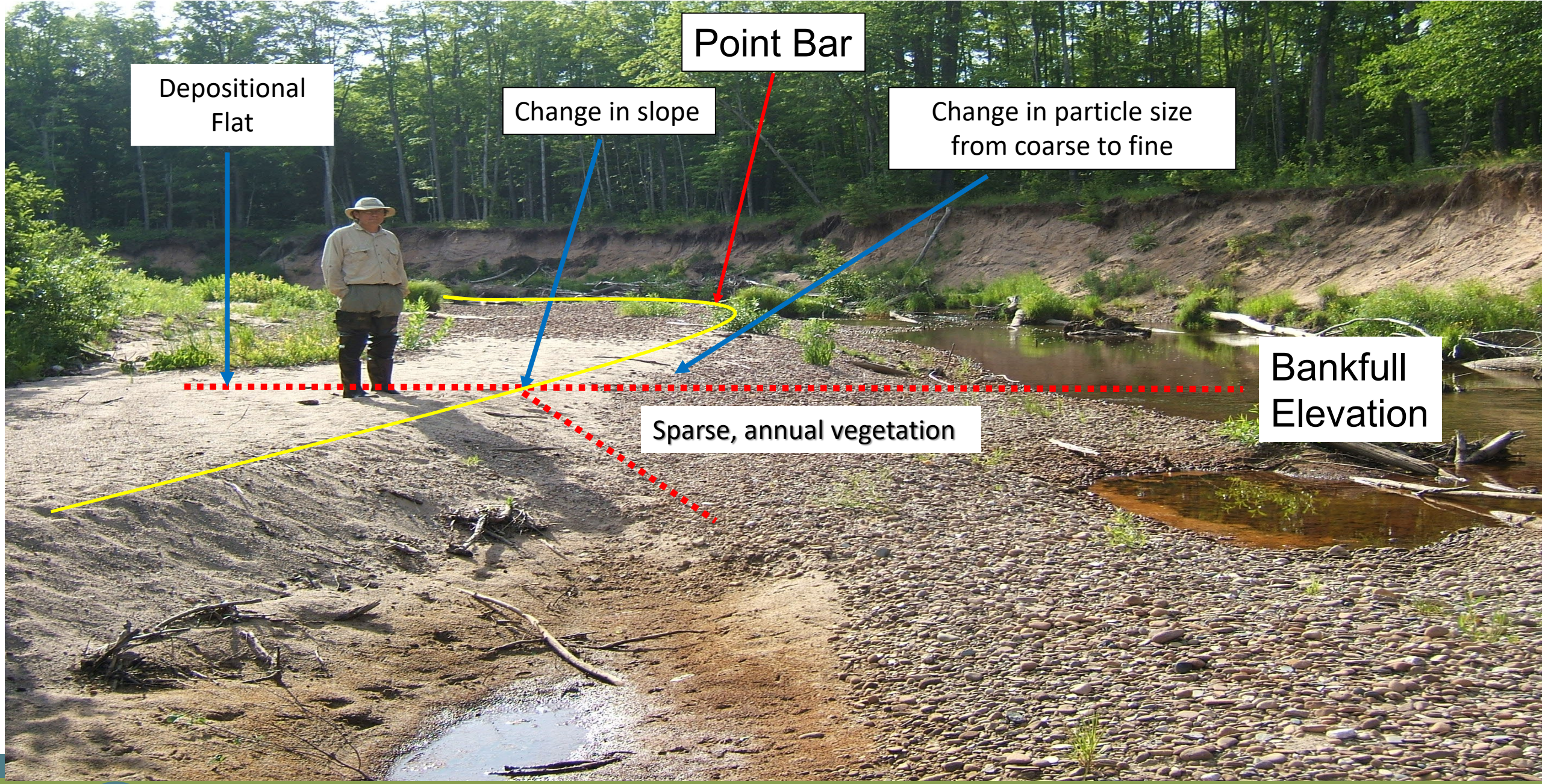
Common Bankfull Field Indicators

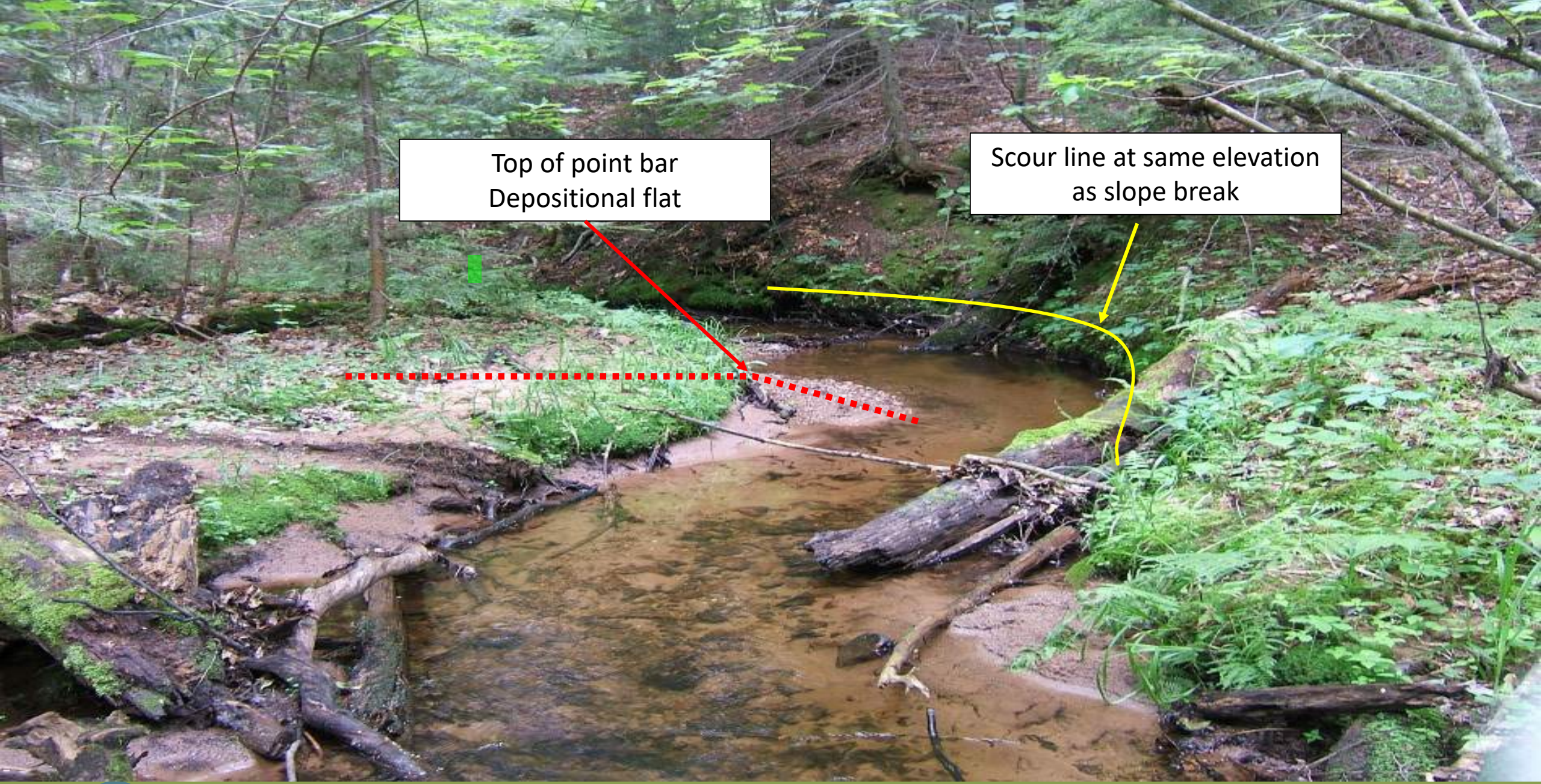
Primary

- Change in bank slope – flowing onto a floodplain
- Deposition and depositional features – silt, sand, debris, point bars, small benches
- Change in particle size – from coarse to fine

