2025 Spring Conference at Rocky Gap Resort
Flintstone, Maryland
Paw Paw Slope Stabilization Project

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Chesapeake & Ohio Canal National Historical Park
National Park Service

May 8, 2025

BIOGRAPHY

- B.S. Engineering – Geneva College
- M.S. Environmental Engineering and Science – Johns Hopkins University
- ≈ 8 years with U.S. Army Corps of Engineers
- ≈ 9 years with National Park Service
- Professional Engineer (MD)
- Certified Floodplain Manager (ASFPM)
- 2022 National Park Service Federal Engineer of the Year – National Society of Professional Engineers
- NPS National Safety Leadership Council
- Federal Highways – National Park Service Bridge Task Force

ABSTRACT

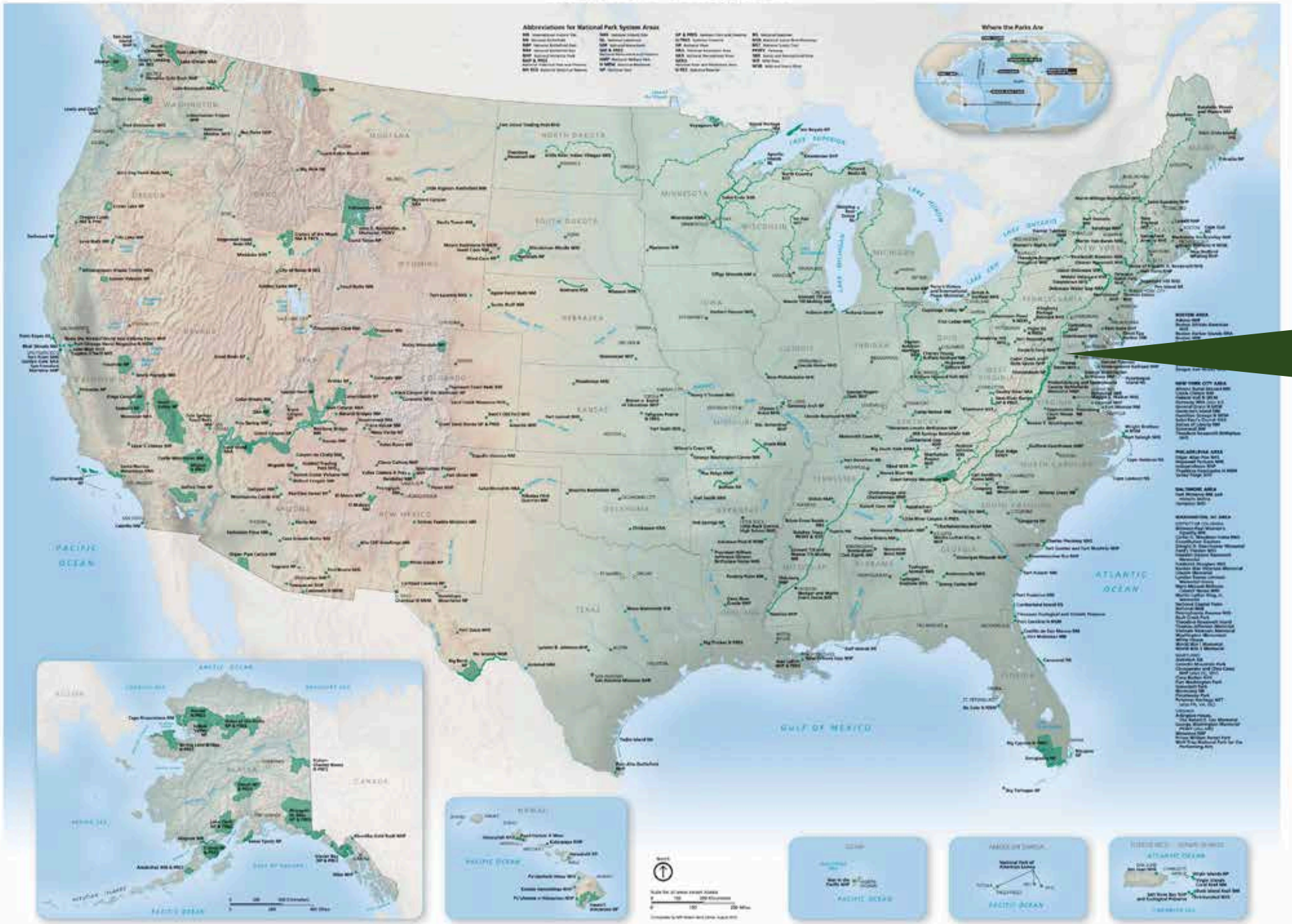
Paw Paw Slope Stabilization Project

- Originally constructed 1828 – 1850, the Chesapeake & Ohio Canal extends 184.5 miles from Washington, DC to Cumberland, MD. In lieu of building over 6.7 miles of canal along the Potomac River, canal builders took a 1.5 mile long shortcut through the mountain. This presentation will discuss the history of the construction including the most recent rock slope stabilization that was completed in 2023.
- 1.0 PDH

Outline

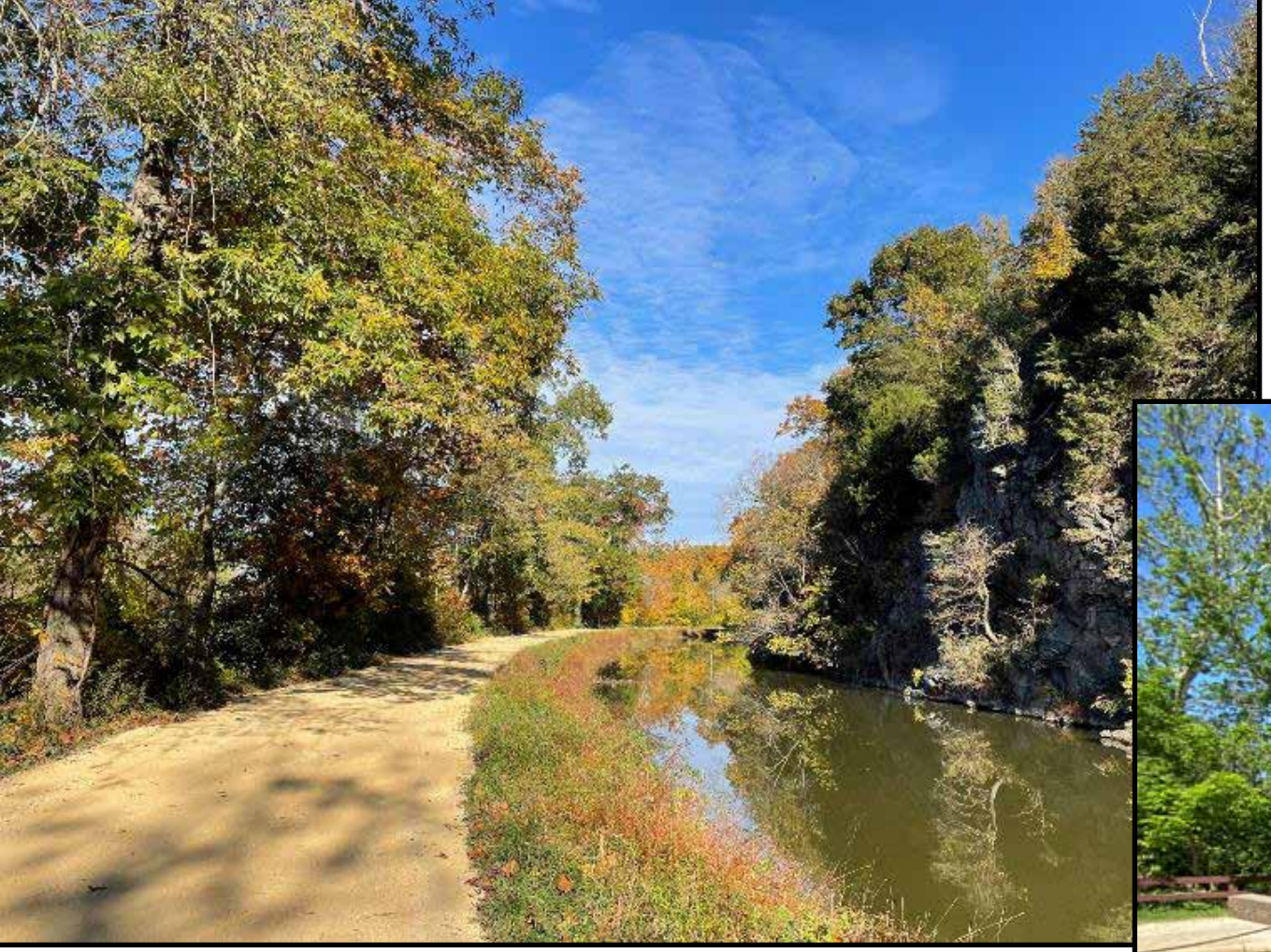
- Overview of C&O Canal
- History of Project Need & Background
- National & International Significance
- Schematic Design Development
- Design Build Execution
- Conclusion

