Stream Crossing Replacements for Continuity and Flood Resiliency

Pennsylvania Dirt Gravel and Low Volume Road Program

Nov 2026



Presenters:

Shaun McAdams

PSU Center for Dirt & Gravel Road Studies

www.dirtandgravelroads.org

Dirt Gravel and Low Volume Road Program



Road/Stream Crossings for Continuity and Flood Resiliency

- **DGLVR Program**
- DGLVR Stream Crossing History
- DGLVR Design and Installation Standard
- Sample Projects to Standard

Center for Dirt and Gravel Road Studies

DGLVR Program

$28 Million Annual Grant Program: started in 1997, funding increase and addition of paved low volume Roads in 2014

Focuses on Environmentally Sensitive Maintenance Practices

- Reduce sediment and erosion
- Reduce long term maintenance costs

DGLVR Program Structure

State: State Conservation Commission

- **Administers statewide program.**
- Allocates money to Conservation Districts.
- Develops statewide Program policy
- Quality Assurance Quality Control process.



$

County: Conservation Districts

Local: Townships(90%+)

DGLVR Program Structure

State: State Conservation Commission

- **Administers statewide program.**
- Allocates money to Conservation Districts.
- Develops statewide Program policy
- Quality Assurance Quality Control process.



$

County: Conservation Districts

- **Administer Program at county level.**
- Receive money based on roads & worksites.
- Work with applicants to develop work plans.
- Provide grants to successful applicants
- Conduct inspection after work is completed.
- Keep records and report to State annually.

65



$

Local: Townships(90%+)

State: State Conservation Commission

- **Administers statewide program.**
- Allocates money to Conservation Districts.
- Develops statewide Program policy
- Quality Assurance Quality Control process.



CDGRS provides education, outreach, technical assistance

$

County: Conservation Districts

- **Administer Program at county level.**
- Receive money based on roads & worksites.
- Work with applicants to develop work plans.
- Provide grants to successful applicants
- Conduct inspection after work is completed.
- Keep records and report to State annually.

66



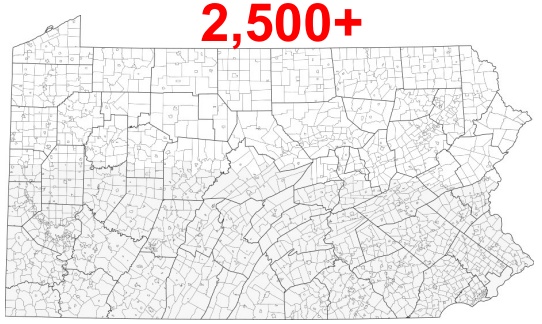
$

Local: Townships(90%+)

- Boroughs, cities, and state agencies also eligible
- Must be “ESM Certified” within last 5 years.
- **Apply to Conservation District for funding.**
- Enter into contract with Conservation District.
- **Complete project work or hire sub-contractors.**

Engineer contracts directly with grant recipient

2,500+

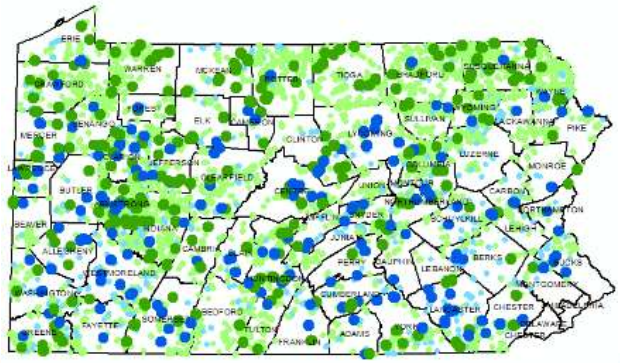


PennState
Center for Dirt and Gravel Road Studies

DGLVR Program

- ~400-500 projects completed annually
- Most project focus on drainage, base improvements, fill, and surface improvements
- **~40 stream crossing replacement annually**

Will be our focus today



1,000+Completed LVR Projects

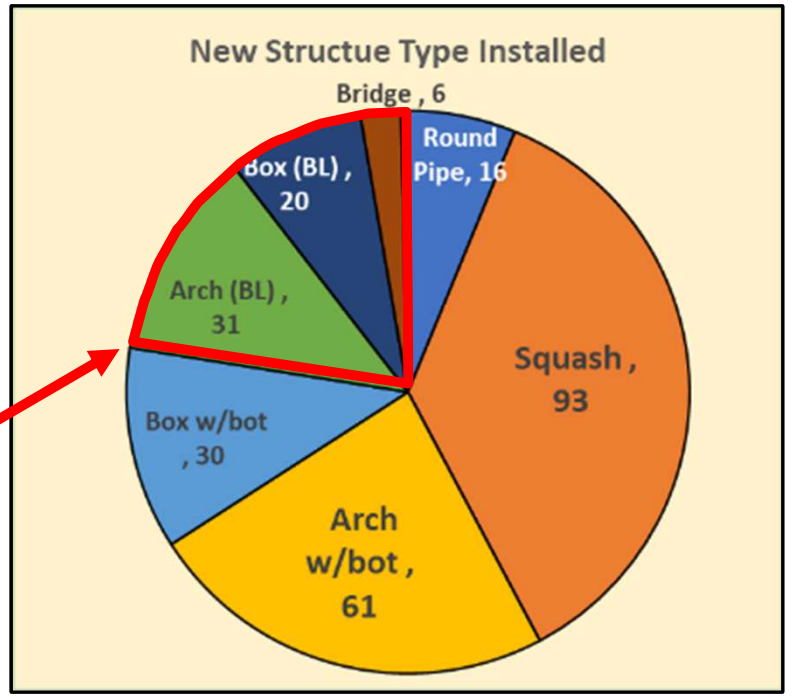
5,000+ Completed DnG Projects

By the Numbers

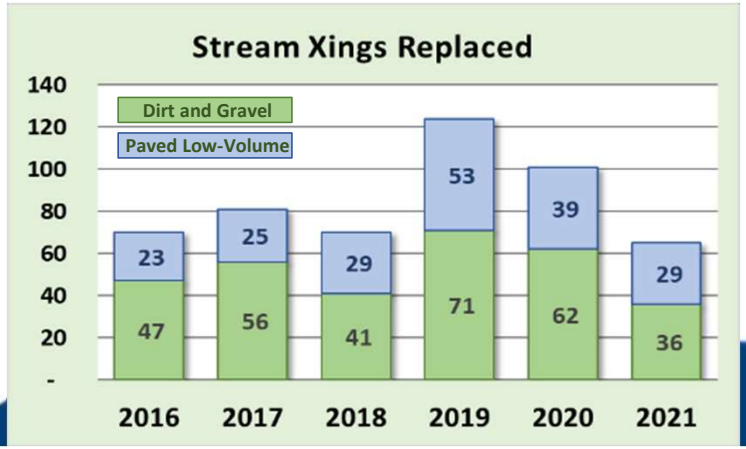
PennState
Center for Dirt and Gravel Road Studies

Stream Crossing Replacements

- 260 replacements **since July 2019**
- **Old Structures:** 74% were round pipes
- **New Structures:**
  - 60% are squash or pipe arch (w/bottom)
  - Only 22% are bottomless (arch/box/bridge)



Most (78%) have an invert – working to decrease that, more on that later

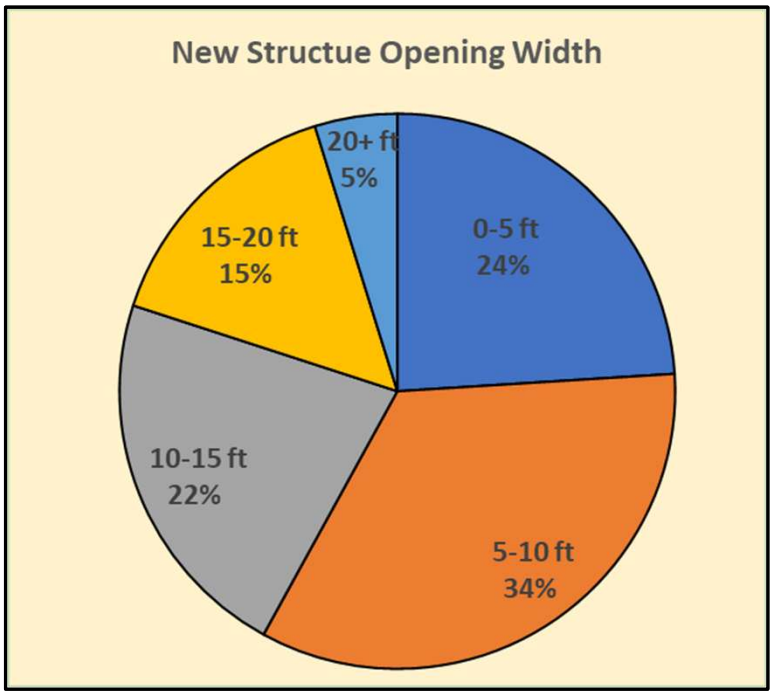


By the Numbers

Center for Dirt and Gravel Road Studies

Stream Crossing Replacements

- 260 replacements **since July 2019**
- **Size:**
  - 58% are under ≤10’ width
  - 5% are over > 20’ in width
  - Avg existing structure width = 4.2’
  - Avg bankfull width = 9.1’
  - Avg new structure width = 10.2’ (112%)



Dirt Gravel and Low Volume Road Program



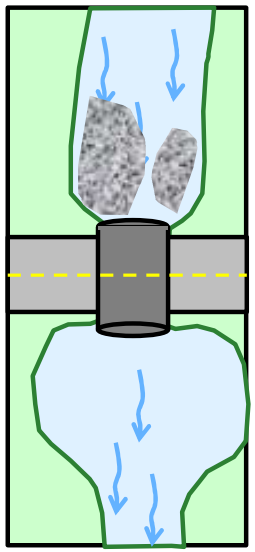
Road/Stream Crossings for Continuity and Flood Resiliency

- DGLVR Program
- **DGLVR Stream Crossing History**
- DGLVR Design and Installation Standard
- Sample Projects to Standard

Background/History

Program began funding replacements in 2014

- Program policy enacted 2015 to focus on environmental benefits
  - Focused on replacing undersized crossings







Undersized structures =

- Erosion
- Sediment deposition
- Constant Maintenance
- Aquatic Passage Issues
- Reduced Structure Lifespan
- Road washouts









PennState
Center for Dirt and Gravel Road Studies

DGLVR Eligibility Policy

Automatically Eligible for Replacement:

1. Multiple Pipes

2. Stream Crossings UNDER 4' diameter (13ft^2) opening.

Stream crossings OVER 4' dia. (13ft^2) opening

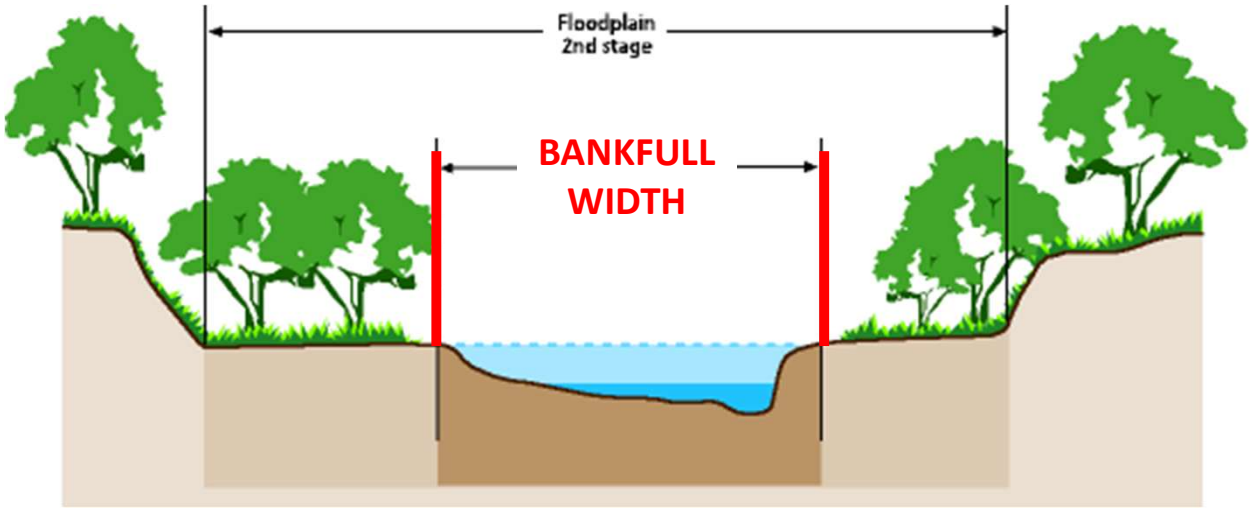
In order to be eligible for replacement, EXISTING structures must have:

1. ***A structure to bankfull width ratio of 75% or less.***
2. ***Signs of stream bank erosion.***
3. ***Streambed erosion/aggradation.***

Background/History

PennState
Center for Dirt and Gravel Road Studies

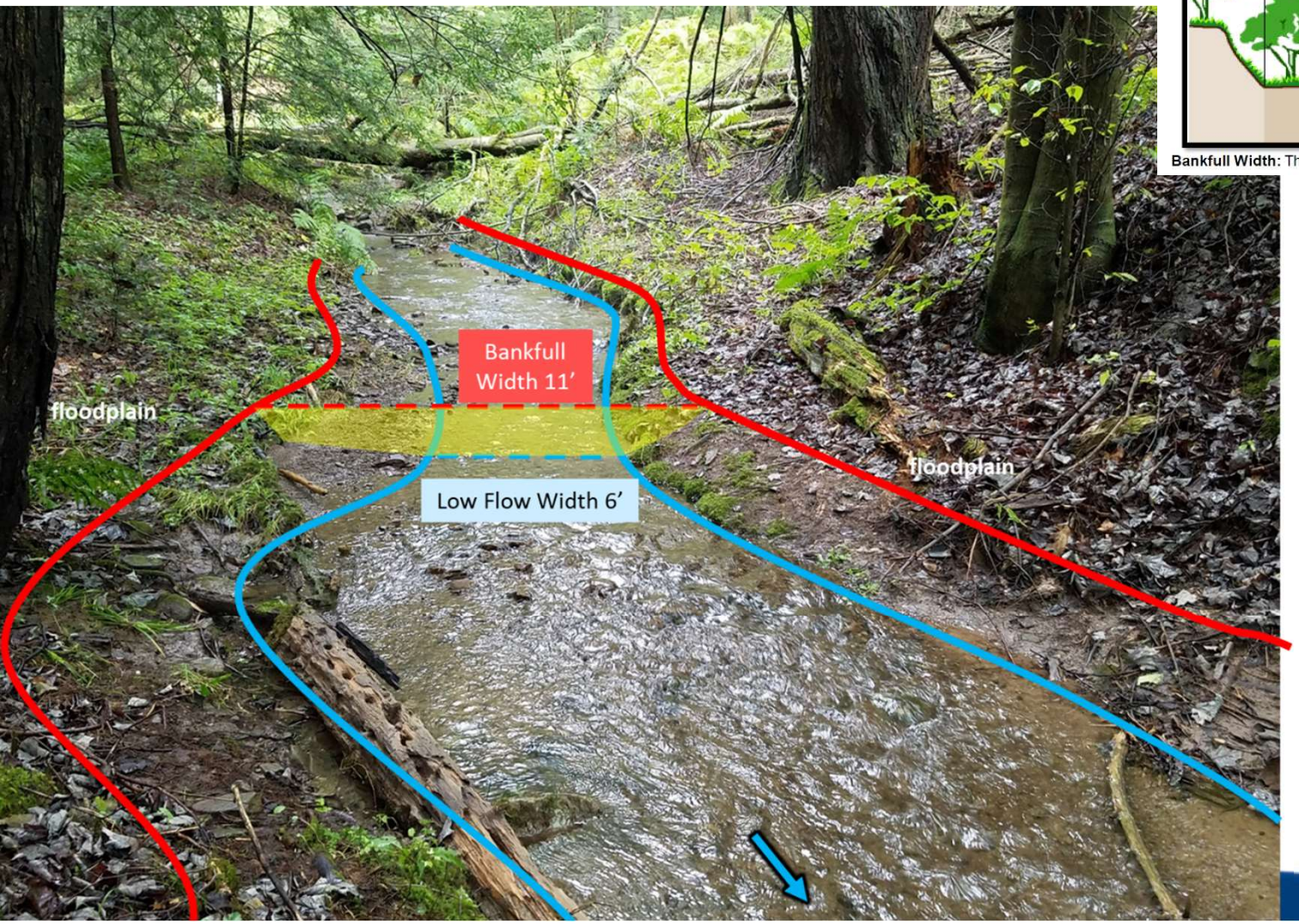
Program policy is based on "Bankfull" width

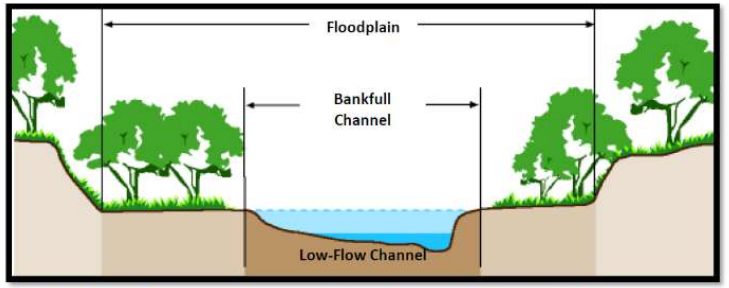


Bankfull elevation: ***Point where water fills the channel just before accessing floodplain***

Bankfull width: ***Width of channel at bankfull elevation.***

Background/History





Bankfull Width: The average width of the channel at the bankfull elevation. (image credit USFS)

Background/History

Program policy enacted in 2015 to focus on environmental benefits

- Focused on replacing undersized crossings
- New crossings had to span bankfull channel and "accommodate Aquatic Organism Passage"

Before



After



Before



After



DGLVR Program

- **First Stream Crossing Policy: 2015**
- **Existing Structures:**
  - **Focus funding on undersized crossings:**
    - Crossings that are undersized < 75% bankfull width



DGLVR Program

- **First Stream Crossing Policy: 2015**
- **Existing Structures:**
  - **Focus funding on undersized crossings:**
    - Crossings that are undersized < 75% bankfull width
- **New Structures:**
  - **Laid out bare minimum of requirements:**
    - 100% bankfull structures
    - "Provide for aquatic organism passage"

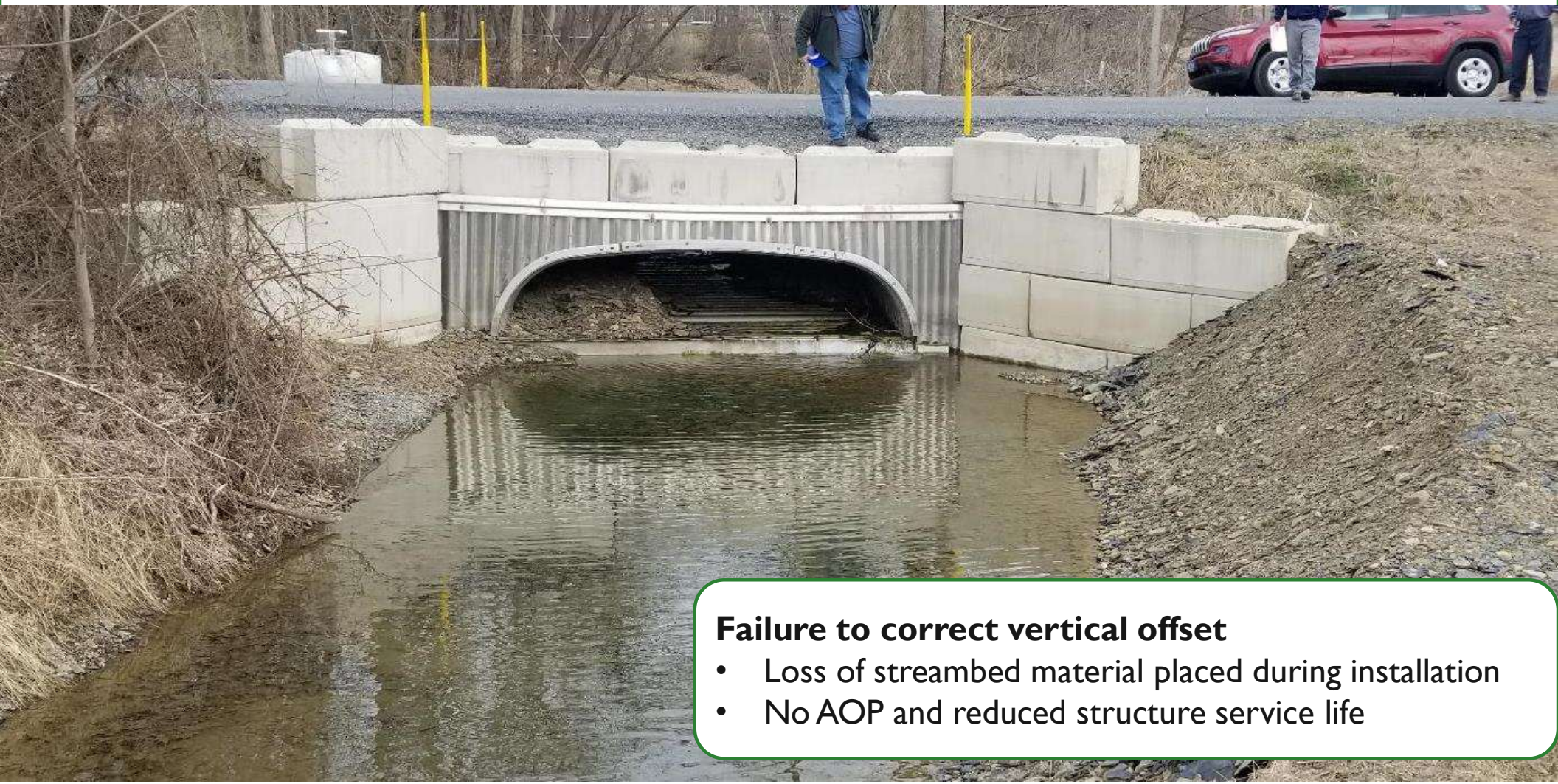
DGLVR Program

- **First Stream Crossing Policy: 2015**
- **Existing Structures:**
  - **Focus funding on undersized crossings:**
    - Crossings that are undersized < 75% bankfull width
- **New Structures:**
  - **Laid out bare minimum of requirements:**
    - 100% bankfull structures
    - "Provide for aquatic organism passage"



Without clear standards for design we were not meeting our goals!