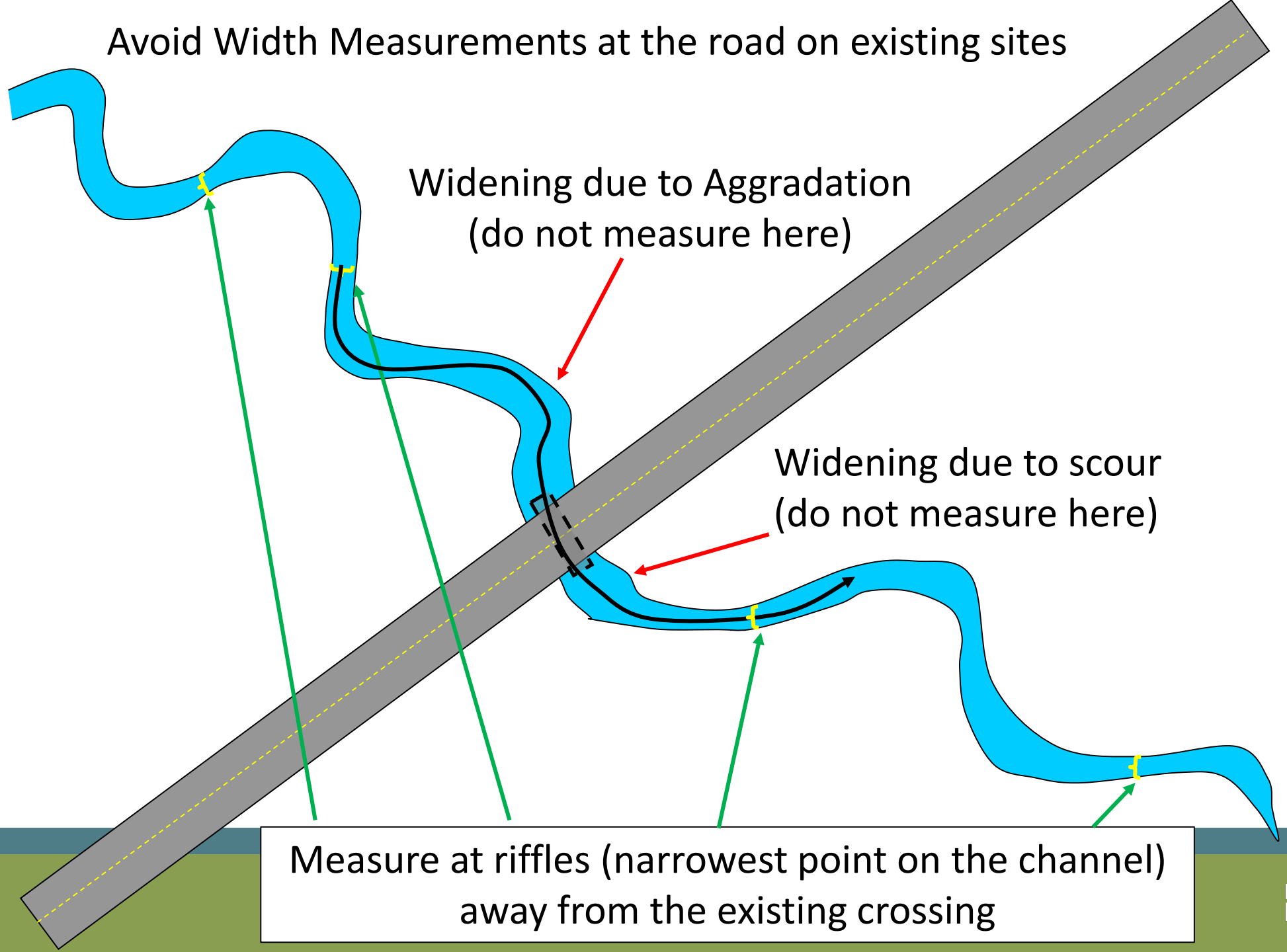
Secondary

- Scour line – exposed roots
- Vegetation – absence of woody, perennial vegetation (use caution)


Point Bar
Depositional Flat
Change in slope
Change in particle size from coarse to fine
Bankfull Elevation
Sparse, annual vegetation


Top of point bar
Depositional flat
Scour line at same elevation
as slope break

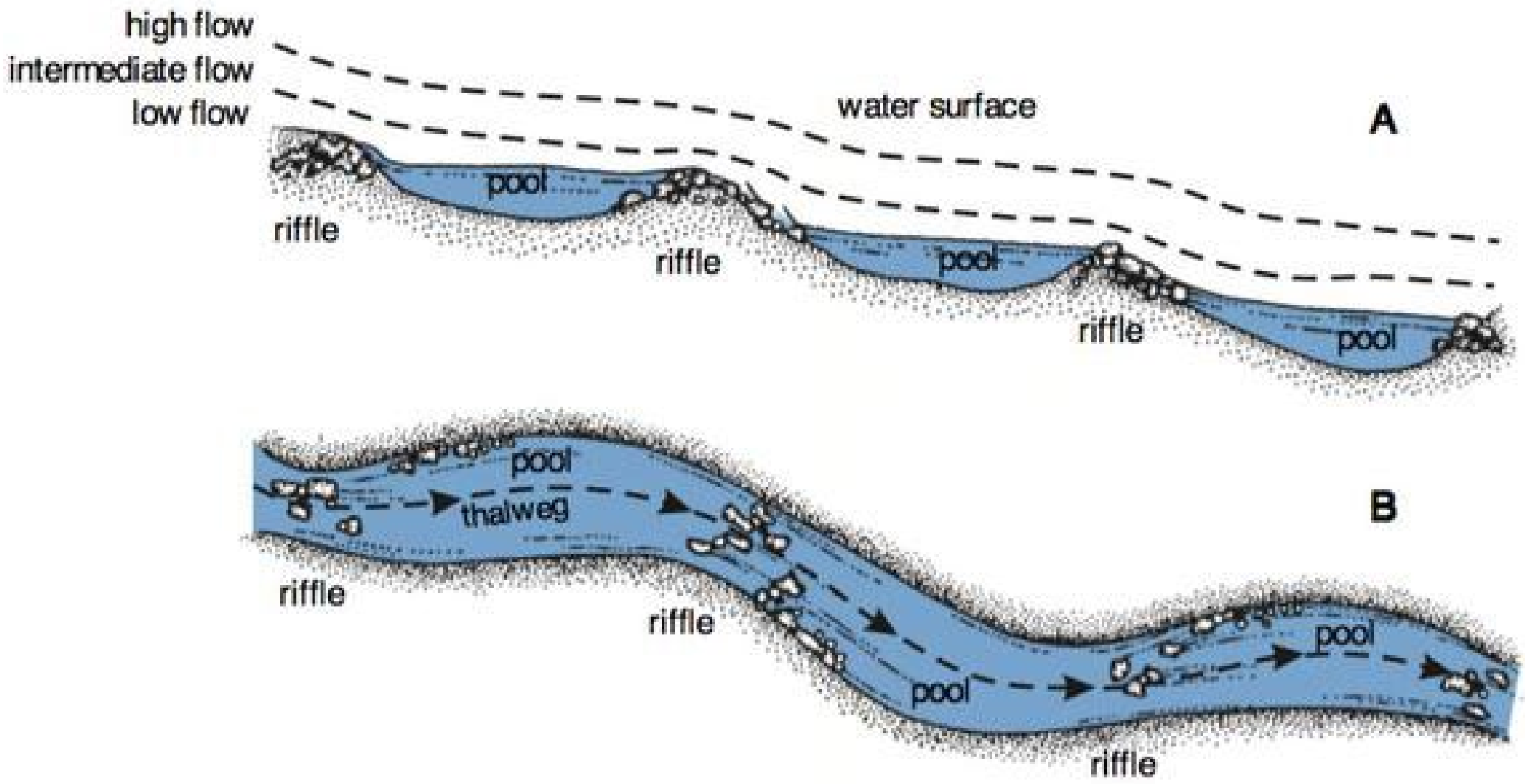
Avoid Width Measurements at the road on existing sites



Measuring Bankfull Width for Culverts

(after finding a consistent BF elevation)

- Measure bankfull width in the middle of a riffle (narrowest part of natural stream)
- No riffles (sand bed stream) = measure in straight runs at narrowest part
- Do not measure width at pools/bends (widest part of natural stream)
- Measure width at multiple riffles
- Away from the influence of structures (culverts, bridges, outfalls, pipes, log jams, etc.)
- Use field indicators or, if none available in the riffle, use the bankfull height above water surface


high flow
intermediate flow
low flow
water surface
A
pool
riffle
riffle
pool
riffle
pool
B
pool
thalweg
riffle
riffle
pool
pool
riffle