National Park System



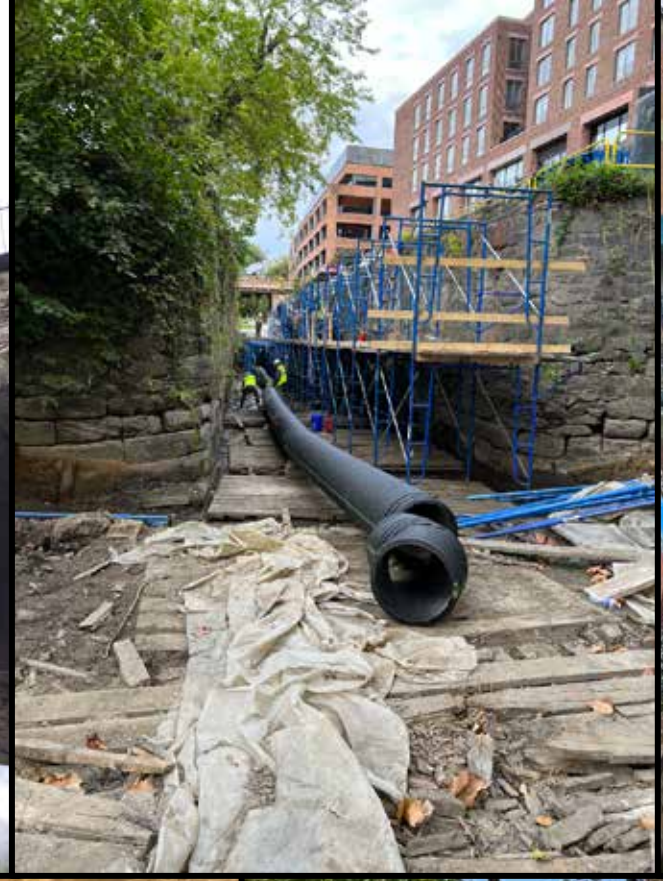
C&O Canal National Historical Park

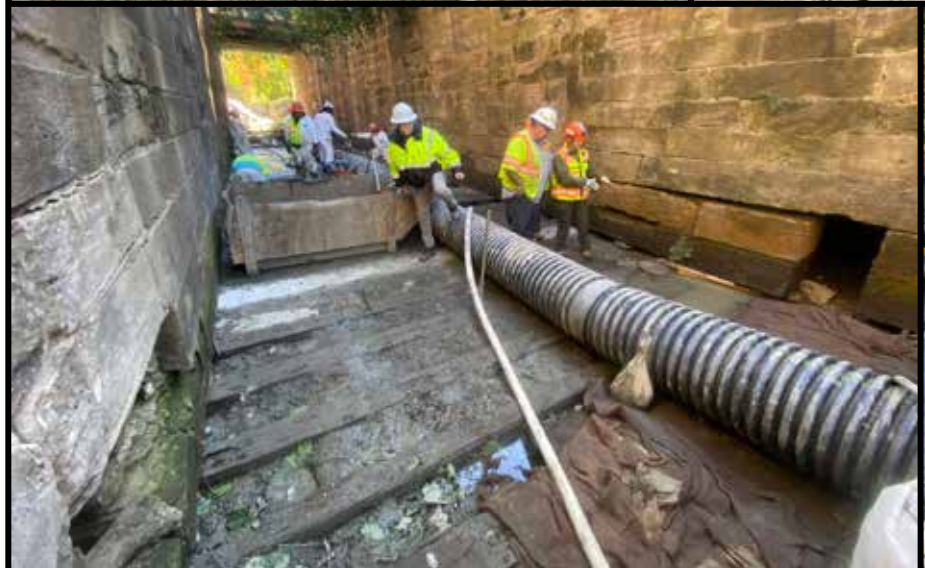
mdres (3750×2774) (nps.gov)