Some all-too-common problems with structures that met 2015 policy



Failure to correct vertical offset

- Loss of streambed material placed during installation
- No AOP and reduced structure service life

Some all-too-common problems with structures that met 2015 policy



Insufficient streambed material placed in structure

- No AOP and reduced structure life
- Upstream erosion and embankment failure

Some all-too-common problems with structures that met 2015 policy



Maintained pre-existing elevations

- Increased scour or deposition
- Low hydraulic capacity

Some all-too-common problems with structures that met 2015 policy



Failure to adjust road elevation

- Capacity and flooding issues

Some all-too-common problems with structures that met 2015 policy



Over-widened without low-flow channel

- Causes deposition in structure
- Reduced capacity / scour along abutments



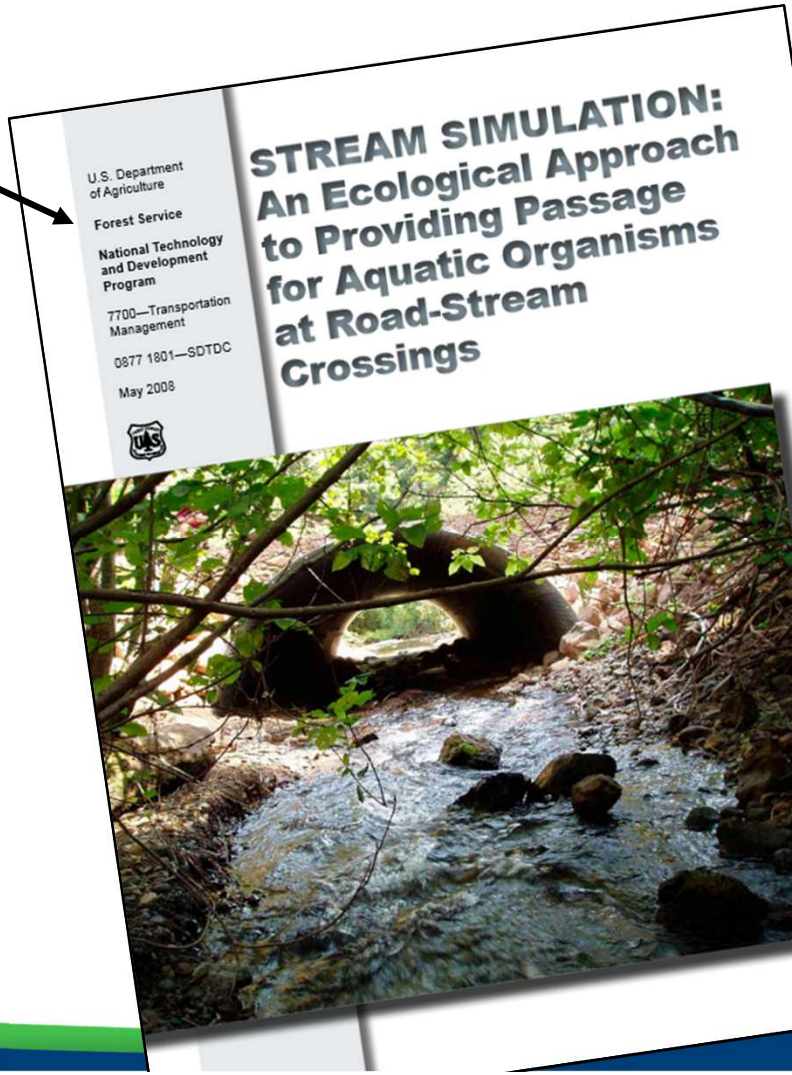
2015-2022: “attempted” AOP with no standard

Permitted: yes
Engineered: yes
Lacking:

- Streambed Depth
- Streambed Material
- Slope
- Grade Control
- Alignment
- **Continuity**

A Better Approach?

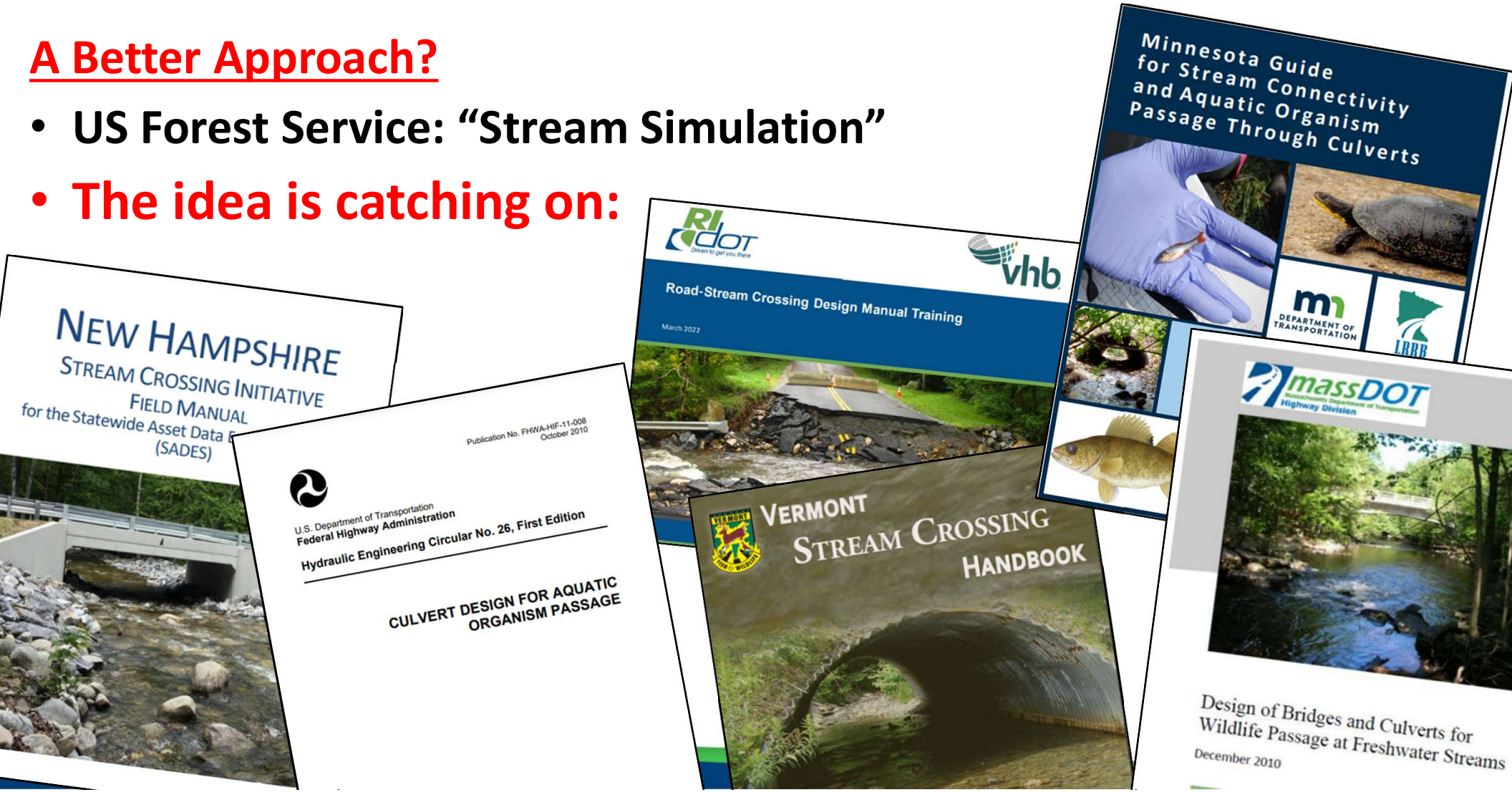
- **US Forest Service: "Stream Simulation"**
  - 20+ year of projects and experience
  - Provide week-long trainings
  - Stream Simulation = **"Let the stream behave like a stream, even through the road."**
  - More than just hydraulics, focus on stream function through the road.
  - Also produces more flood resilient roads!



Center for Dirt and Gravel Road Studies

A Better Approach?

- **US Forest Service: "Stream Simulation"**
- **The idea is catching on:**

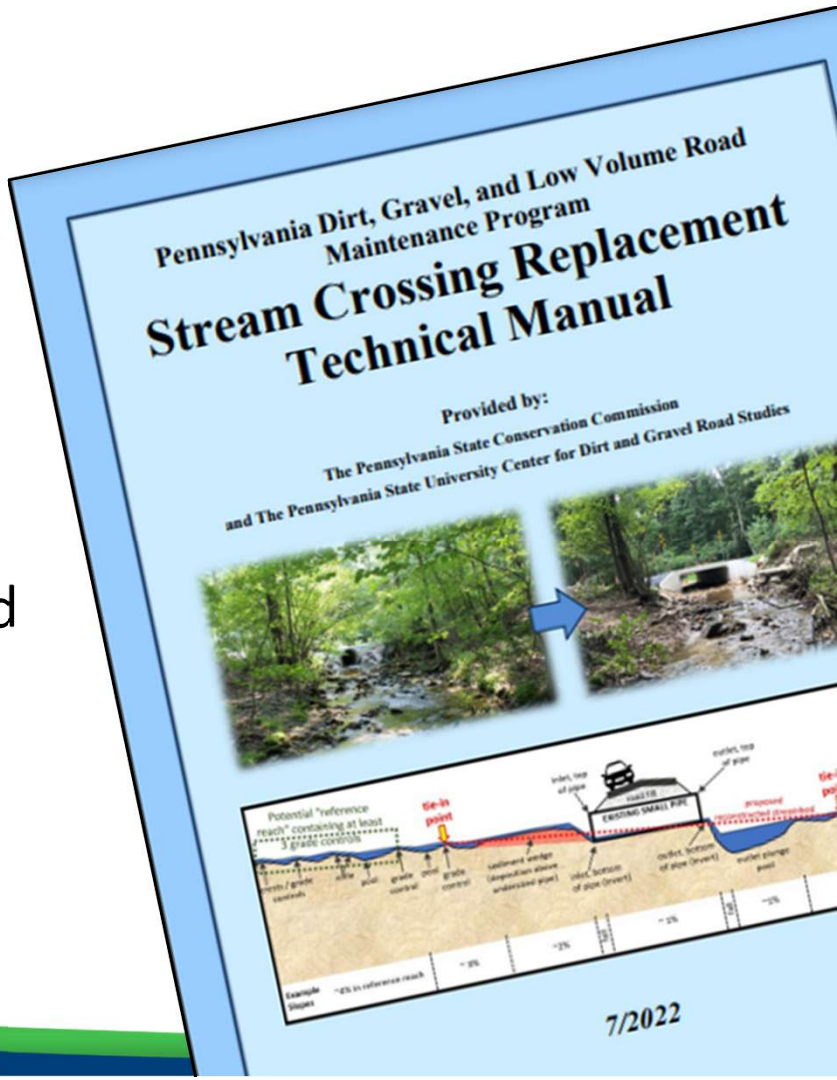


Back to Pennsylvania…

- The first question asked by most engineers: "Ok, where's your standard?"
- PA has no official guidance.
- Most culverts are designed on for hydraulic capacity, not stream function.
- Because DGLVR is replacing ~60 crossings a year, we worked in 2021-2022 to develop standard and guidance for use in the Program.