Riffle
Run
Pool
Glide
Riffle

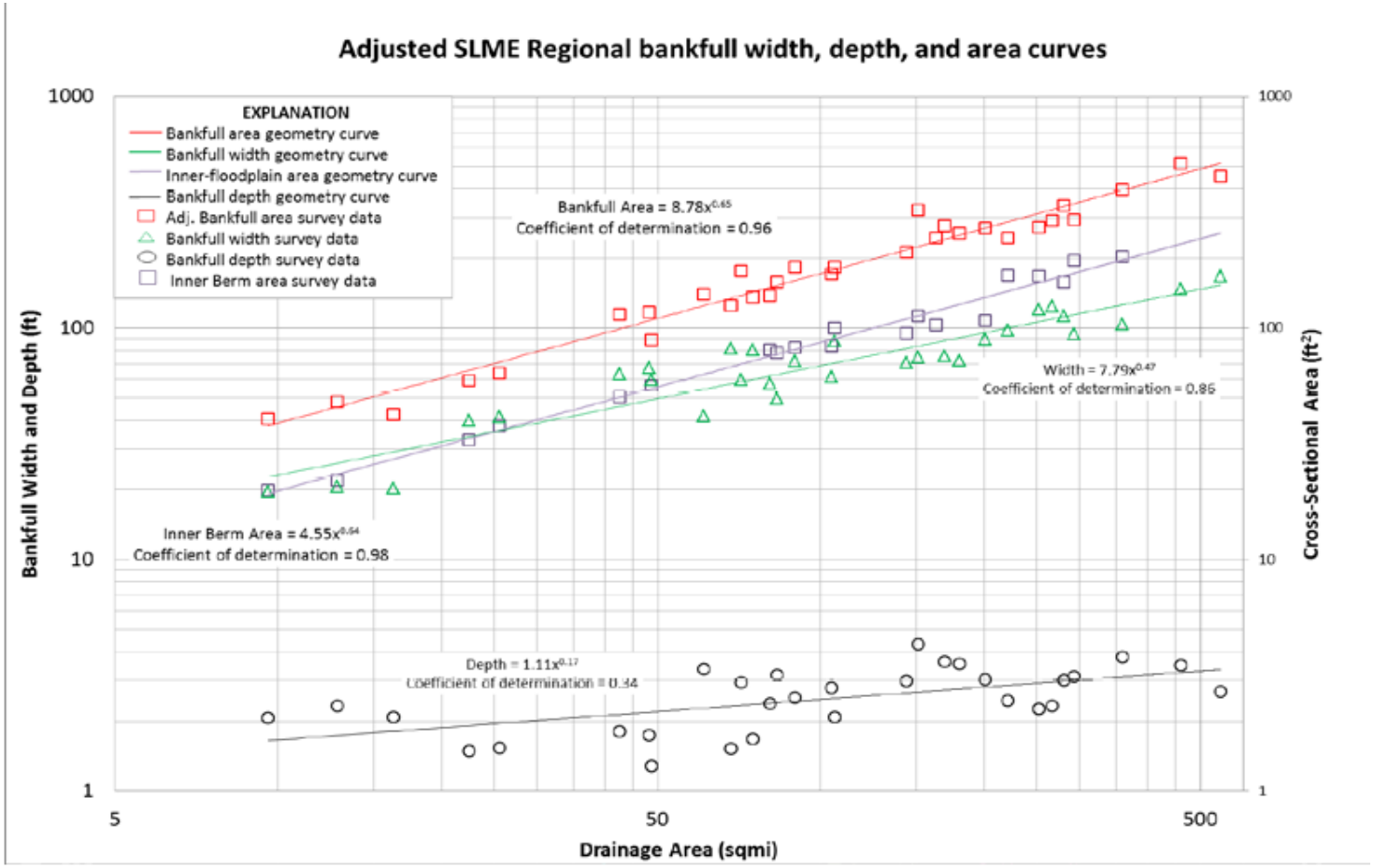
No BF indicators on site?

Find a nearby reference reach (upstream or downstream)

Could be a natural reach…

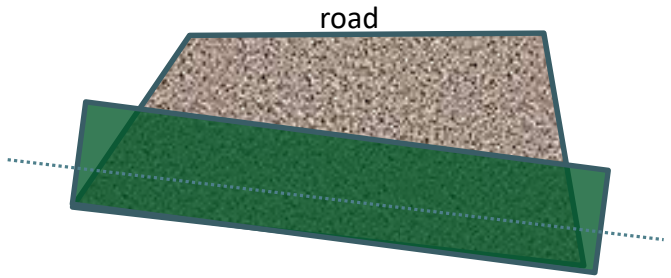
…or a stable, recovered reach

No BF indicators on site?
Need to verify bankfull?
Use Regional Reference Curves

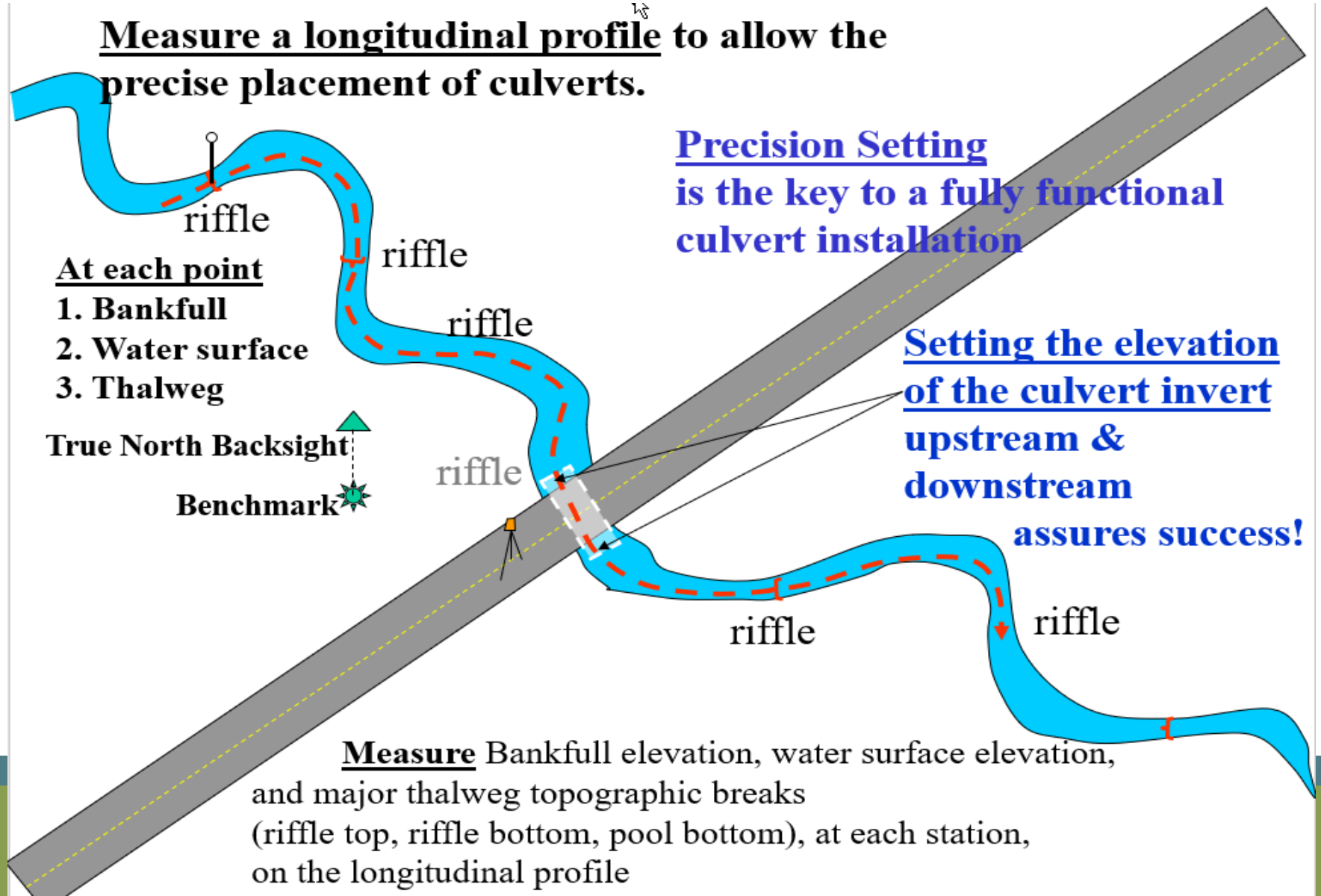


Adjusted SLME Regional Hydraulic Geometry and Discharge Equations
$Width = 7.79\ x\ DA^{.47}\ (R^2 = 0.86)$
$Depth = 1.11\ x\ DA^{.17}\ (R^2 = 0.34)$
$Inner\ Berm = 4.55\ x\ DA^{.64}\ (R^2 = 0.98)$
$Area = 8.78\ x\ DA^{.65} (R^2 = 0.96)$
$Discharge = 18.19\ x\ DA^{.68}\ (R^2 = 0.89)$