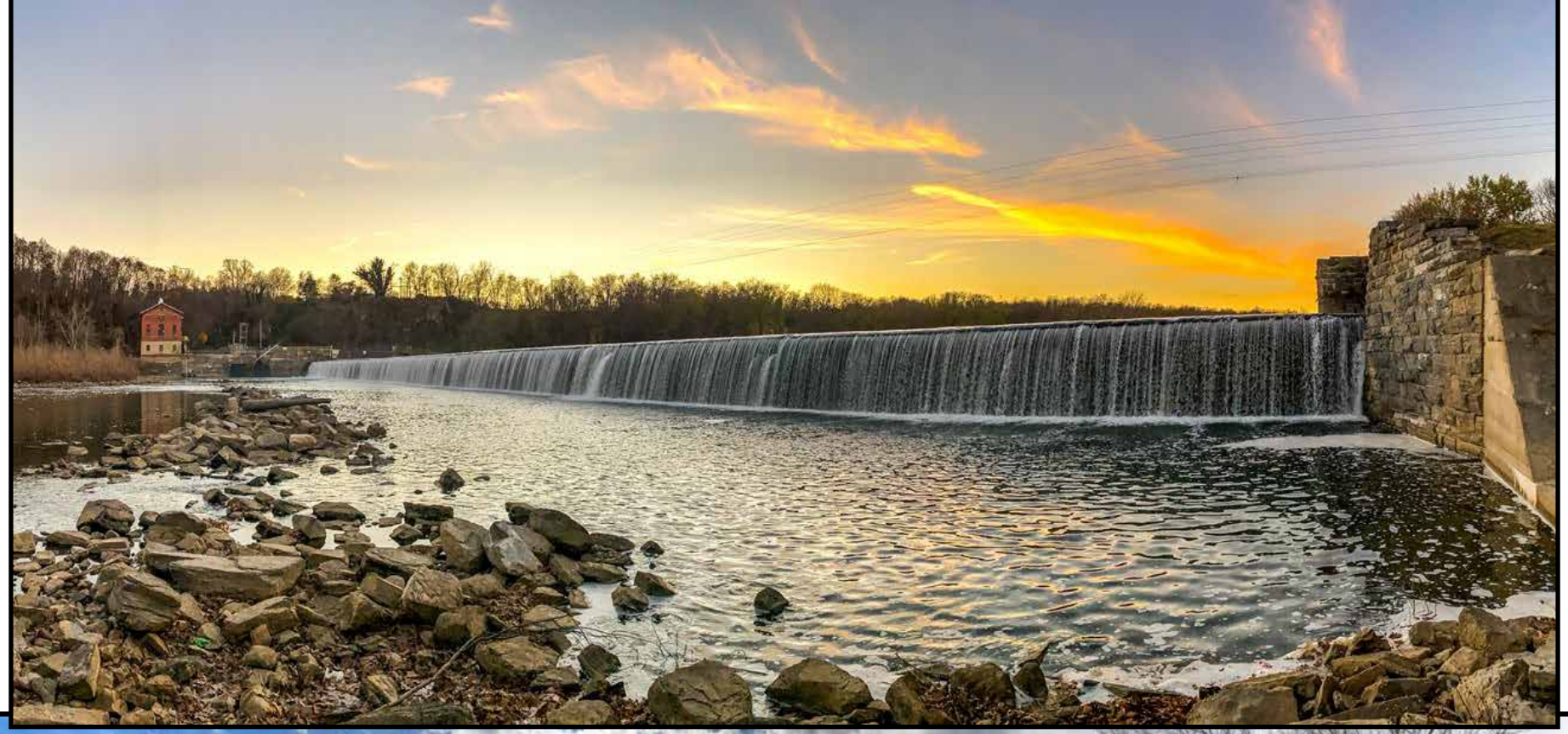

CAT

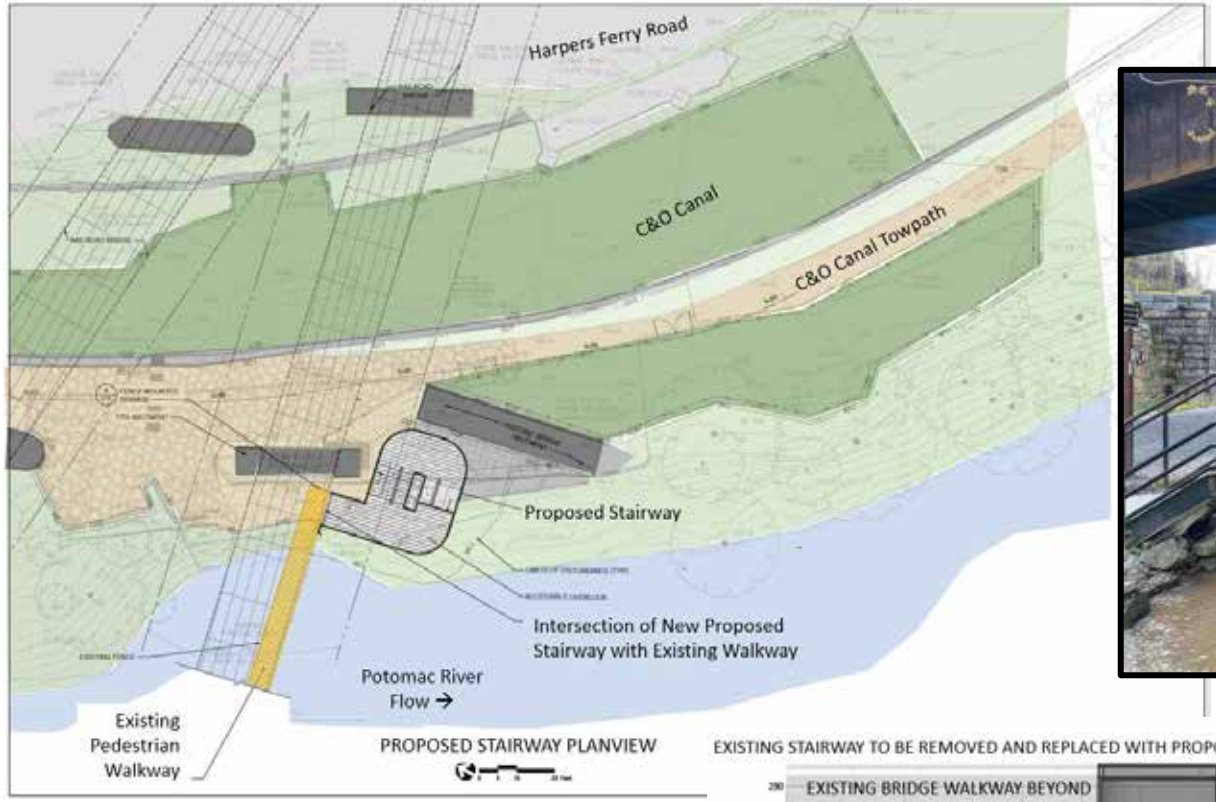

SPEED
LIMIT
10
WEIGHT
LIMIT



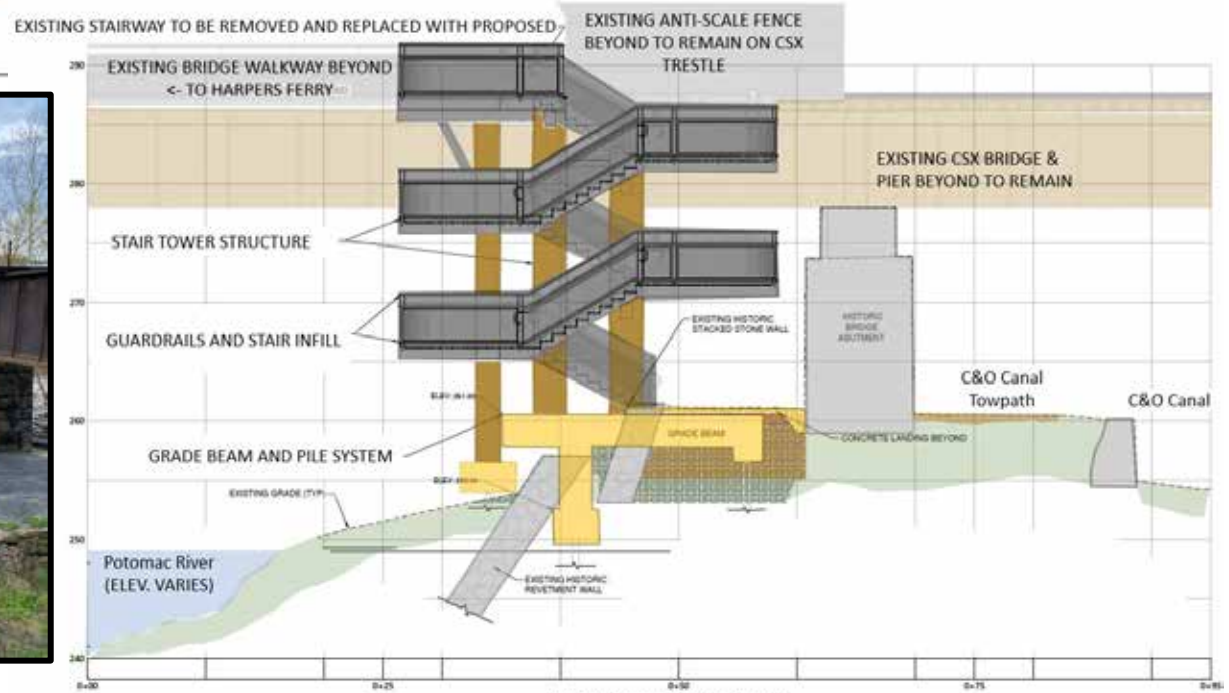



Takeuchi





PROPOSED STAIRWAY PLANVIEW

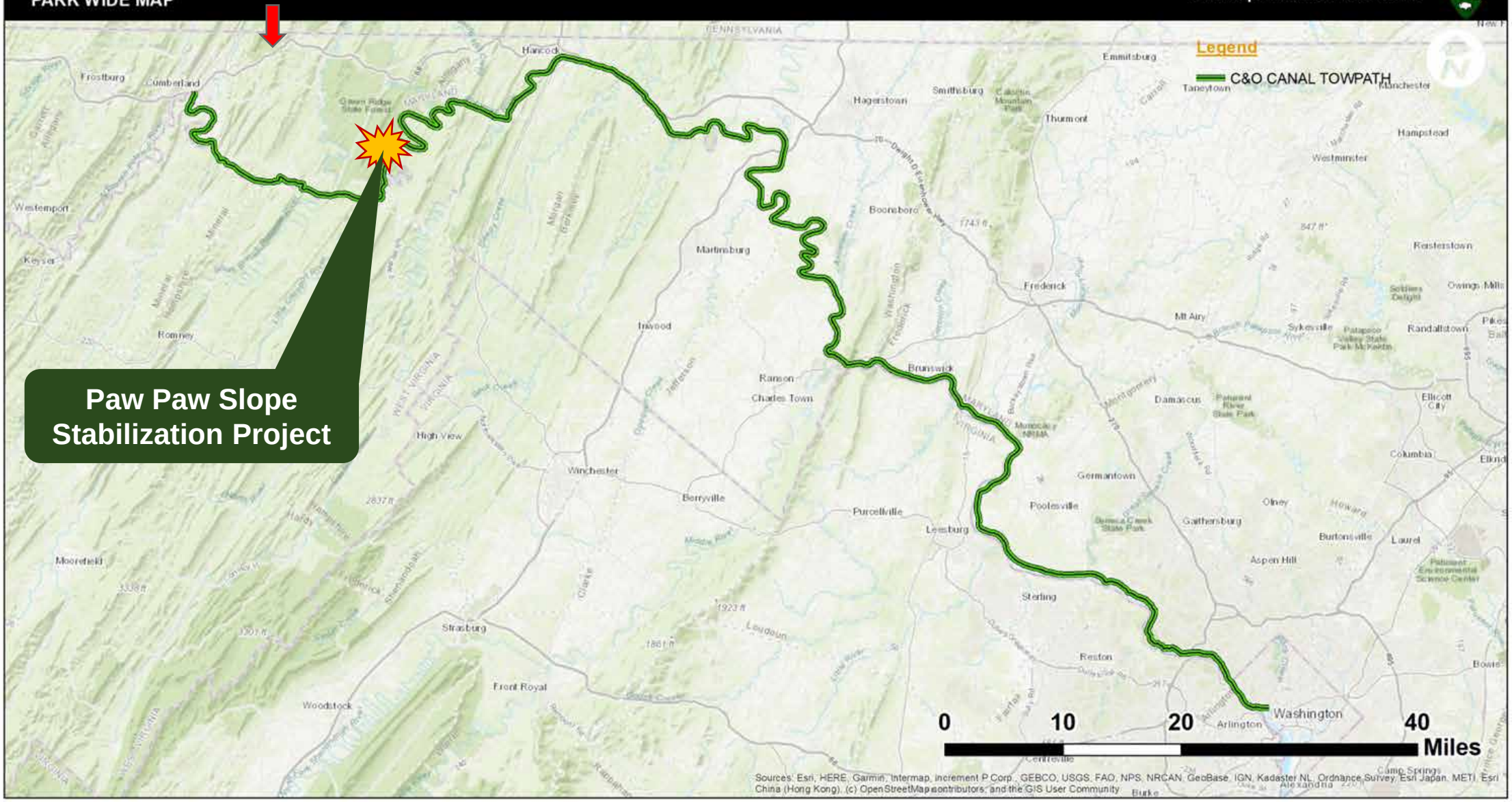


PROPOSED STAIRWAY SECTION


ASSOCIATION OF ENVIRONMENTAL
& ENGINEERING GEOLOGIST'S
2024 OUTSTANDING ENVIRONMENTAL AND
ENGINEERING GEOLOGIC PROJECT AWARD
Congratulations to National Park Service,
Chesapeake and Ohio Canal National Historical Park,
and their consultants for design and construction
delivery of this slope stabilization project helping
to preserve it for current and future generations.
Visitors can continue to visit the storied and historic
Chesapeake & Ohio Canal and the notable
Paw Paw Tunnel to not only learn more about the
historic engineering of this marvel but also the