DGLVR Documents

- **Policy:**
  - Directed at CDs who run the Program
  - Minimal discussion in this training
- **Standard:**
  - 9-page design and installation standard
- **Technical Manual:**
  - Mostly written for CDs, provides background and explanations
  - Chap 2: Walkthrough of Standard
  - Chap 12: Engineering Considerations



Dirt Gravel and Low Volume Road Program



Road/Stream Crossings for Continuity and Flood Resiliency

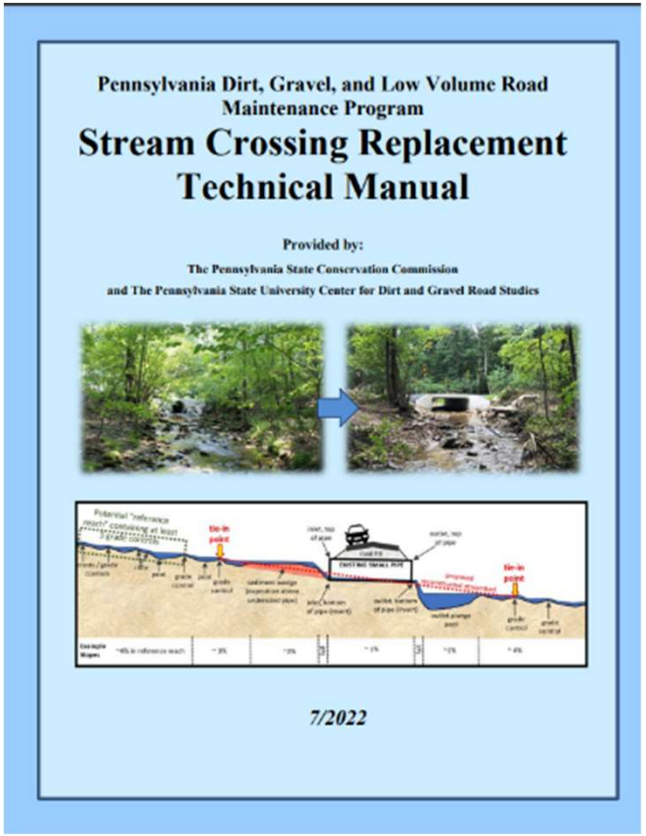
- DGLVR Program
- DGLVR Stream Crossing History
- **DGLVR Design and Installation Standard**
- Sample Projects to Standard

2022 DGLVR Stream Crossing Standard

- Policy
- Standard
- Technical Manual

Reviewed previously, available online

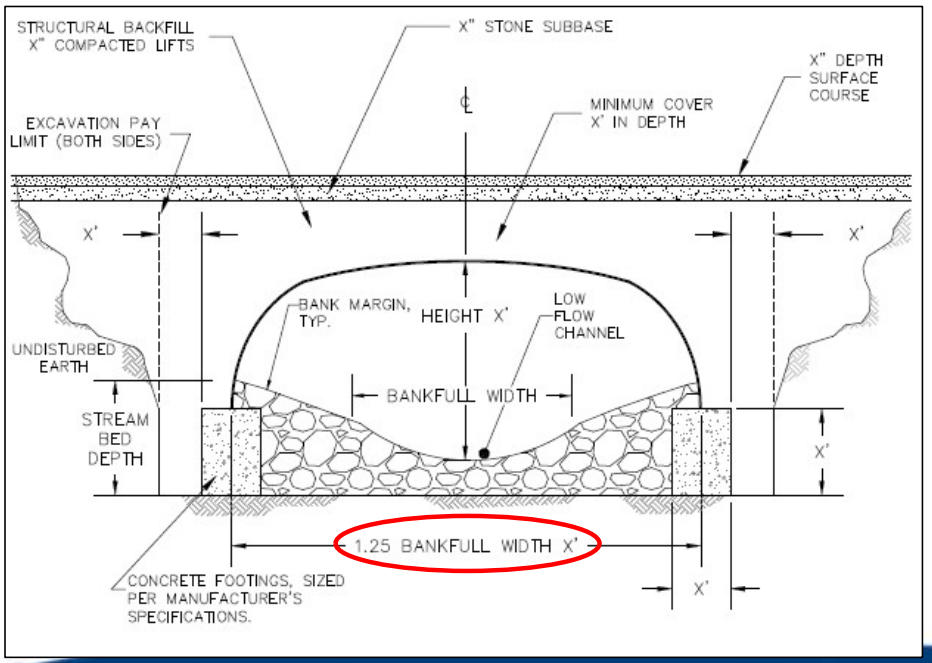
Based off USFS methodology to promote Stream Continuity



Standard

Center for Dirt and Gravel Road Studies

- *Increase <u>minimum</u> structure width from 100% to 125% bankfull channel*
- *Must pass Q100 at 80% of opening height & grade control stable at Q100*
- *Must meet minimum requirements for invert / footer bury depth*

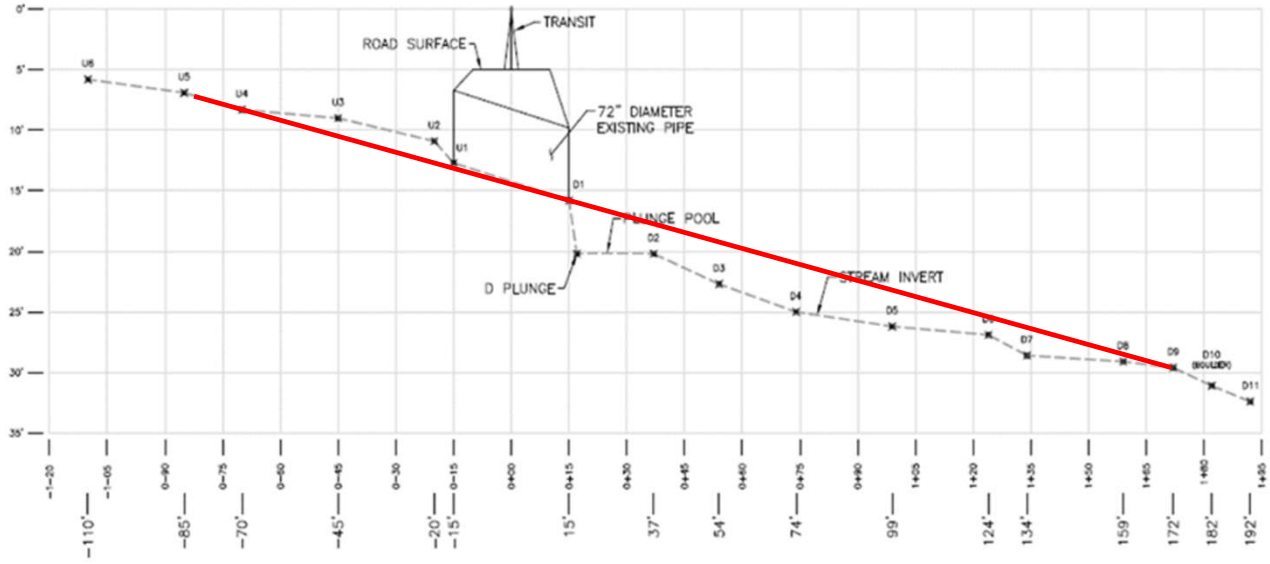




Standard

- *Increase minimum structure width from 100% to 125% bankfull channel*
- *Must pass Q100 at 80% of opening height & grade control stable at Q100*
- *Design based on site-specific morphology with goal of stream continuity*





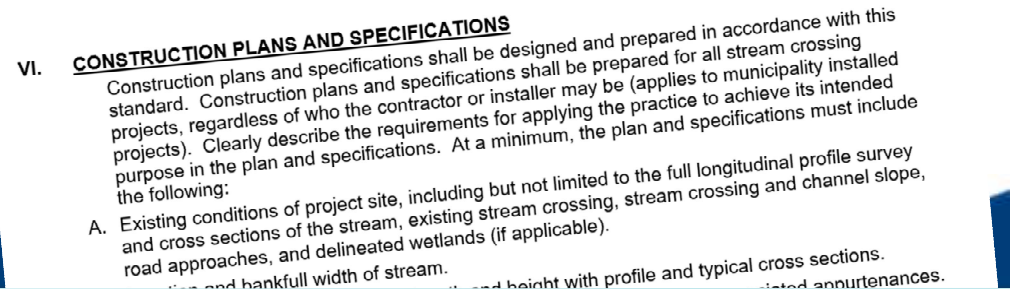
Standard

- *Increase minimum structure width from 100% to 125% bankfull channel*
- *Must pass Q100 at 80% of opening height & grade control stable at Q100*
- *Design based on site-specific morphology with goal of stream continuity*
- *Require added streambed depth in structures (min 2'), and low-flow channels*
- *Requiring bottomless structures over 4% slopes or 20' width*
- *Discourage low profile structures*



Standard

- *Increase minimum structure width from 100% to 125% bankfull channel*
- *Must pass Q100 at 80% of opening height & grade control stable at Q100*
- *Design based on site-specific morphology with goal of stream continuity*
- *Require added streambed depth in structures, and low-flow channels*
- *Requiring bottomless structures over certain slopes*
- *Discourage low profile structures*
- *"Stream-centric" construction design plan requirements from engineers*
- *Oversight and inspection from engineers (critical stages)*
- *Engineer certification / redlines*



VI. **CONSTRUCTION PLANS AND SPECIFICATIONS**

Construction plans and specifications shall be designed and prepared in accordance with this standard. Construction plans and specifications shall be prepared for all stream crossing projects, regardless of who the contractor or installer may be (applies to municipality installed projects). Clearly describe the requirements for applying the practice to achieve its intended purpose in the plan and specifications. At a minimum, the plan and specifications must include the following:

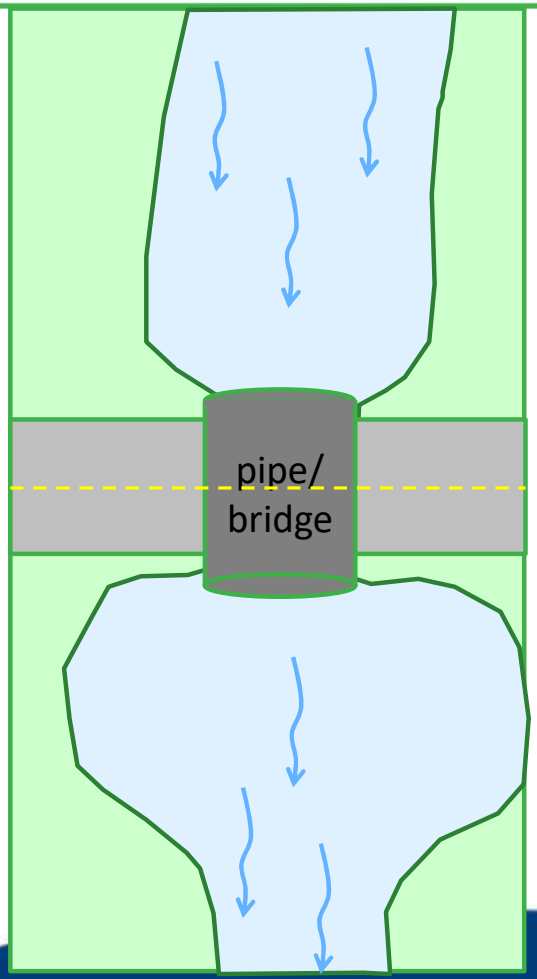
A. Existing conditions of project site, including but not limited to the full longitudinal profile survey and cross sections of the stream, existing stream crossing, stream crossing and channel slope, road approaches, and delineated wetlands (if applicable).