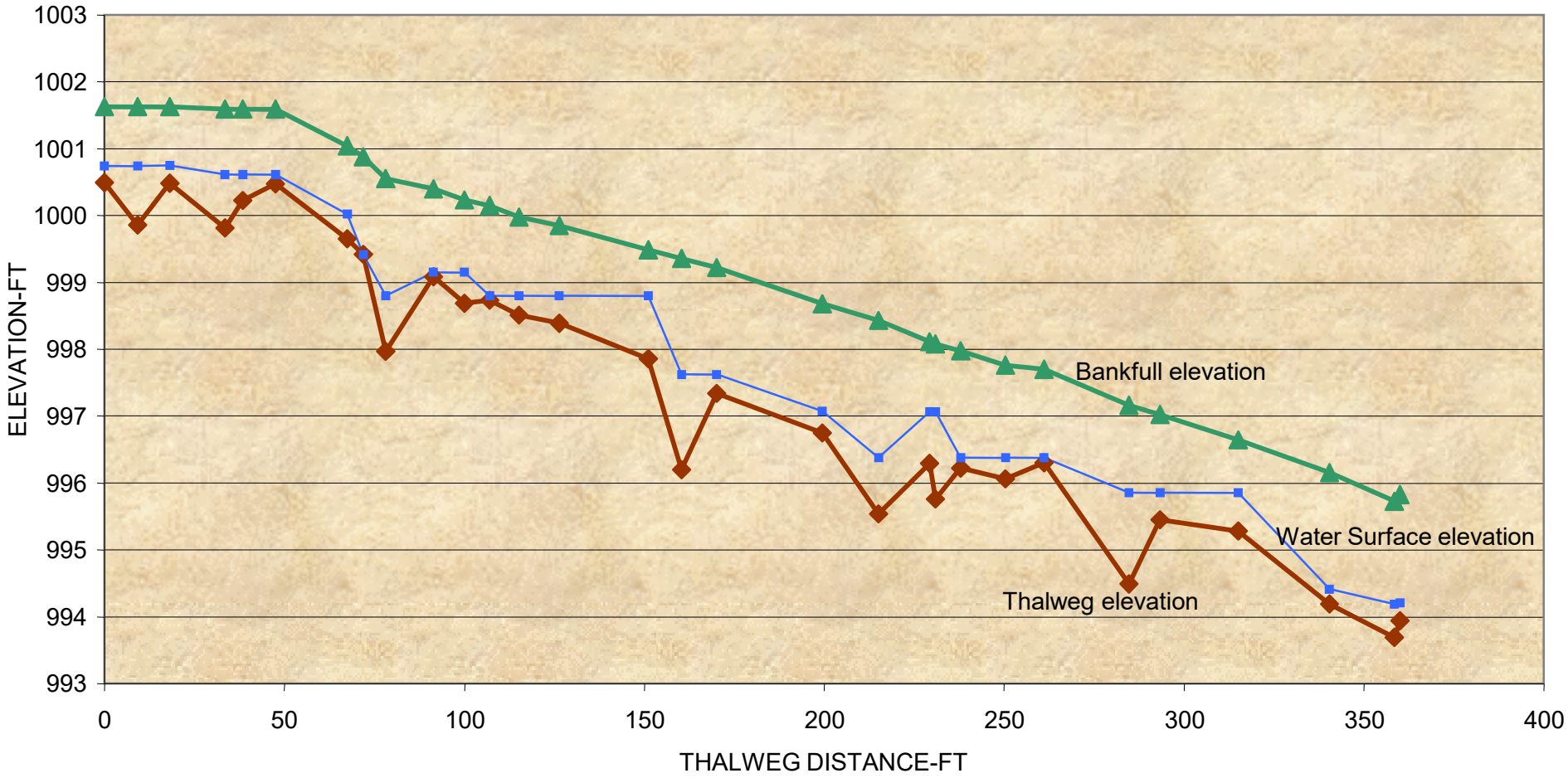
E – Extend through side slope

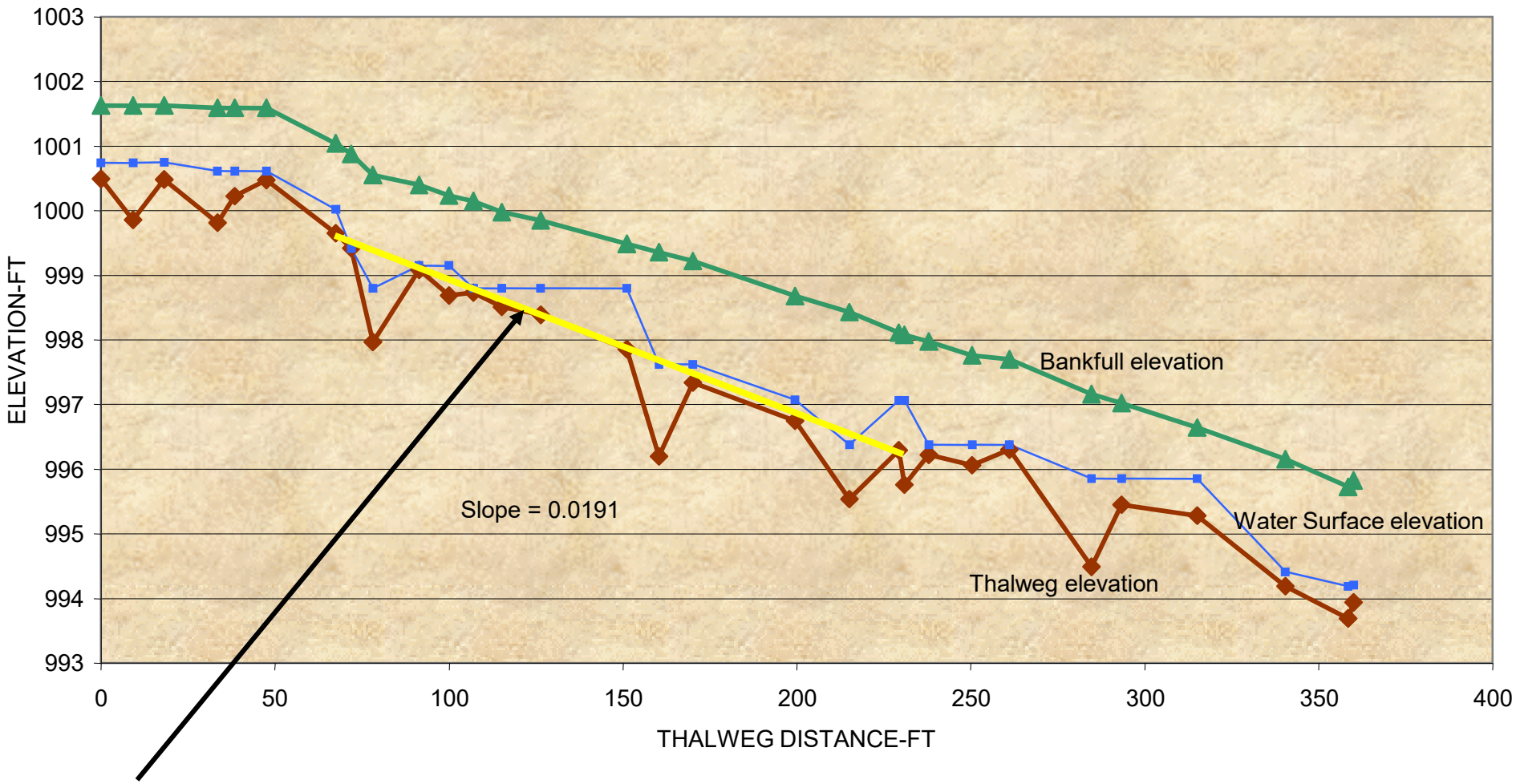


S – Slope same as stream slope

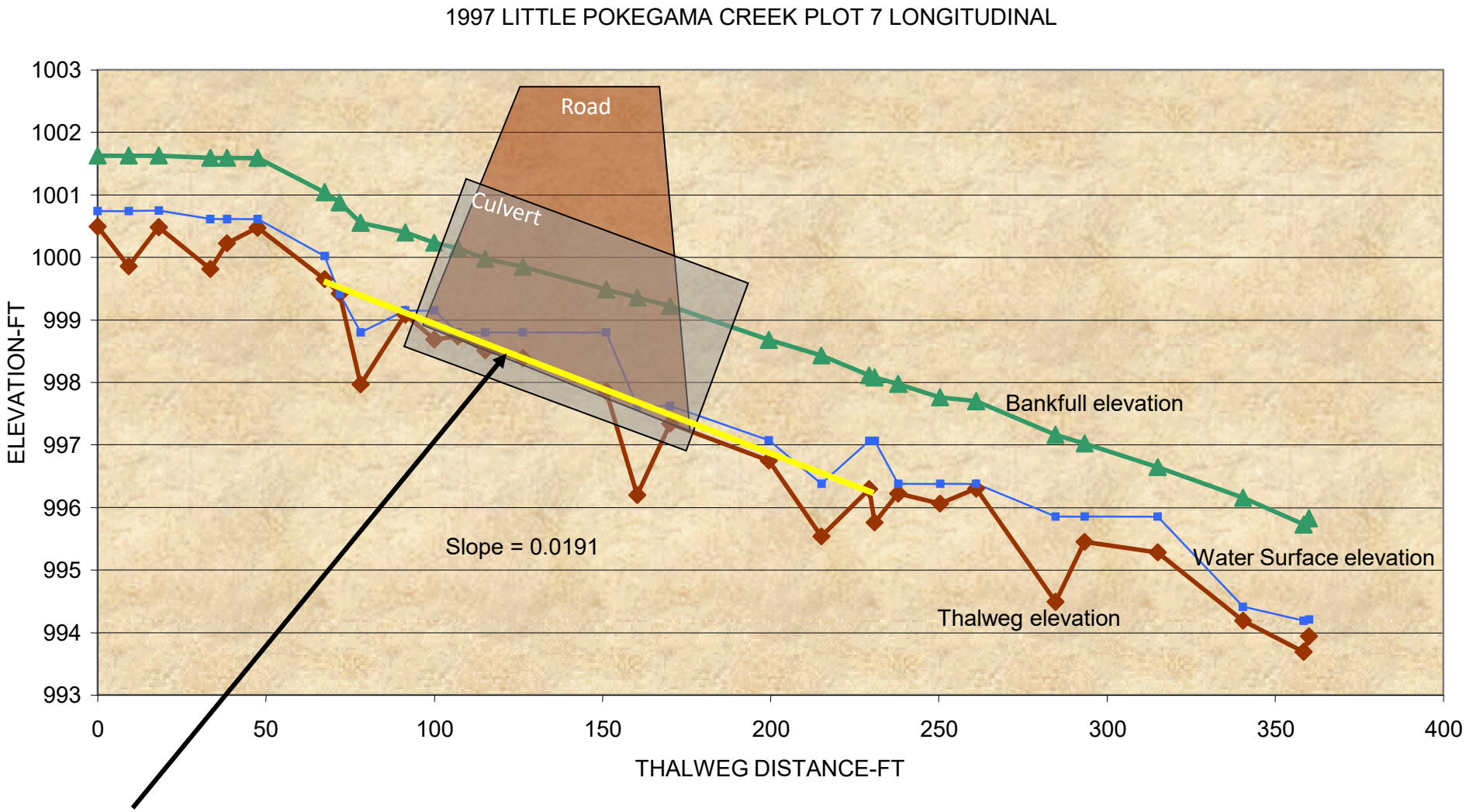


1997 LITTLE POKEGAMA CREEK PLOT 7 LONGITUDINAL





A line connecting the thalweg riffle points from above and below the crossing site is the most accurate estimate of stream slope