fascinating geology that makes this setting so unique.
PAW PAW SLOPE STABILIZATION –
CHESAPEAKE & OHIO CANAL
NATIONAL HISTORICAL PARK
is recognized by the
Association of Environmental & Engineering Geologists
as the
AEG OUTSTANDING ENVIRONMENTAL AND
ENGINEERING GEOLOGIC PROJECT
FOR 2024
THE ASSOCIATION OF ENVIRONMENTAL & ENGINEERING
GEOLOGISTS IS HONORED TO DESIGNATE THE
PAW PAW SLOPE STABILIZATION – CHESAPEAKE
& OHIO CANAL NATIONAL HISTORICAL PARK
AS AN OUTSTANDING ENVIRONMENTAL
AND ENGINEERING
GEOLOGIC PROJECT
AWARDED: SEPTEMBER 11, 2024

Chesapeake & Ohio Canal National Historical Park
PARK WIDE MAP

National Park Service
U.S. Department of the Interior



PRODUCED BY: C & O CANAL NHP - ENGINEERING SERVICES

23 AUGUST 2021

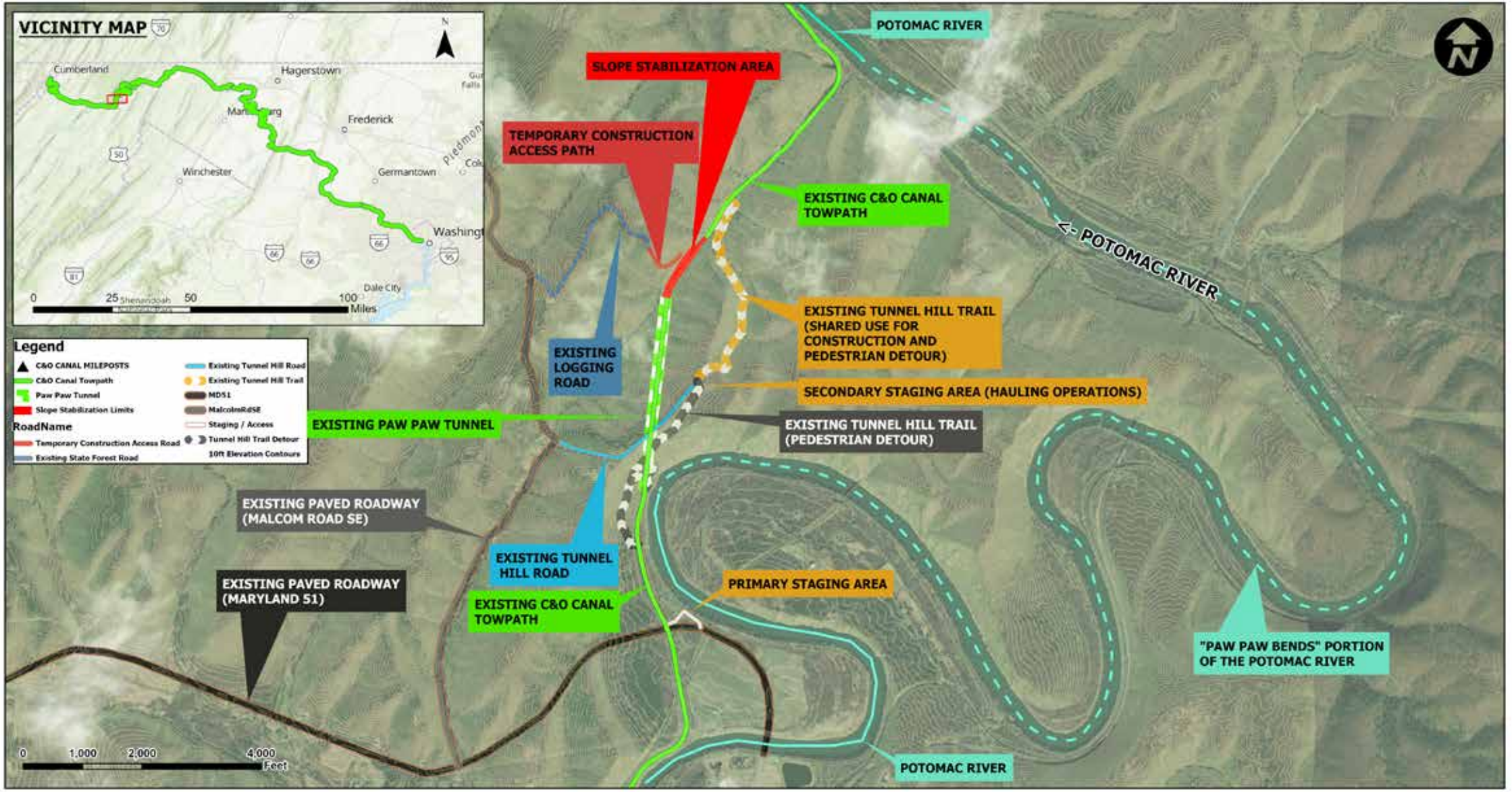
Data Sources: ESRI Roads, NPS Park Data, MD 2011 Imagery, etc