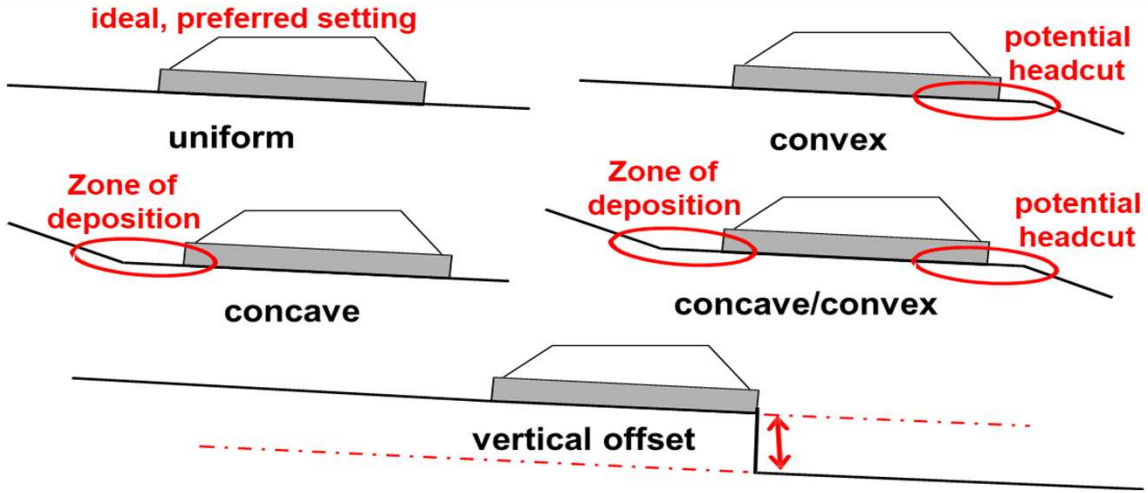
and bankfull width of stream.

and height with profile and typical cross sections.

ated appurtenances.

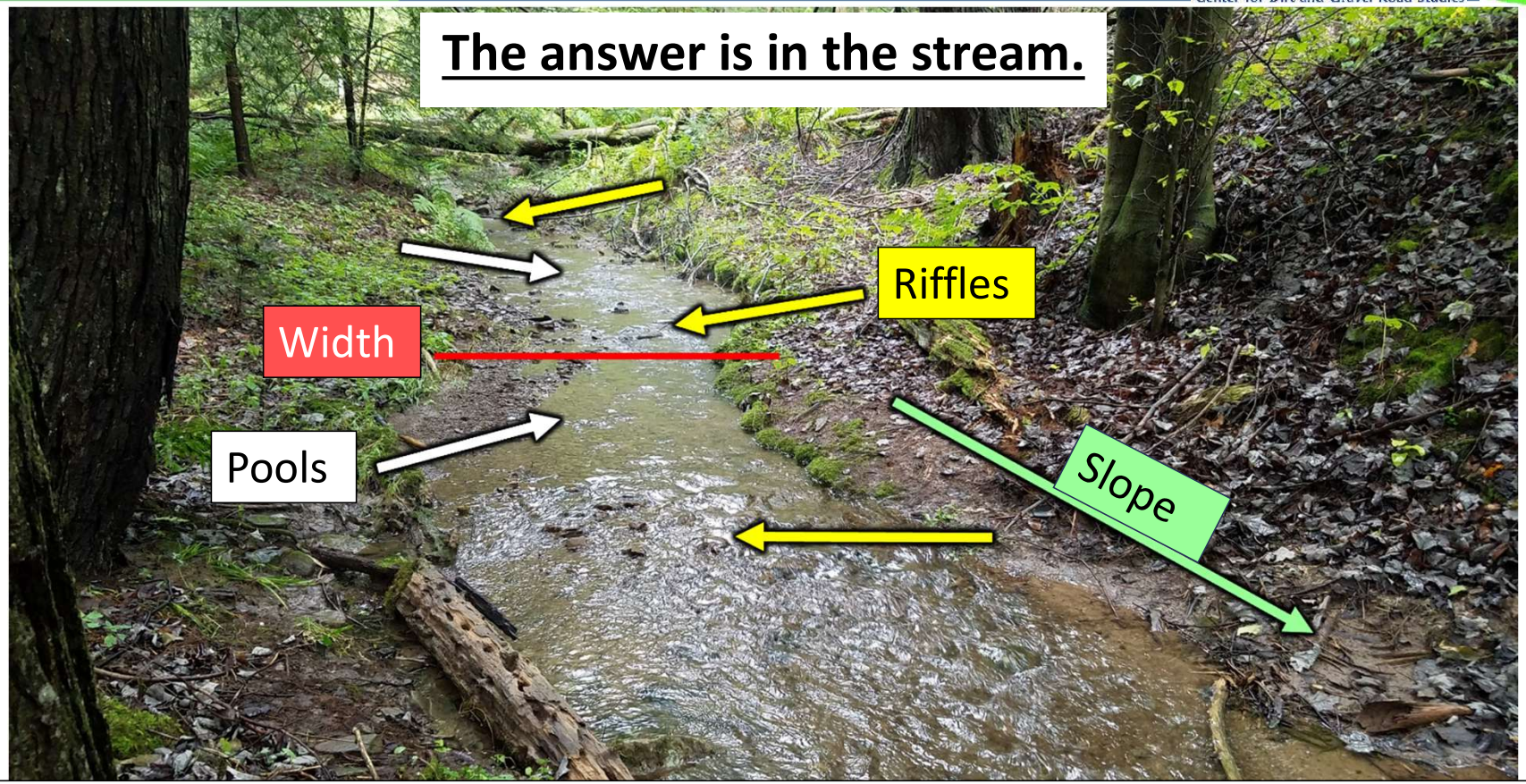
Field Survey – Site Assessment







Designing for Channel Continuity



The stream shows us the dimensions it needs to be more stable (balance).

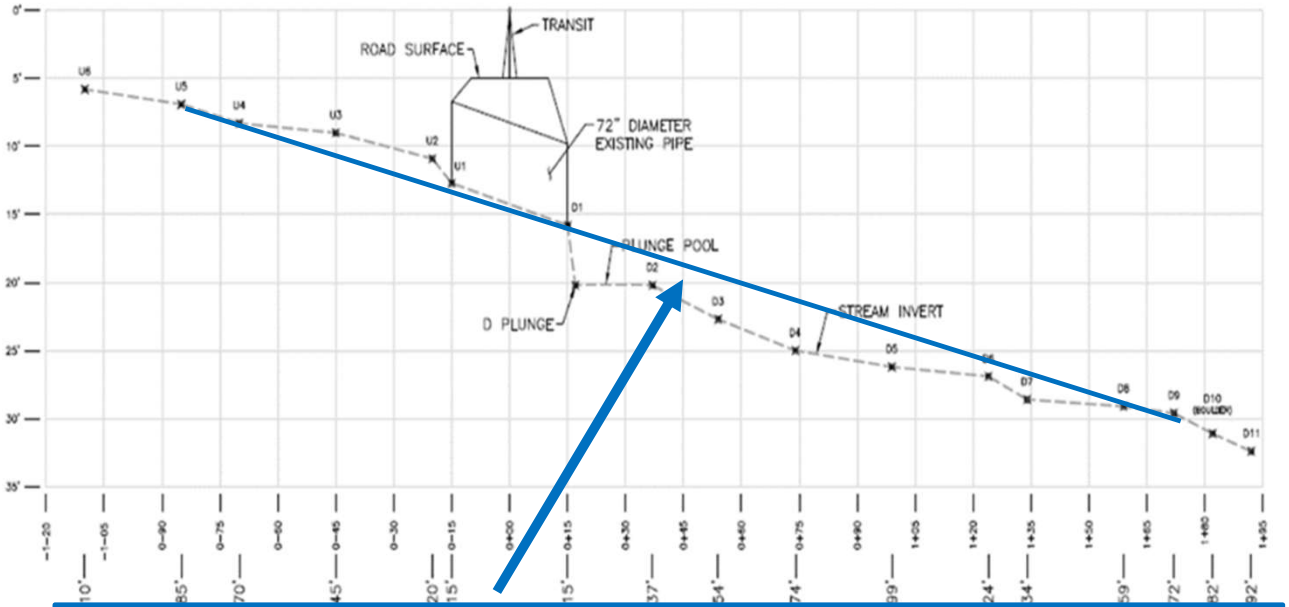
Designing for Channel Continuity



Measurements from the stream are the basis for design.

Designing Better Stream Crossings - Continuity

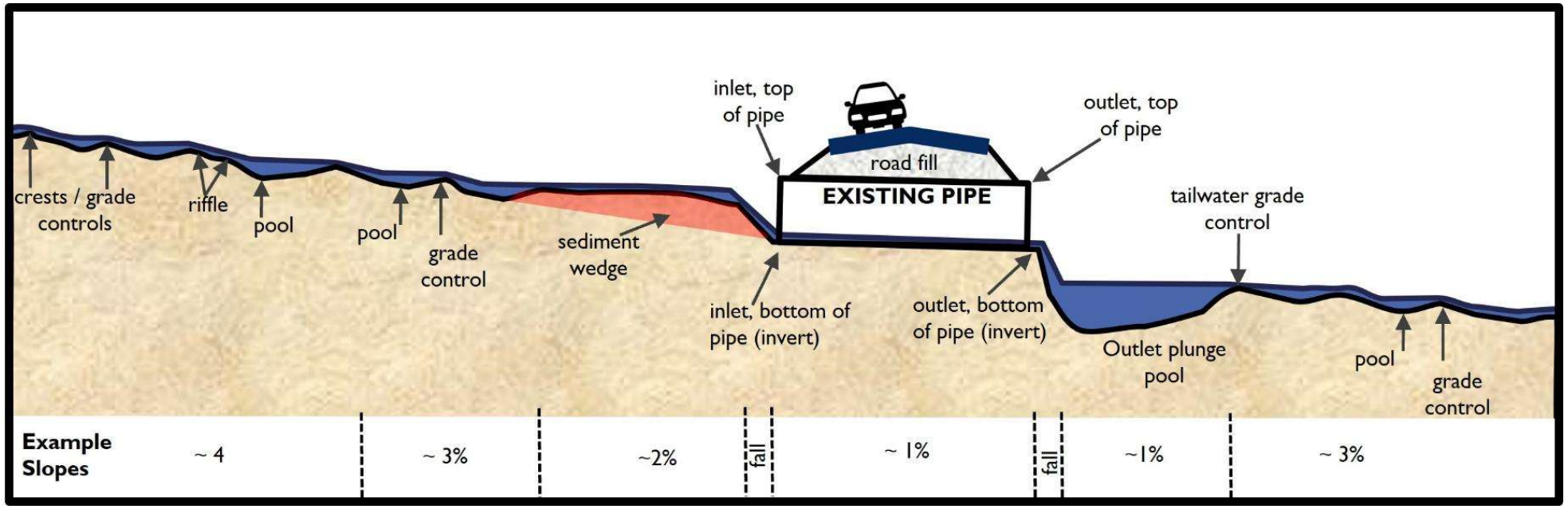
- **Continuity is the Key**
  - "Re-establish and maintain geomorphic continuity through the road/stream crossing"
    - Slope
    - Width
    - Cross-sectional dimensions
    - Grade controls (riffles, steps, clusters, cascades)
- **<u>Reconnection</u> – means going beyond the footprint of the crossing**



<u>Continuity slope</u> – the slope of the reconstructed stream reach needed to reestablish a relatively-consistent bed slope upstream, through, and downstream of the crossing