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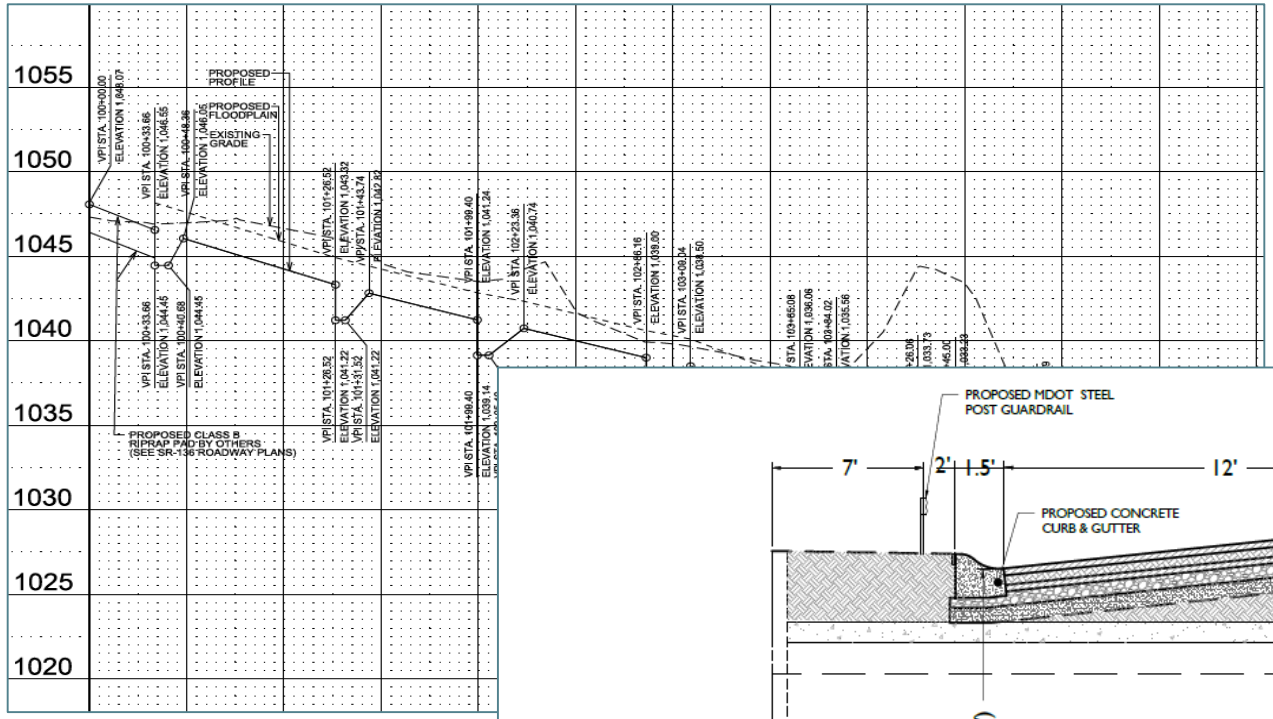
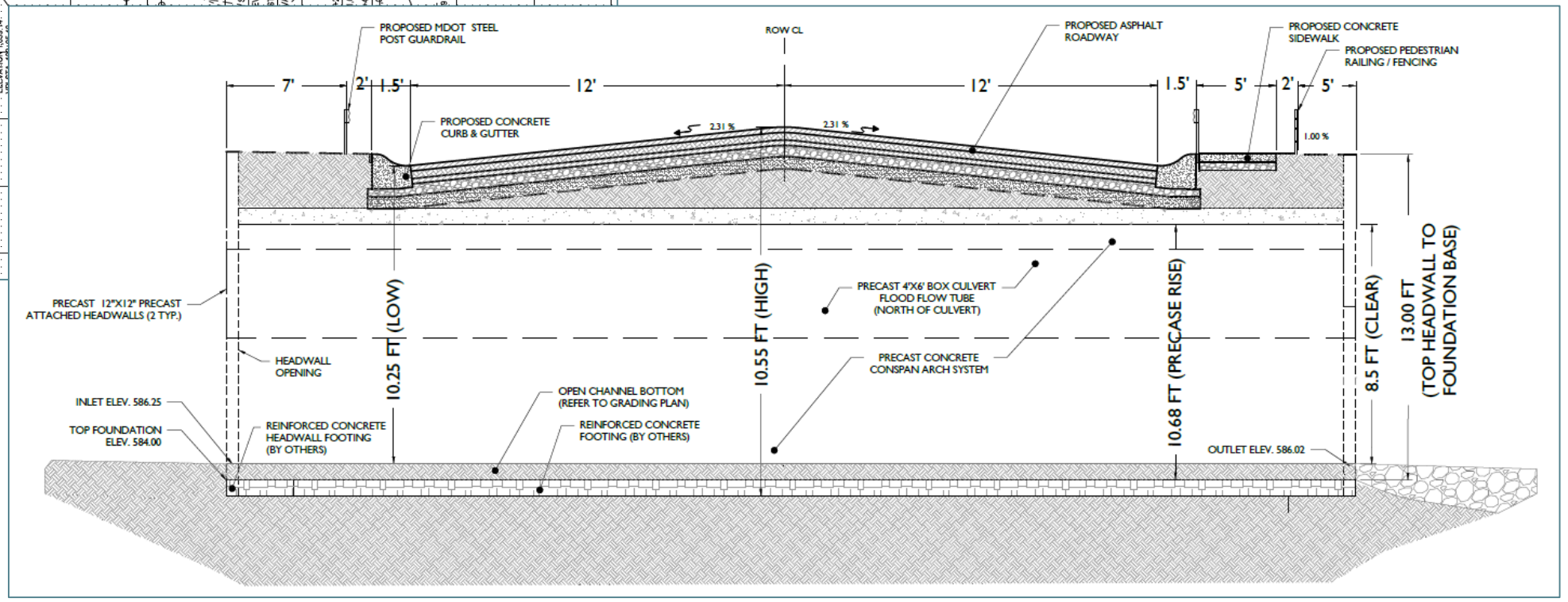
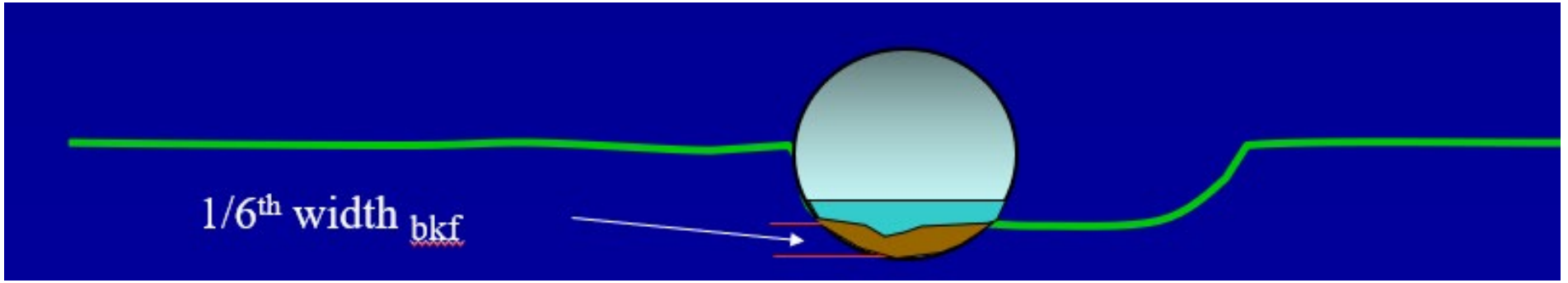

1055
1050
1045
1040
1035
1030
1025
1020
PROPOSED PROFILE
PROPOSED FLOODPLAIN
EXISTING GRADE
PROPOSED CLASS B RIPRAP PAD BY OTHERS (SEE SR-136 ROADWAY PLANS)


PROPOSED MDOT STEEL POST GUARDRAIL
ROW CL
PROPOSED ASPHALT ROADWAY
PROPOSED CONCRETE SIDEWALK
PROPOSED PEDESTRIAN RAILING / FENCING
7'
2'
1.5'
12'
12'
1.5'
5'
2'
5'
PROPOSED CONCRETE CURB & GUTTER
2.31 %
2.31 %
1.00 %
PRECAST 12"X12" PRECAST ATTACHED HEADWALLS (2 TYP.)
HEADWALL OPENING
10.25 FT (LOW)
10.55 FT (HIGH)
PRECAST 4'X6' BOX CULVERT FLOOD FLOW TUBE (NORTH OF CULVERT)
PRECAST CONCRETE CONSPAN ARCH SYSTEM
10.68 FT (PRECASE RISE)
8.5 FT (CLEAR)
13.00 FT (TOP HEADWALL TO FOUNDATION BASE)
INLET ELEV. 586.25
TOP FOUNDATION ELEV. 584.00
REINFORCED CONCRETE HEADWALL FOOTING (BY OTHERS)
OPEN CHANNEL BOTTOM (REFER TO GRADING PLAN)
REINFORCED CONCRETE FOOTING (BY OTHERS)
OUTLET ELEV. 586.02