History of Project Need & Background

Chesapeake and Ohio Canal National Historical Park

CHOH 241450 - Paw Paw Slope Stabilization

National Park Service
U.S. Department of the Interior



Produced by CHOH Professional Services
Williamsport, Maryland

JULY 15, 2024

History of Project Need & Background

Original Cut Excavation for Approaches & Paw Paw Tunnel

- (1836-1850)
- Tunnel Holed June 5, 1840 – At that time was the longest tunnel in the U.S.*
- Approaches were up to 79' Deep*
- Estimated 213,229 CY*
- Cost $218,000*

C&O Canal Company Operations

- (1850 – 1938)
- At Tunnel - Single direction of boat traffic – alternated right of way using semaphore.
- 1857 Rock Slide*
- Reports of Continual Rockslides
- 1924 – Commercial Navigation Ceases.
- NOTE: 1924 – 1938 – minimal maintenance done.

Post C&O Canal Company & Federal Oversight

- (1938 – 1971)
- U.S. Government Purchased C&O Canal in 1938.
- 1950's – Mission 66 Work by NPS
- 1961 National Monument Designation
- 1960's Repairs
- 1968 Slide
- 1969 Slide*

NPS Management

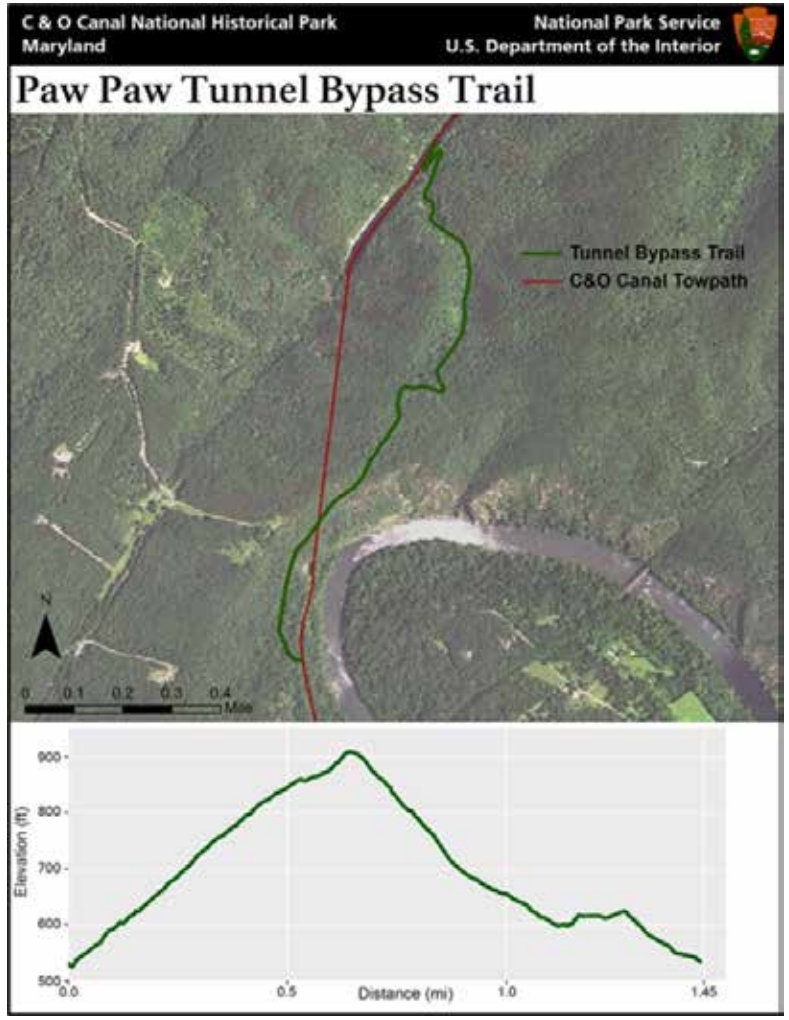
- **(1971 – Present)**
- **1971 National Historical Park Designation**
- **1974 Slide**
- **1975 Slide**
- **1977 Slide**
- **1970's Repairs**
- **1997 Slide**
- **2013 (Jan) Slide & Repairs**
- **2016 Slide**
- **2017 – 2019 Interim Repairs**
- **2020 – 2023 Repairs (This Project)**

*The Geology and Engineering Structures of the Chesapeake & Ohio Canal – William Davies. 1999. candocanal.org/histdocs/Davies-book.pdf
Includes Summary of Rockfall Events from Rockfall Geohazard Evaluation Report (2020).

History of Project Need & Background

National & International Significance

- This section of the canal provides unparalleled access to a unique historic engineering marvel (Paw Paw Tunnel) that serves as a focal point of the western portion of the towpath. It is a destination for group biking and camping.
- This area also hosts the C&O Canal's educational programs, Canal Classrooms, where park rangers & retired teachers volunteer to lead educational programs within the park for thousands of students.
- Serves as a critical link on the:
  - 184.5 mile long C&O Canal between Washington, DC & Cumberland, MD
  - 327.5 mile long Potomac Heritage National Scenic Trail
  - 150 mile long Greater Allegheny Passage (GAP), that when connected with C&O Canal extends 335 miles between Washington, DC and Pittsburgh, PA.
  - 6,800+ mile long American Discovery Trail
- This project preserves towpath continuity and provides a critical link since it is the only bicycle passage through the mountains of Western Maryland.
- Alternate detour extends 1.5 miles and an elevation change of approximately 400'.
- This region is notorious for having limited communications coverage and difficult rescue capability due to remoteness.
- 250,000 annual through visitors with heavy loaded bicycles would have difficult time with detour (based on past experience).