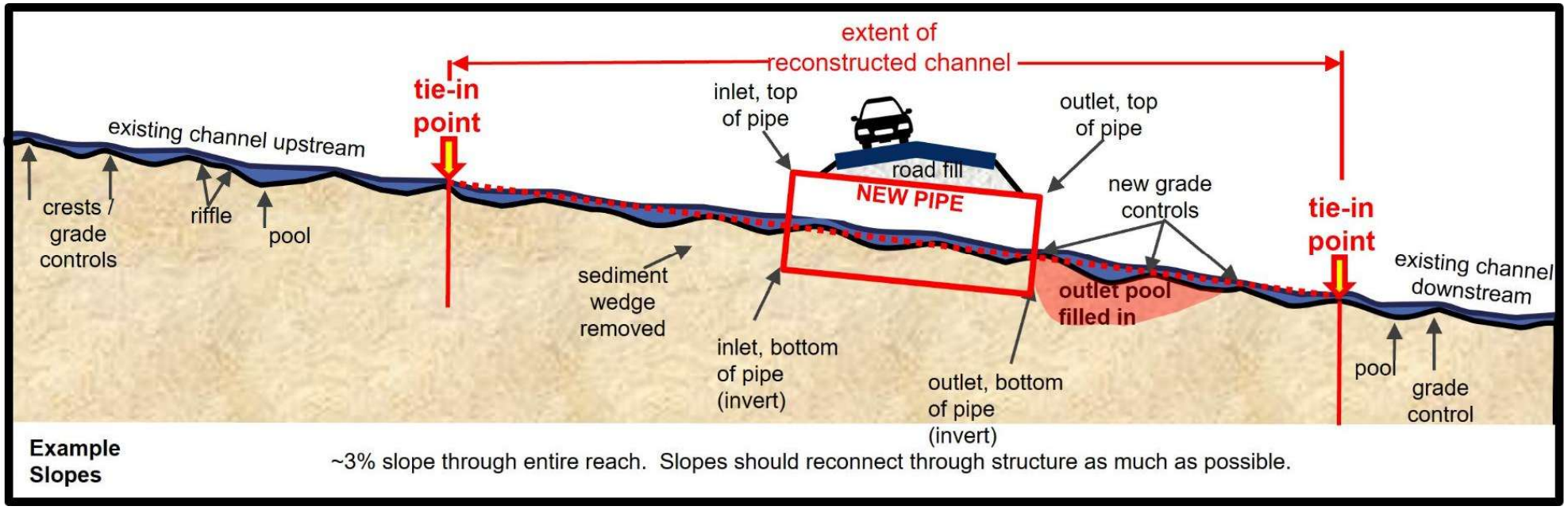
Designing for Channel Continuity

Typical Existing Undersized Structure



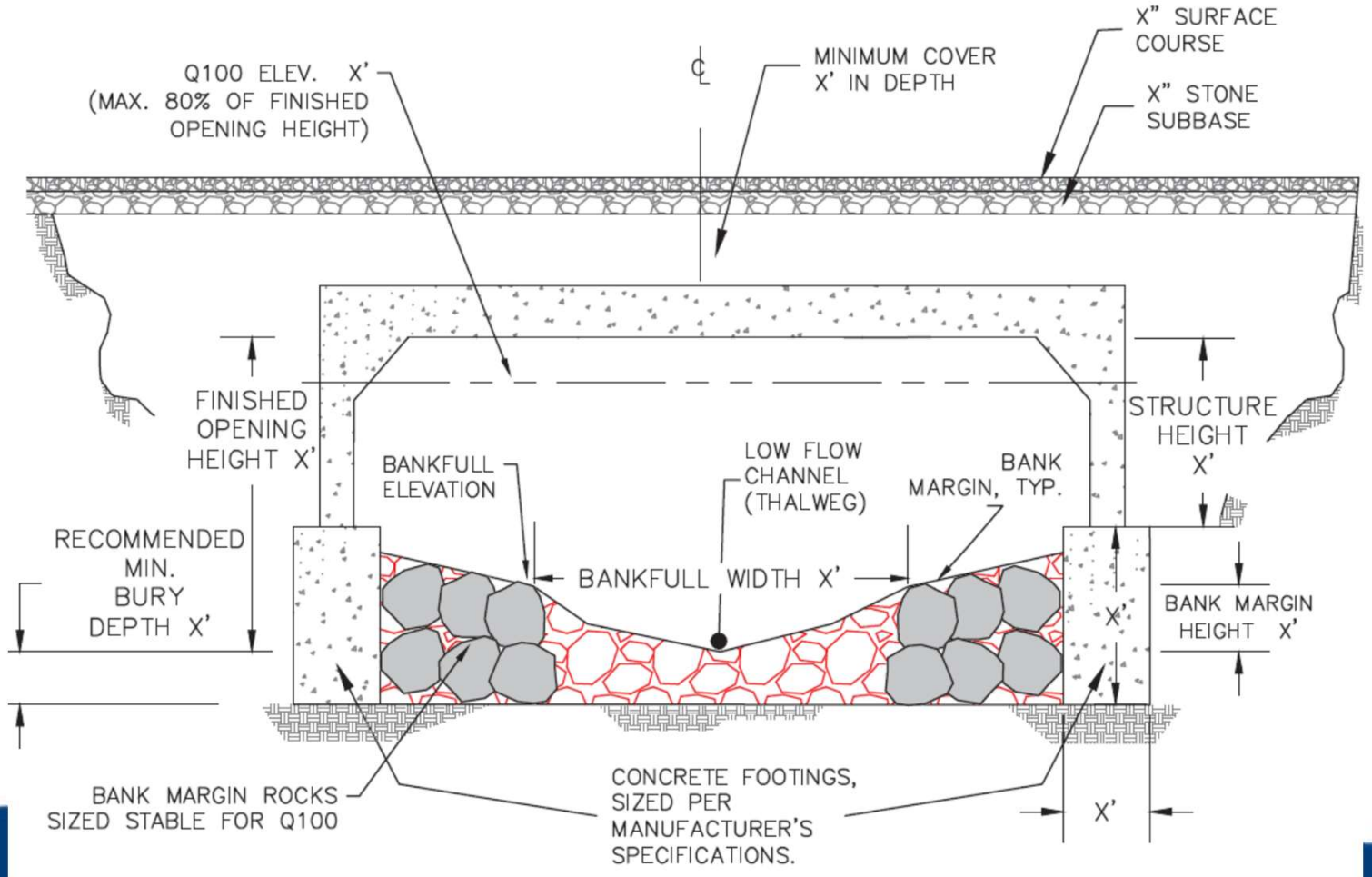
Designing for Channel Continuity

Typical New Structure Installation



Designing Better Stream Crossings

Center for Dirt and Gravel Road Studies



Designing for Channel Continuity

How do we get the balance back?

- Flood performance (resiliency)
- Service life
- Reduced maintenance
- Minimize risk and long-term expense
- Address environmental impacts (less sediment)



Designing for Channel Continuity

Let the stream be a stream!





CDGRS Stream Trainings

- **Conservation Districts**
  - **New Staff:** *4-day in-person*
  - **Refresher:** *1½ day virtual/in-person*
- **Engineers**: For engineers, *1½ day virtual/in-person*
- **DEP**: For permit review staff, *1½ day in-person*
- **Others**:
  - Western PA Conservancy
  - PA Game Commission
  - DCNR Bureau of Forestry







Other Collaborations

- **PSATS (township convention)**
  - Presentations to engineer's track
- **STAC presentation (Chesapeake Bay)**
  - Presentation at brook trout workshop
- **DEP Stream Continuity Video**
  - Interactive Videos – Introductory training
  - Short videos of stream continuity basics

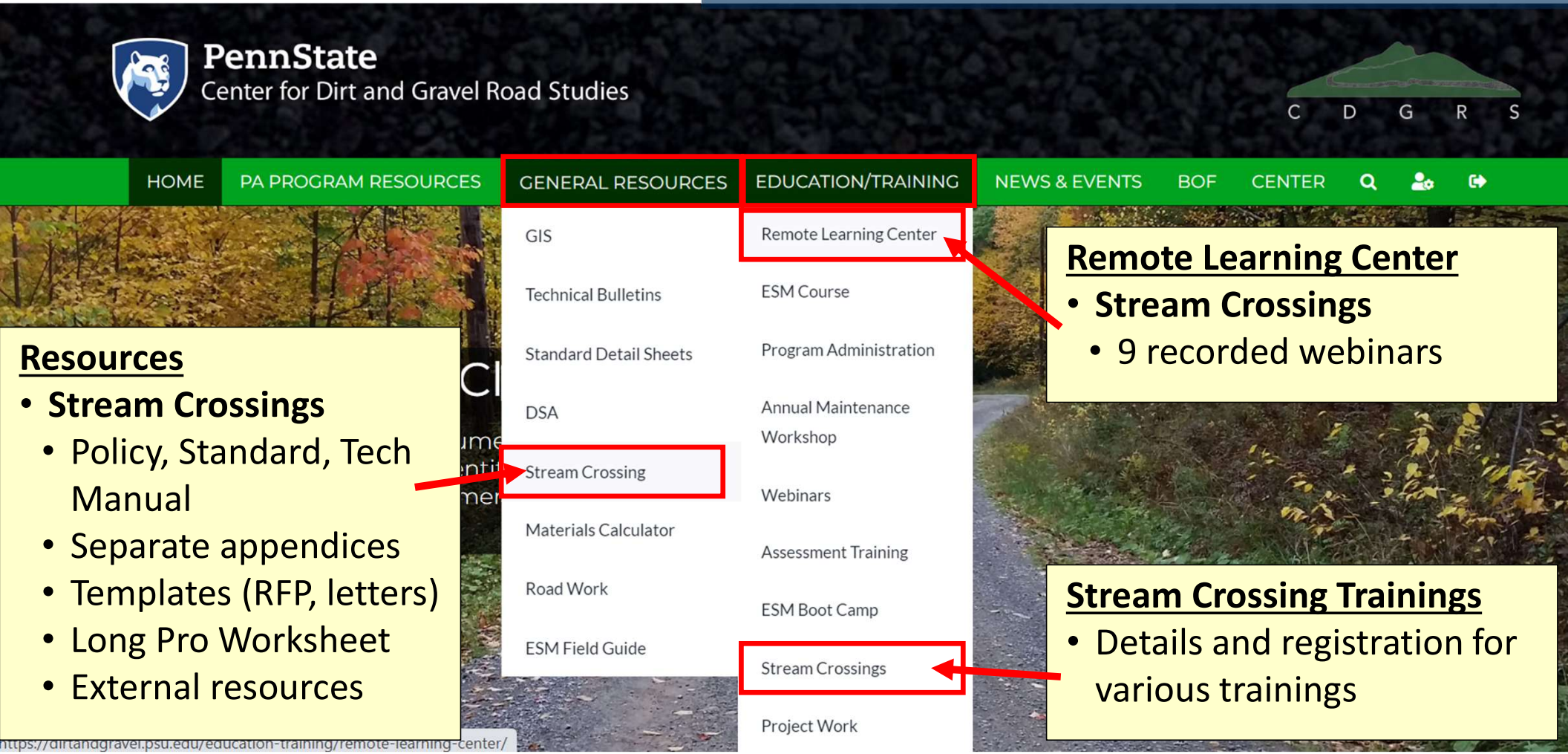
  PA Clean Water Academy
  https://pacleanwateracademy.remote-learner.net/course/view.php?id=1747