B – Bury 1/6th bankfull width

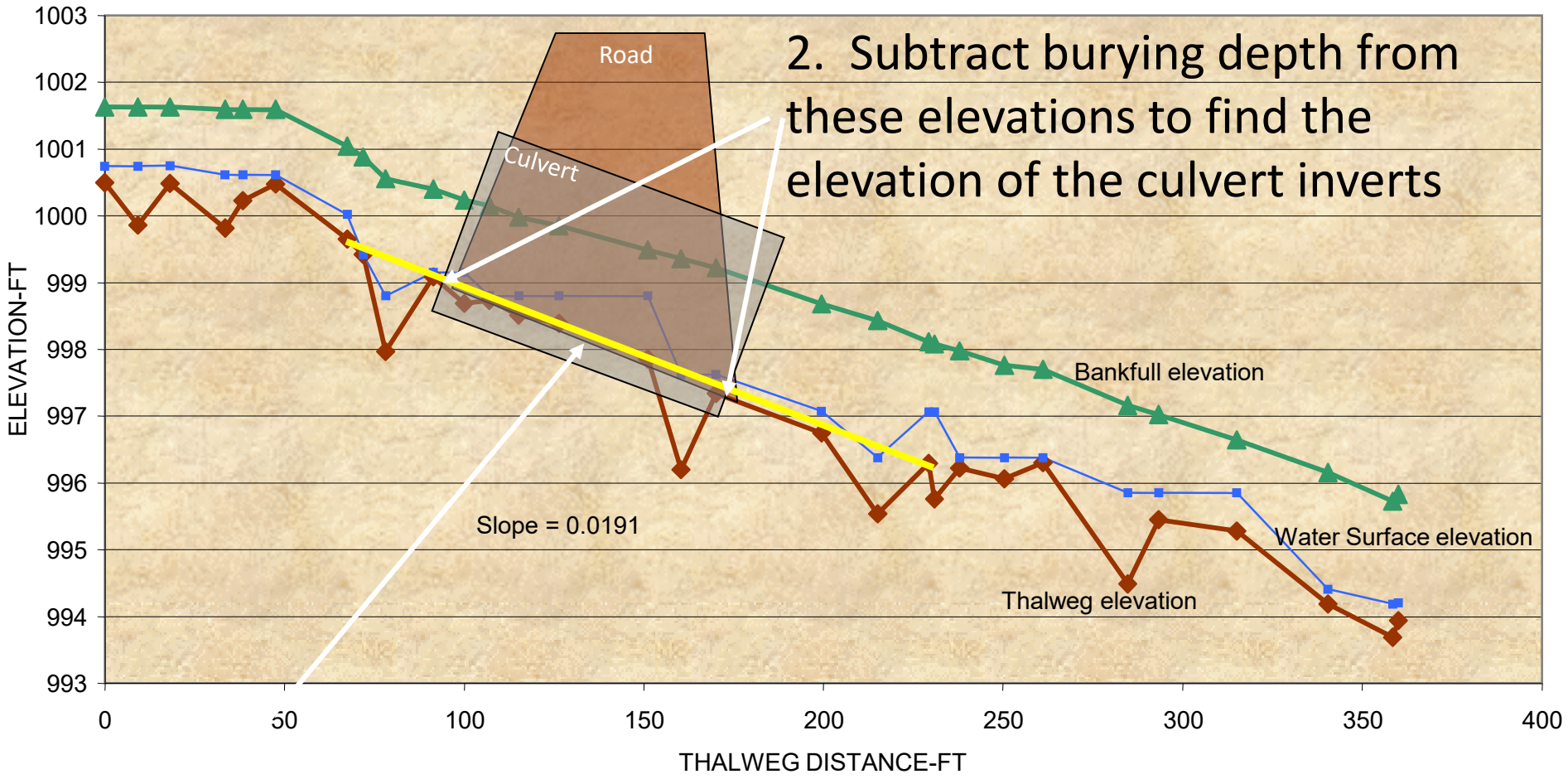


Bankfull Width	Culvert Diameter	Bury Depth
4 ft	48”	8”
5 ft	60”	10”
6 ft	72”	12”
7 ft	84”	14”
8 ft	96”	16”
10 ft	120	20”
12	144”	2’ max
14	168”	2’ max

Why Bury?
Streams mobilize the bed and may be naturally degrading.

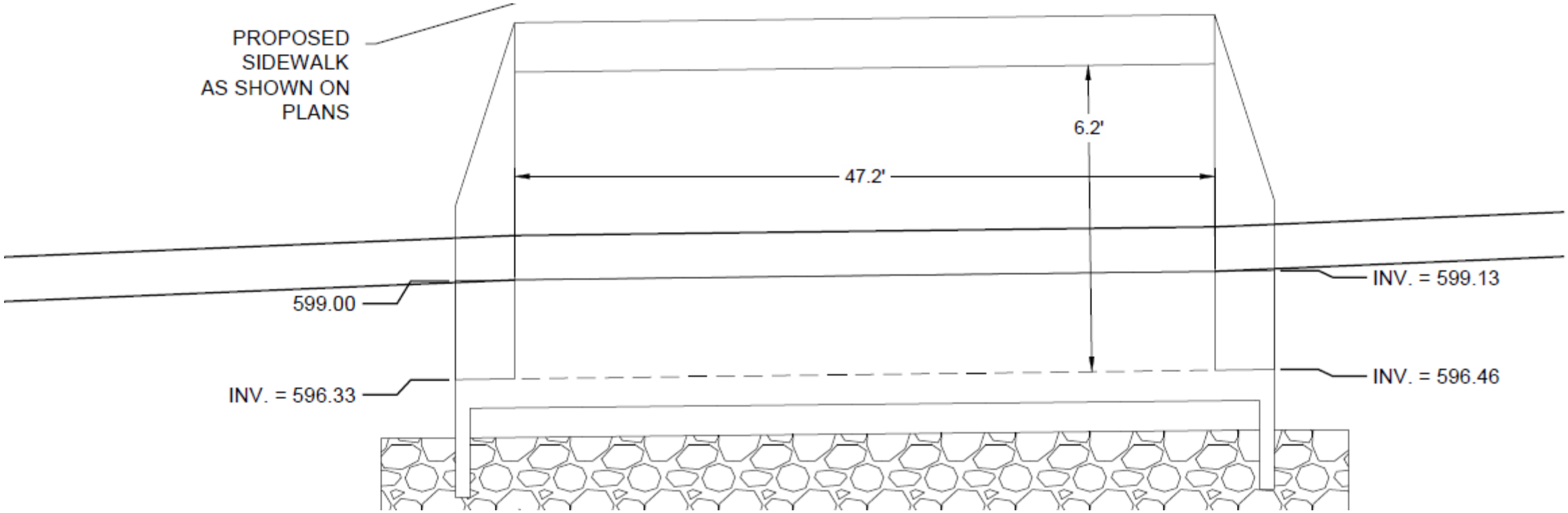
1979 – Siegel Ck, LNF

1998 – Siegel Ck, LNF



1. A line connecting the thalweg riffle points from above and below the crossing site is the most accurate estimate of stream slope