Schematic Design Development

- Pre-Design through Schematic Design developed 2019 – 2020.
  - Developed concept designs, performed a choosing by advantage (value analysis) workshop, generated cost estimates, creation of Design Build Request for Proposal (RFP) documents, and supplemental services.
    - Review of existing historic documentation.
    - Work and Health/Safety Plans.
    - Site Reconnaissance and Reference Surveys.
    - Rock Fall Inventory and Risk Assessment.
    - Small Unmanned Aerial System (sUAS) & Terrestrial Photogrammetry.
    - Geologic and Rock Structure Mapping.
    - Laboratory Testing.
    - Rock Mass Characterization & Engineering Analysis.
    - Topographical and Terrestrial Surveys.
    - Visual Inspection of Tunnel.
    - Assessments of the condition of adjacent tunnel, portals, and associated historic features.
    - Limited evaluation of seepage into tunnel and drainage adjacent to it.
    - Limited dye tracing, and geophysics to local historic features.
  - Environmental Assessment completed by National Park Service (https://parkplanning.nps.gov/projectHome.cfm?projectID=92111).
  - Construction constraints document for access, resources, and available disposal areas for talus material.
    - Globally Rare Appalachian Shale Barren Habitats.
    - Culturally significant landscape with multiple historic structures on the National Register of Historic Places within the Area of Potential Effect (APE).
    - Majority of access areas and potential on-site spoil areas were within the 100-year Special Flood Hazard Area for the Potomac River.
    - Historic Structures were within and adjacent to all access routes which required special protection and mitigations.

https://www.loc.gov/pictures/resource/hhh.md0889.sheet.00001a/?co=hh

Schematic Design Development

Risk Score = Probability x Consequence

- Slope Height
- Catchment Ditch Effectiveness*
- Structural Condition (Discontinuity, Joints, Orientation, etc.)*
- Rock Friction*
- Block Size*
- Volume of Rockfall/Event
- History of Rockfall/Event
- Climate and Presence of Water*

- Life Safety Hazard
- Historic & Natural Resource Hazard (consideration included during the Value Analysis)