Additional Information and Resources

www.dirtandgravelroads.org

Steve Bloser: smb201@psu.edu
Eric Chase: ehc111@psu.edu
Justin Challenger: jchallenge@pa.gov



Resources

- **Stream Crossings**
  - Policy, Standard, Tech Manual
  - Separate appendices
  - Templates (RFP, letters)
  - Long Pro Worksheet
  - External resources

Remote Learning Center

- **Stream Crossings**
  - 9 recorded webinars

Stream Crossing Trainings

- Details and registration for various trainings

Dirt Gravel and Low Volume Road Program



Road/Stream Crossings for Continuity and Flood Resiliency

- DGLVR Program
- DGLVR Stream Crossing History
- DGLVR Design and Installation Standard
- **Sample Projects to Standard**

Projects to DGLVR Stream Crossing Standard

- Standard implemented July 2022, only applied to new contracts
- 2022-2024 saw a lot of pre-standard projects we tried to get “as close as possible”
- 2024 Finally saw the first projects completed under standard
- ~25 more in pipeline under standard, ~10 expected for 2025

Project Walkthrough: Elk County, Gardner Hill Road

2024: $130K Grant, $45K in-kind

- 4’ pipe in 12’ channel, outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings

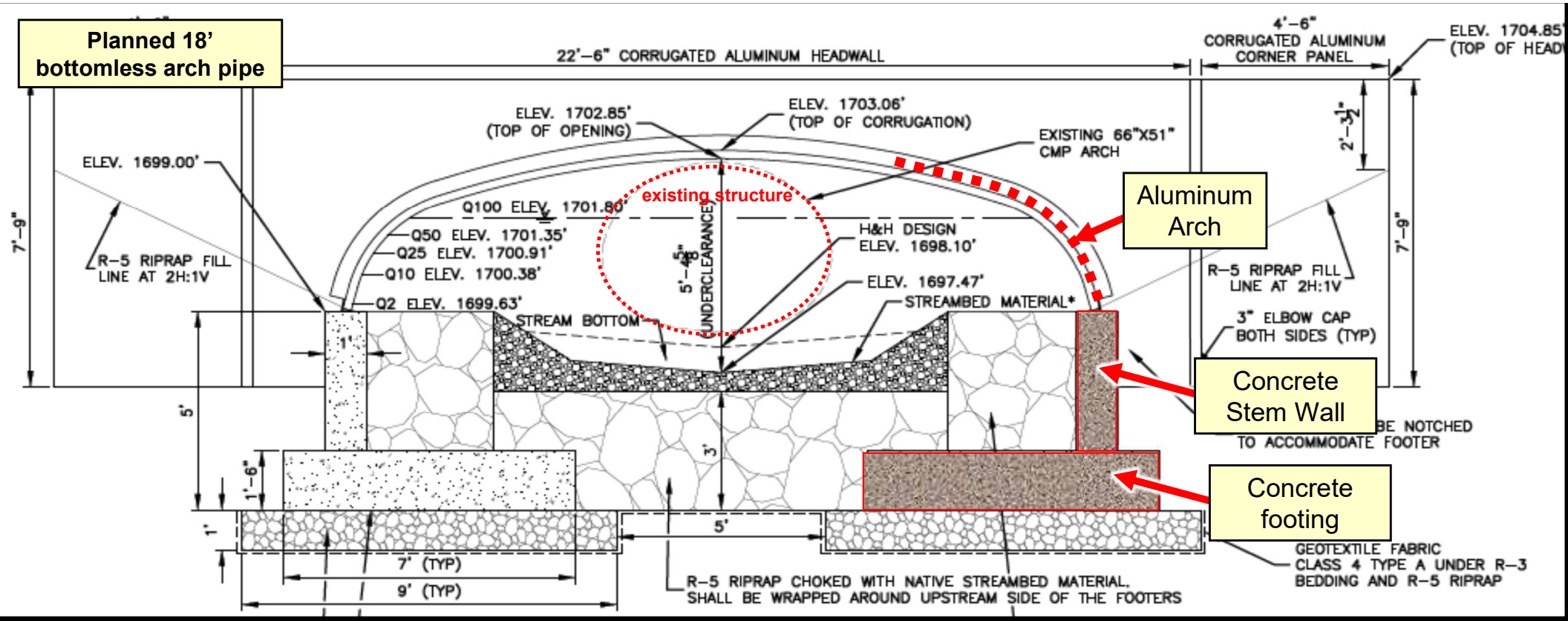






Elk, Gardner Hill 2/10

- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings


Planned 18' bottomless arch pipe
22'–6" CORRUGATED ALUMINUM HEADWALL
4'–6" CORRUGATED ALUMINUM CORNER PANEL
ELEV. 1704.85' (TOP OF HEAD
ELEV. 1702.85' (TOP OF OPENING)
ELEV. 1703.06' (TOP OF CORRUGATION)
EXISTING 66"X51" CMP ARCH
existing structure
Aluminum Arch
ELEV. 1699.00'
Q100 ELEV. 1701.80'
Q50 ELEV. 1701.35'
Q25 ELEV. 1700.91'
Q10 ELEV. 1700.38'
Q2 ELEV. 1699.63'
5'-4" UNDERCLEARANCE
H&H DESIGN ELEV. 1698.10'
ELEV. 1697.47'
STREAMBED MATERIAL*
STREAM BOTTOM
7'–9"
R–5 RIPRAP FILL LINE AT 2H:1V
2'–3½"
3" ELBOW CAP BOTH SIDES (TYP)
Concrete Stem Wall
BE NOTCHED TO ACCOMMODATE FOOTER
Concrete footing
5'
1'–6"
1'
3'
7' (TYP)
9' (TYP)
R–5 RIPRAP CHOKED WITH NATIVE STREAMBED MATERIAL, SHALL BE WRAPPED AROUND UPSTREAM SIDE OF THE FOOTERS
GEOTEXTILE FABRIC CLASS 4 TYPE A UNDER R–3 BEDDING AND R–5 RIPRAP



Elk, Gardner Hill 4/10

- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings

DURING



Elk, Gardner Hill 5/10

- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings


DURING
Stem walls allow streambed construction before installing top
stem wall
stem wall
Setting Grade Control Rocks
Bobcat
E45

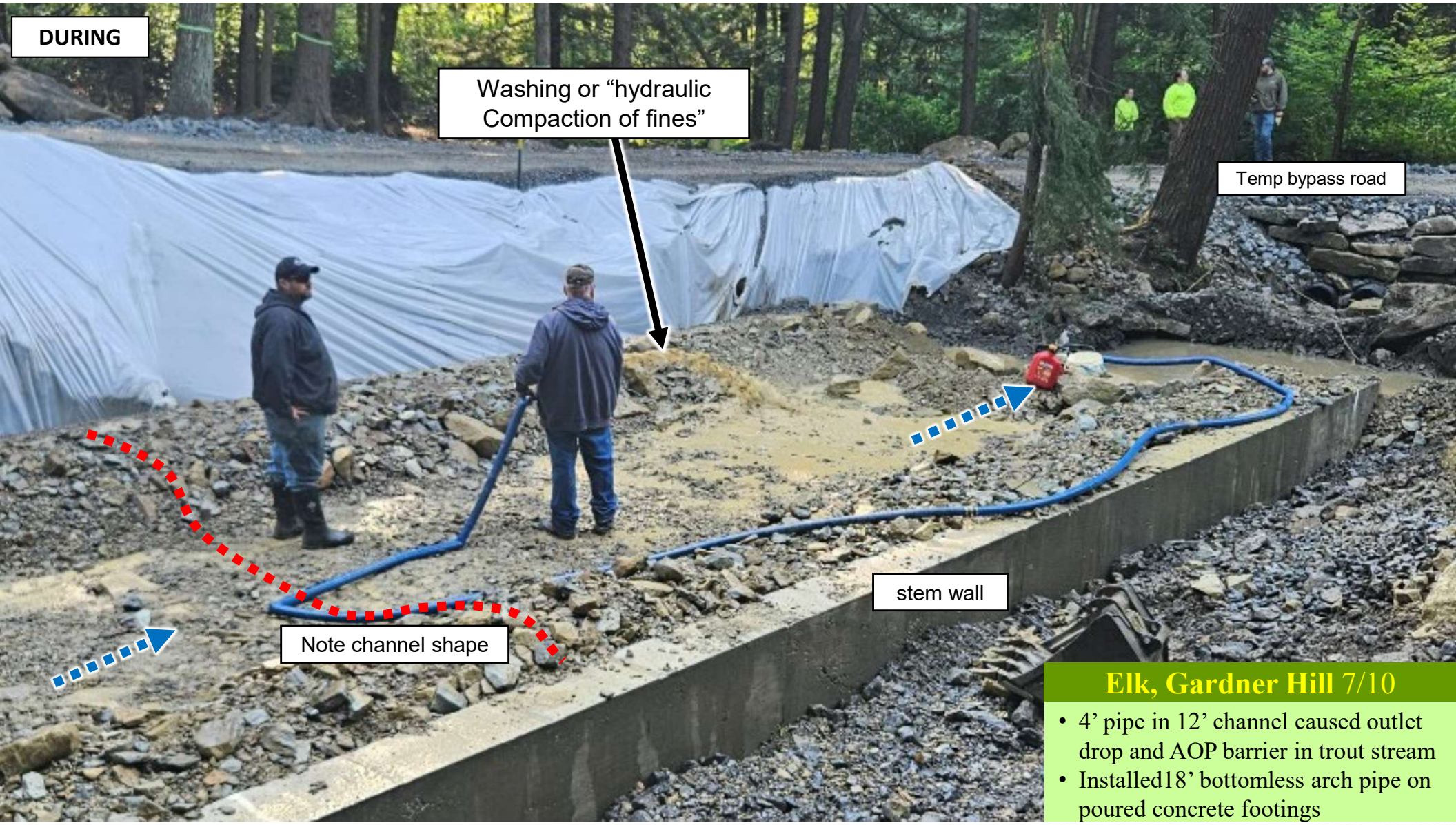
DURING



Easier than building the streambed with top on!