Proper labeling ensures proper construction



O – Offset multiple culverts

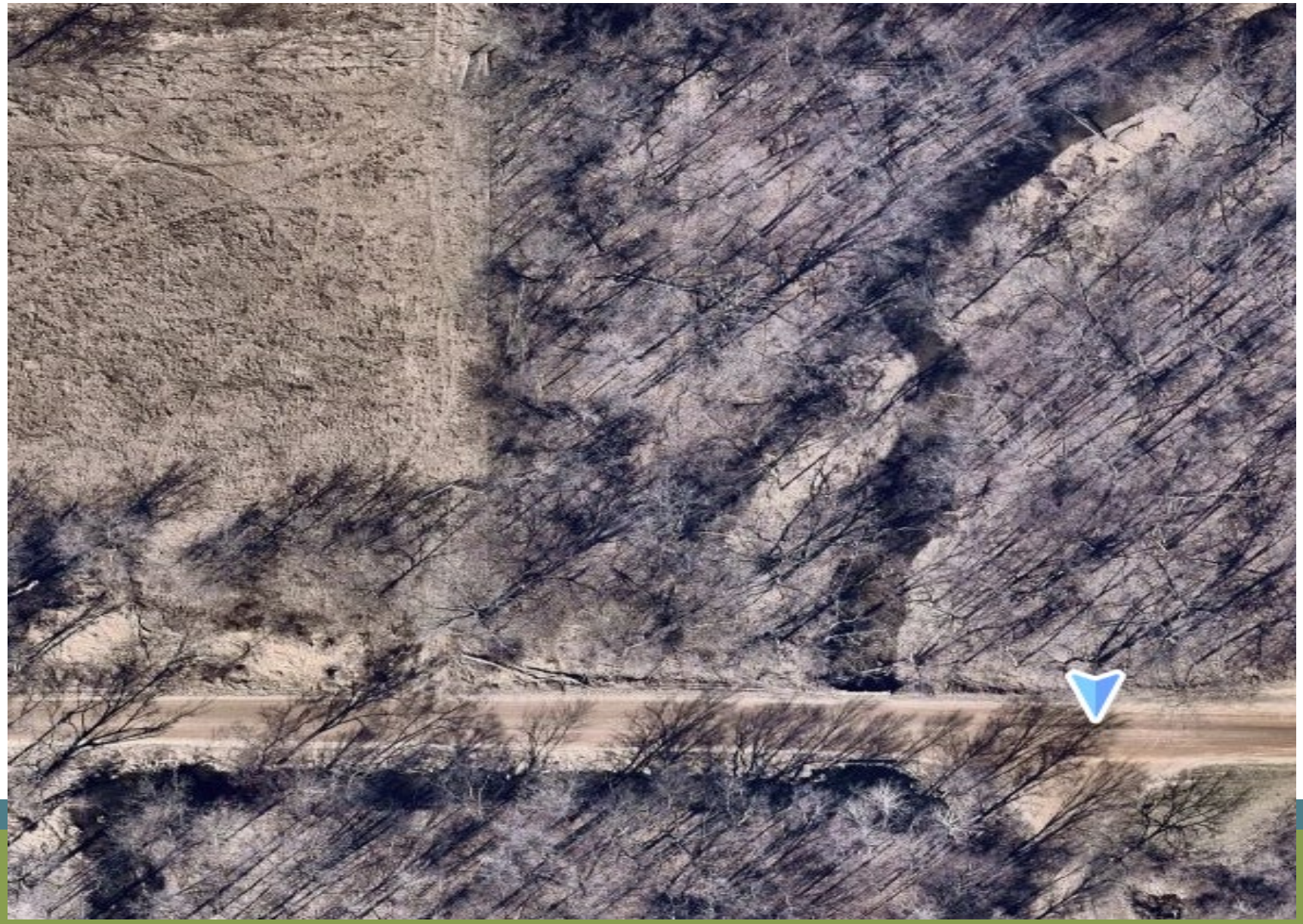
2nd culvert is set at bankfull elevation

- Cases where more capacity is needed.
- Overhead cover is limited.

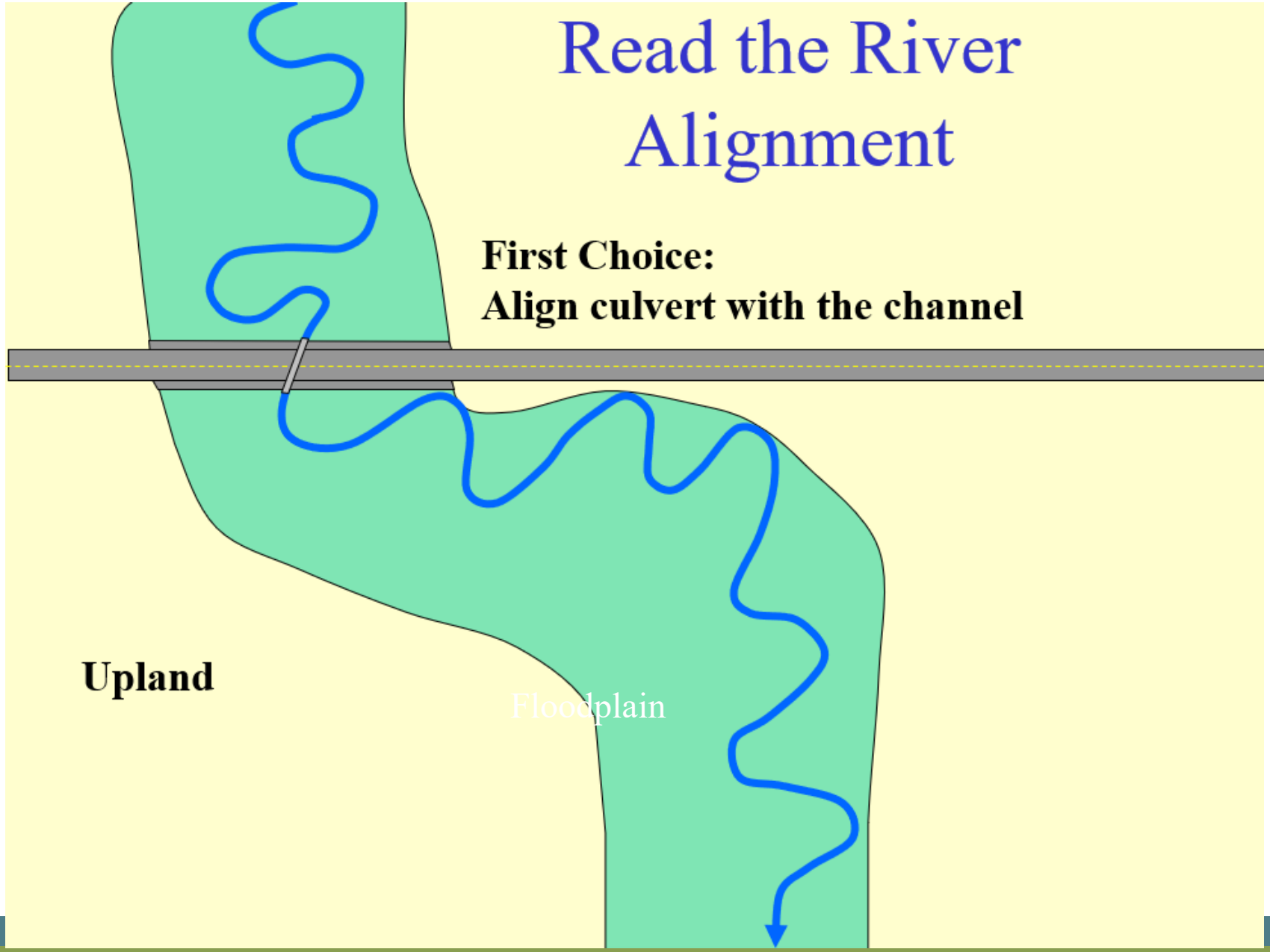
- Multiple culverts at same elevation
- Typically, one side fills with sediment