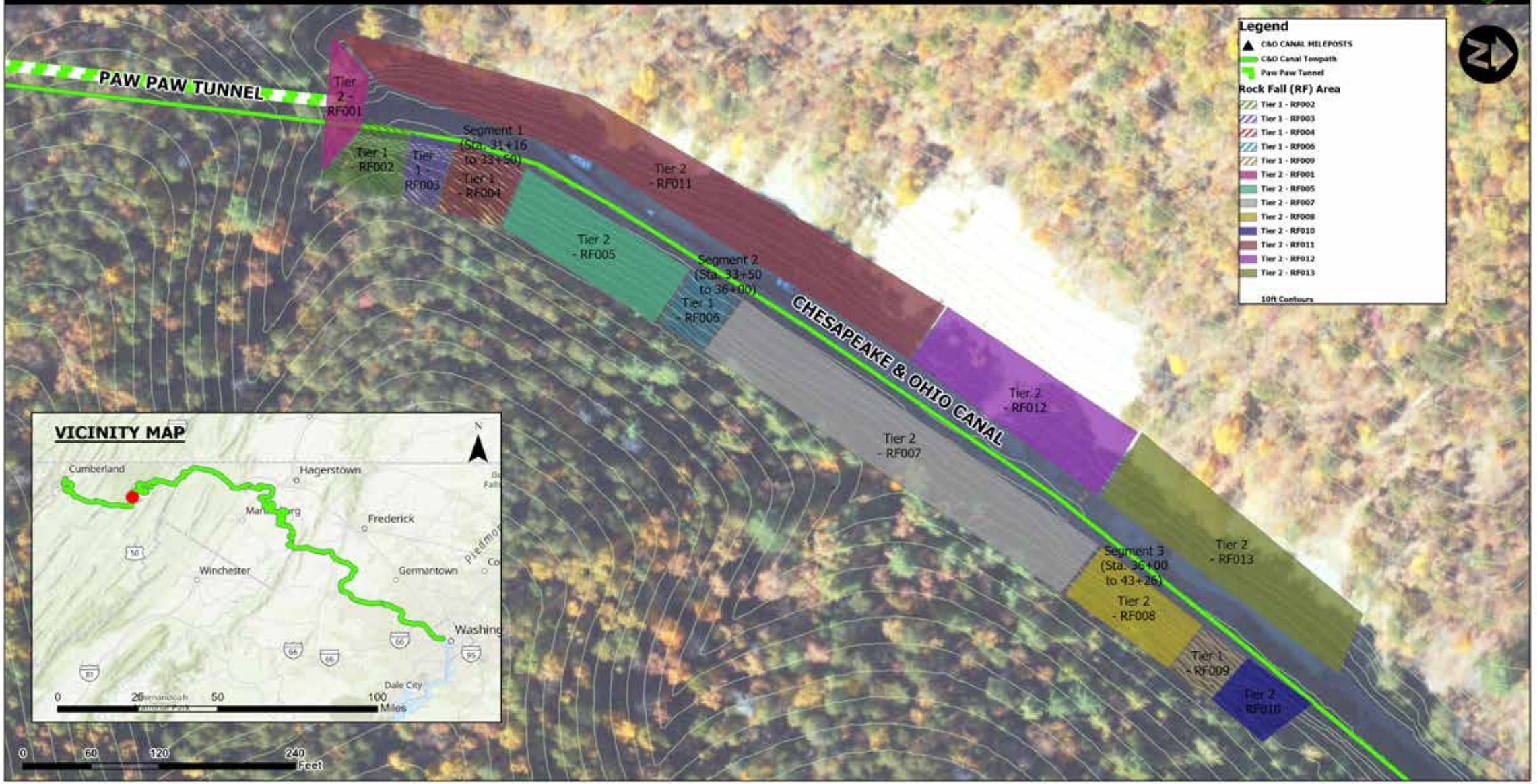
Higher Score = Higher Risk

*Items that can be directly addressed with proposed treatment meth

Chesapeake and Ohio Canal National Historical Park

CHOH 241450 - Paw Paw Slope Stabilization - Rock Fall (RF) Areas

National Park Service
U.S. Department of the Interior

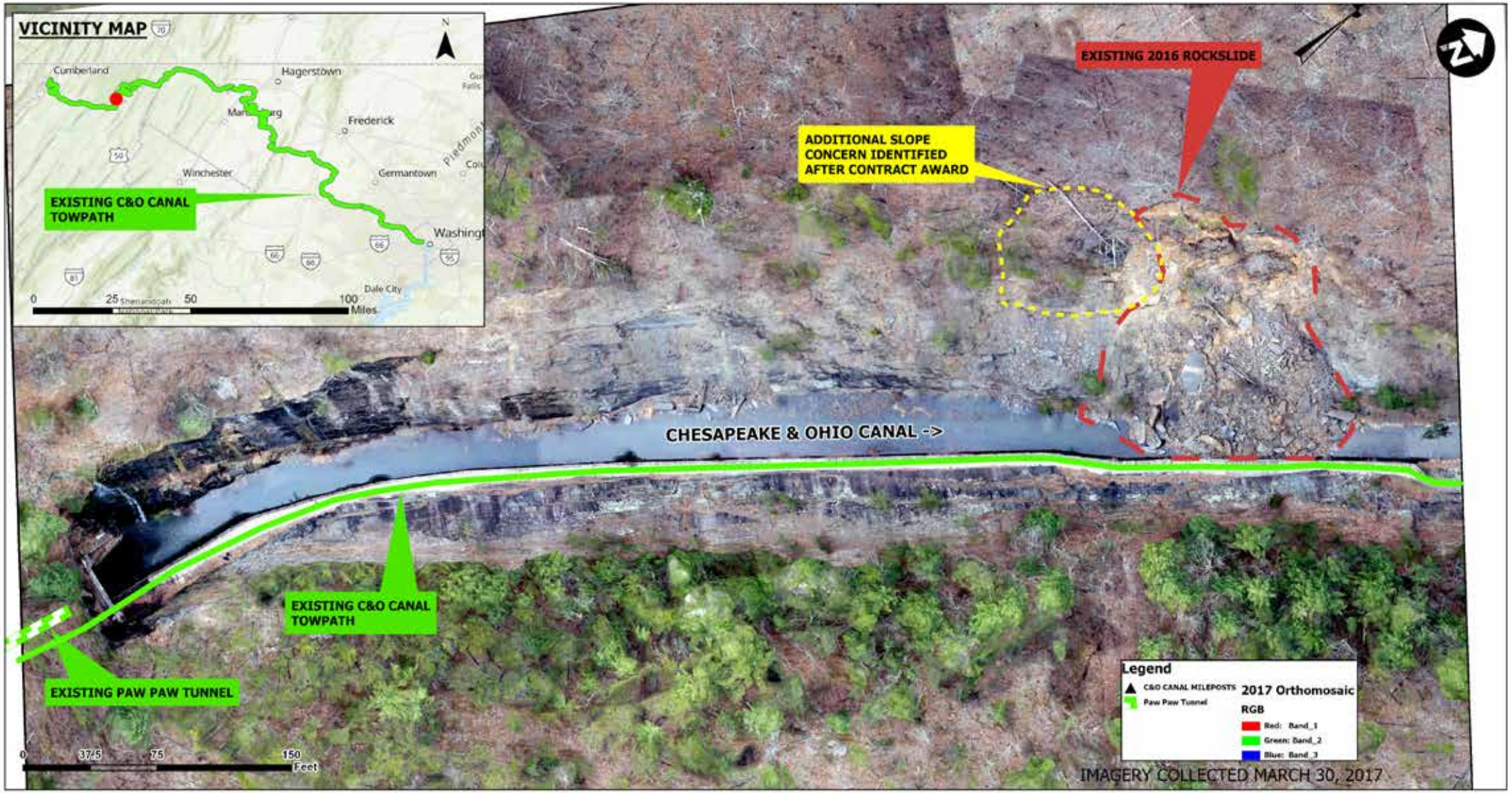


Produced by CHOH Professional Services
Williamsport, Maryland

JULY 12, 2024

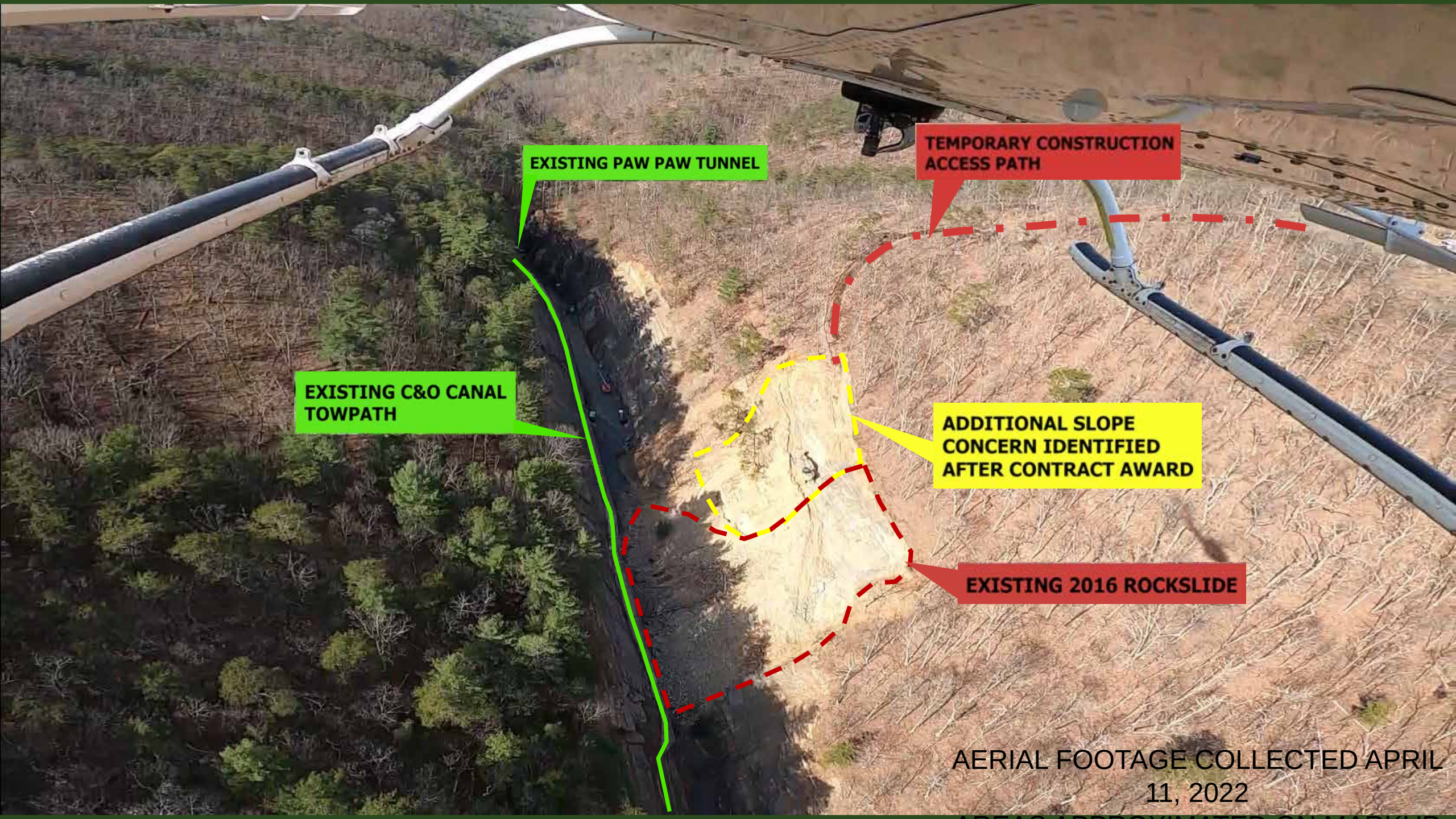
Chesapeake and Ohio Canal National Historical Park
CHOH 241450 - Paw Paw Slope Stabilization