stem wall

Setting Grade Control Rocks



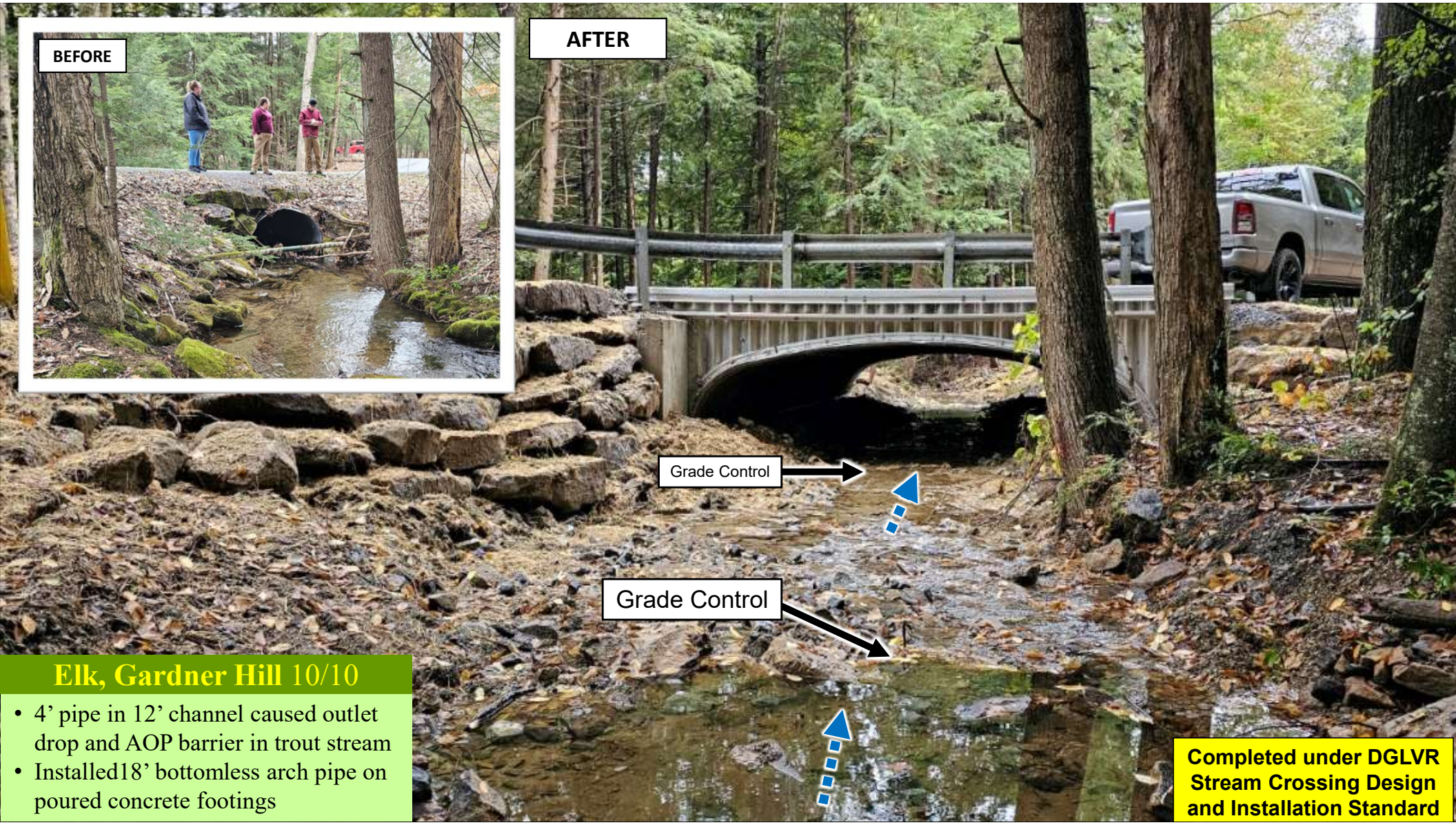
Elk, Gardner Hill 7/10

- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings



Elk, Gardner Hill 8/10

- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings



Elk, Gardner Hill 10/10

- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings

Completed under DGLVR Stream Crossing Design and Installation Standard

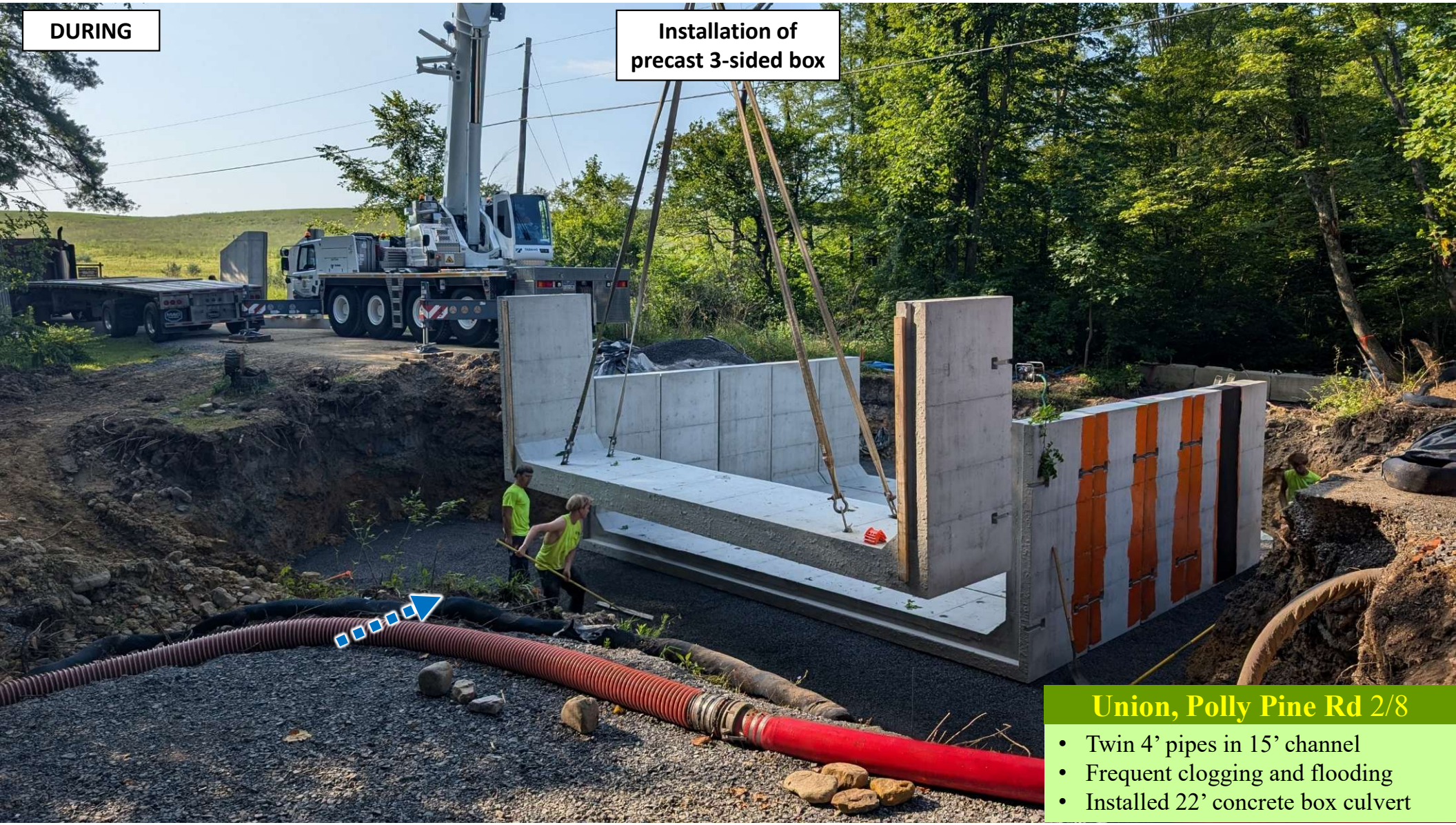
Project Walkthrough: Union County, Polly Pine Road

2024: $160K Grant, $86K in-kind

- Twin 4’ pipes in 15’ channel
- Frequent clogging and flooding
- Installed 22’ concrete box culvert with 5 grade controls







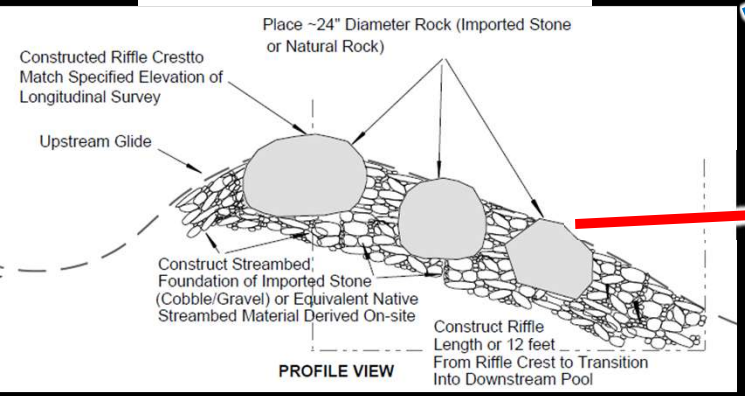
Union, Polly Pine Rd 2/8

- Twin 4’ pipes in 15’ channel
- Frequent clogging and flooding
- Installed 22’ concrete box culvert

DURING

Placement of grade controls

Typical Grade Control





Union, Polly Pine Rd 4/8

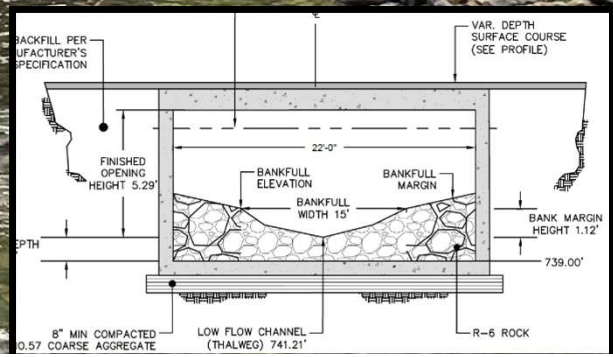
- Twin 4’ pipes in 15’ channel
- Frequent clogging and flooding
- Installed 22’ concrete box culvert

BEFORE



AFTER

Grade Controls



Union, Polly Pine Rd 5/8

- Twin 4’ pipes in 15’ channel
- Frequent clogging and flooding
- Installed 22’ concrete box culvert

Hurricane Debbie: ~7” of rain, 3 weeks post construction



Union, Polly Pine Rd 6/8

- Twin 4’ pipes in 15’ channel
- Frequent clogging and flooding
- Installed 22’ concrete box culvert


Hurricane Debbie: ~7” of rain, 3 weeks post construction



Union, Polly Pine Rd 8/8

- Twin 4’ pipes in 15’ channel
- Frequent clogging and flooding
- Installed 22’ concrete box culvert

Completed under DGLVR Stream Crossing Design and Installation Standard

Project Walkthrough: Monroe County, Whitey B Road

2024: $178K Grant, $20K in-kind

- Existing 3’ pipe frequently clogged
- Installed 12’ bottomless arch on express footers with stem walls



BEFORE



Completed under DGLVR Stream Crossing Design and Installation Standard





Monroe, Whitey B Rd 2/10

- Existing 3’ pipe frequently clogged
- Installed 12’ bottomless arch on express footers with stem walls



Monroe, Whitey B Rd 4/10

- Existing 3’ pipe frequently clogged
- Installed 12’ bottomless arch on express footers with stem walls



Monroe, Whitey B Rd 5/10

- Existing 3’ pipe frequently clogged
- Installed 12’ bottomless arch on express footers with stem walls

During

Checking finished channel and grade control elevations

y 16, 2



May 16

Hydraulic compaction (washing in fines)



Monroe, Whitey B Rd 6/10

- Existing 3’ pipe frequently clogged
- Installed 12’ bottomless arch on express footers with stem walls



Monroe, Whitey B Rd 7/10

- Existing 3’ pipe frequently clogged
- Installed 12’ bottomless arch on express footers with stem walls



Monroe, Whitey B Rd 9/10

- Existing 3’ pipe frequently clogged
- Installed 12’ bottomless arch on express footers with stem walls



Monroe, Whitey B Rd 10/10

- Existing 3’ pipe frequently clogged
- Installed 12’ bottomless arch on express footers with stem walls



Stream Crossing Replacements for Continuity and Flood Resiliency

Pennsylvania Dirt Gravel and Low Volume Road Program

QUESTIONS?

Presenters:

Steve Bloser

PSU Center for Dirt & Gravel Road Studies

Shaun McAdams

PSU Center for Dirt & Gravel Road Studies

www.dirtandgravelroads.org