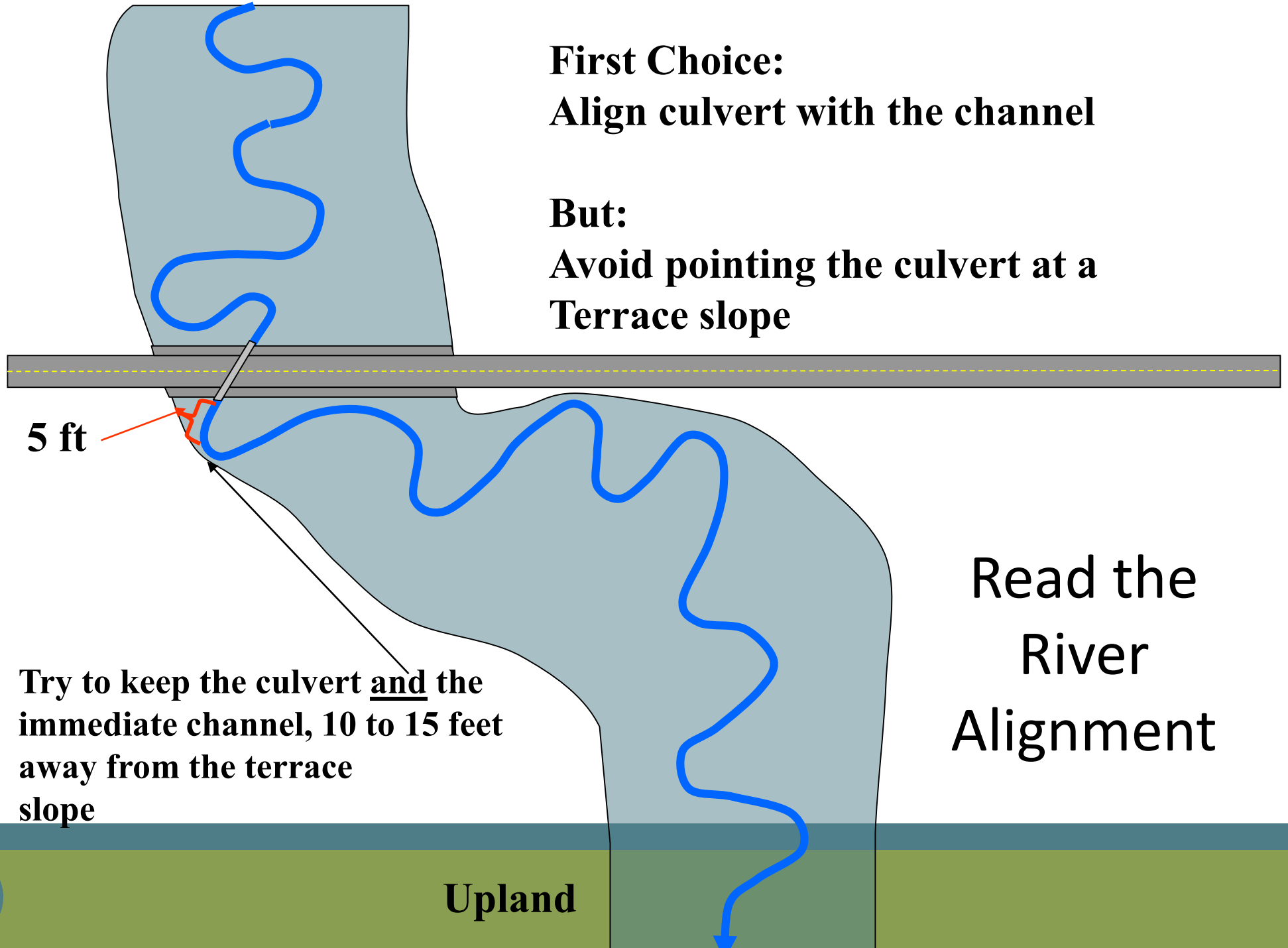
EGLE

A – Align with natural meanders



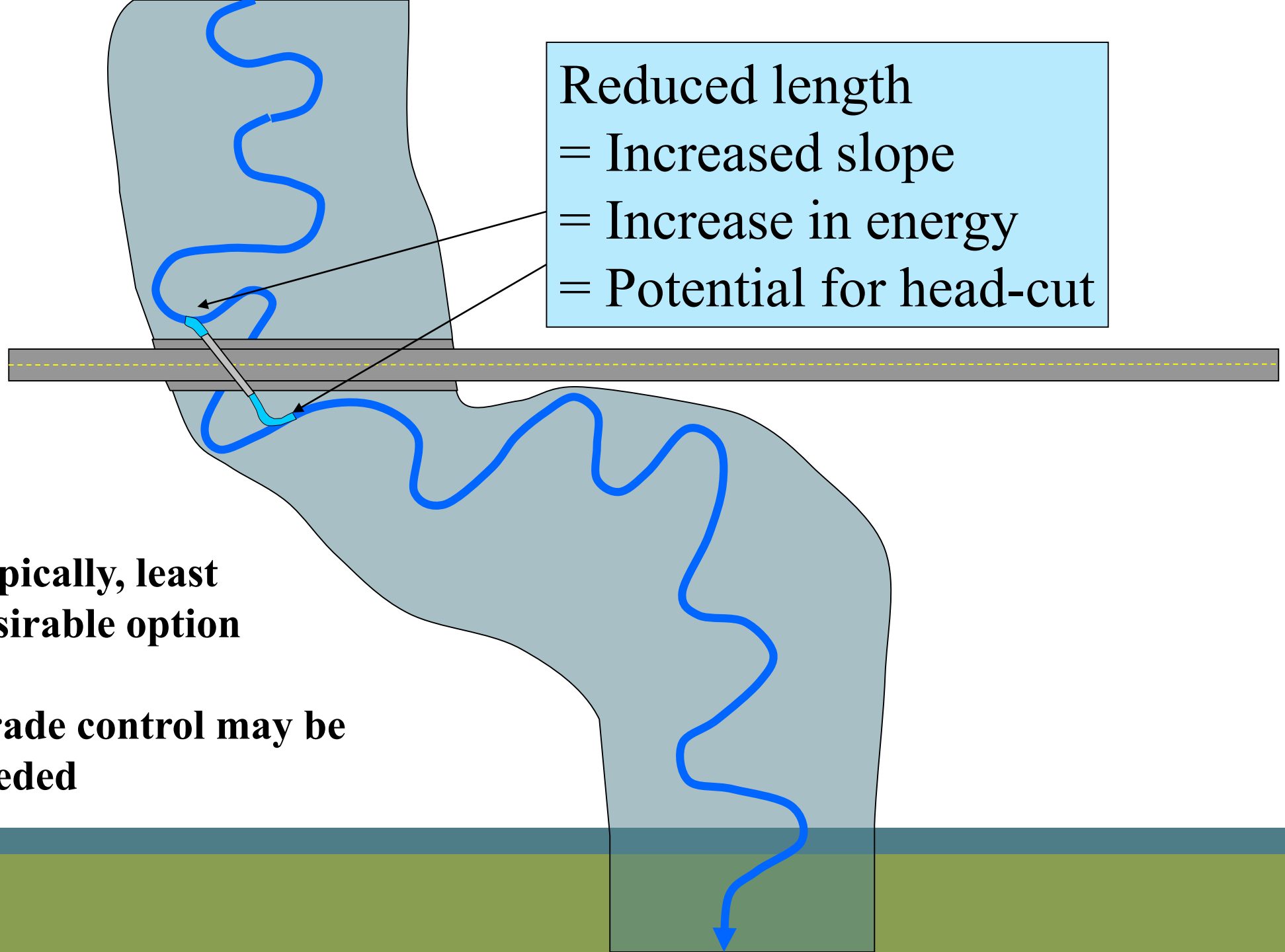
Read the River Alignment





Read the River Alignment

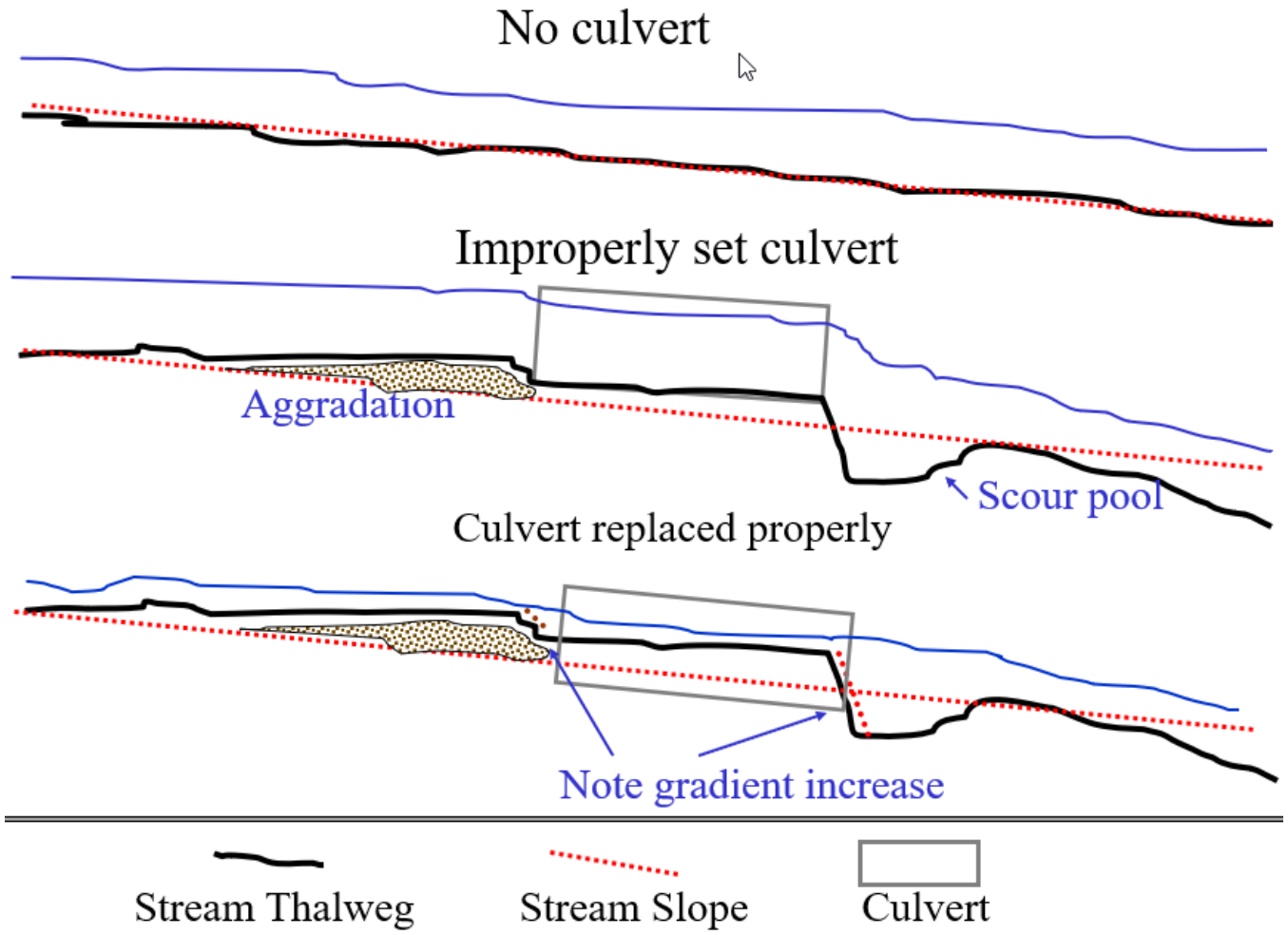
EGLE



Typically, least desirable option

Grade control may be needed

C – Consider headcuts



- Replacing a culvert on the proper slope may induce an upstream headcut.
- This may or may not be critical.

Avoid a headcut -
Use cross vanes as grade control to permanently set
a channel invert

Thank you!

Questions?

<u>Contact Info</u>

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