National Park Service
U.S. Department of the Interior

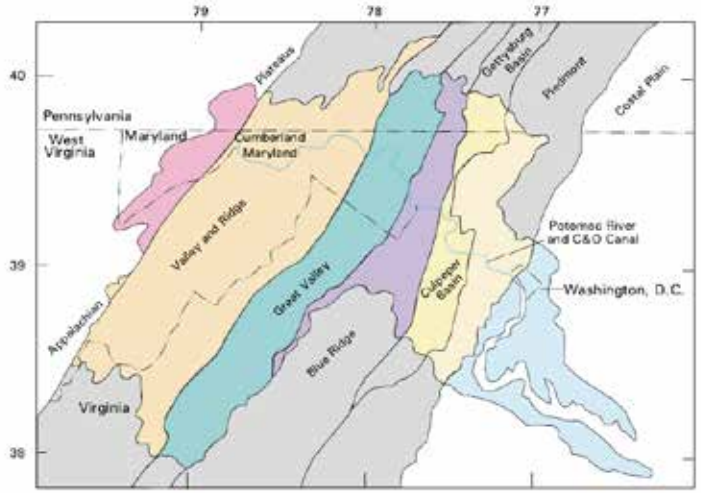


Produced by CHOH Professional Services
Williamsport, Maryland

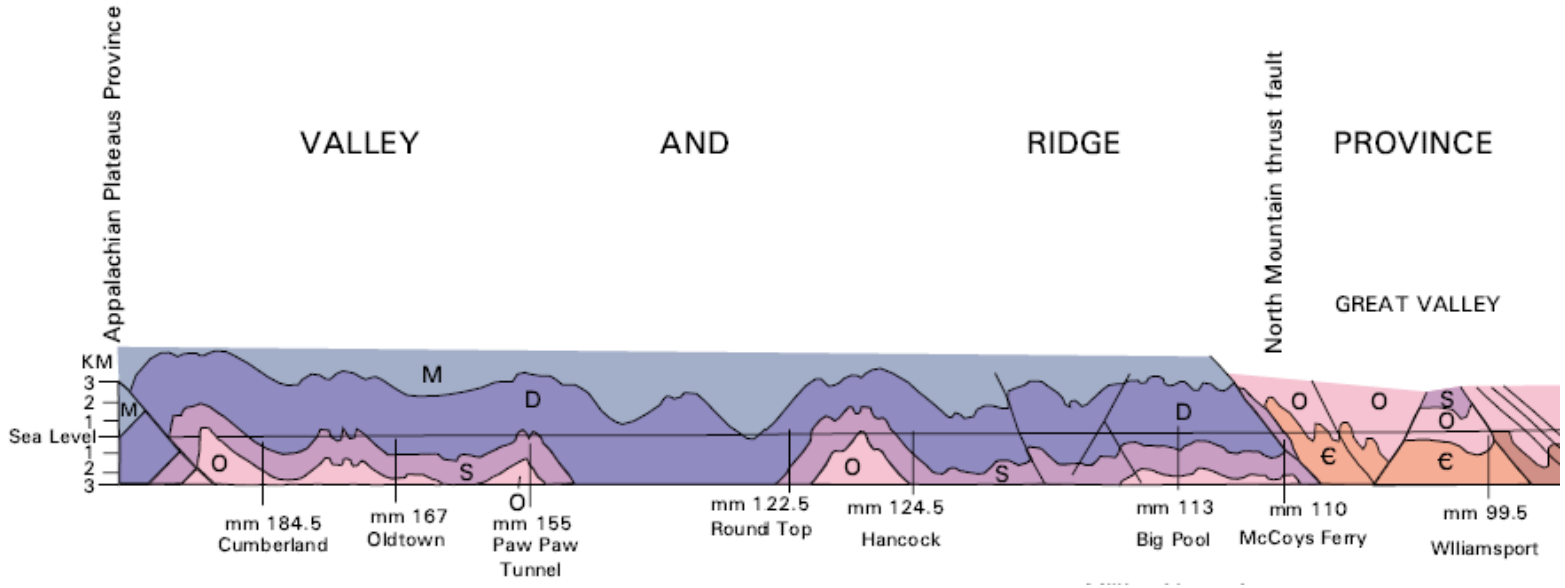
JULY 15, 2024


EXISTING PAW PAW TUNNEL
TEMPORARY CONSTRUCTION ACCESS PATH
EXISTING C&O CANAL TOWPATH
ADDITIONAL SLOPE CONCERN IDENTIFIED AFTER CONTRACT AWARD
EXISTING 2016 ROCKSLIDE
AERIAL FOOTAGE COLLECTED APRIL 11, 2022

Geologic Setting

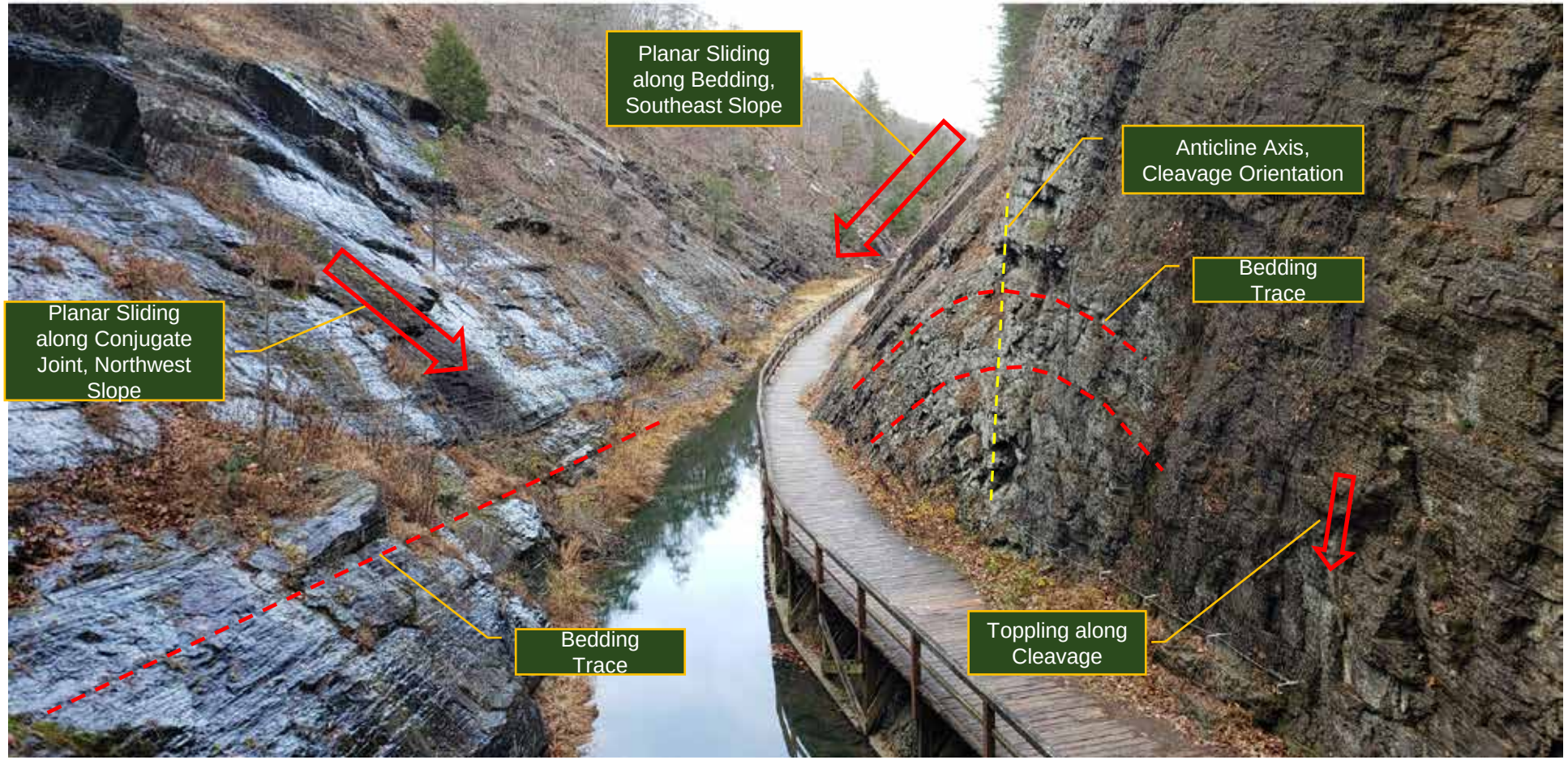


Formation: bedded shale, siltstone, and sandstone of the Upper Devonian Brallier Shale which represent submarine turbidity flow deposition.



From: USGS, Southworth et al, 2001

Engineering Geology

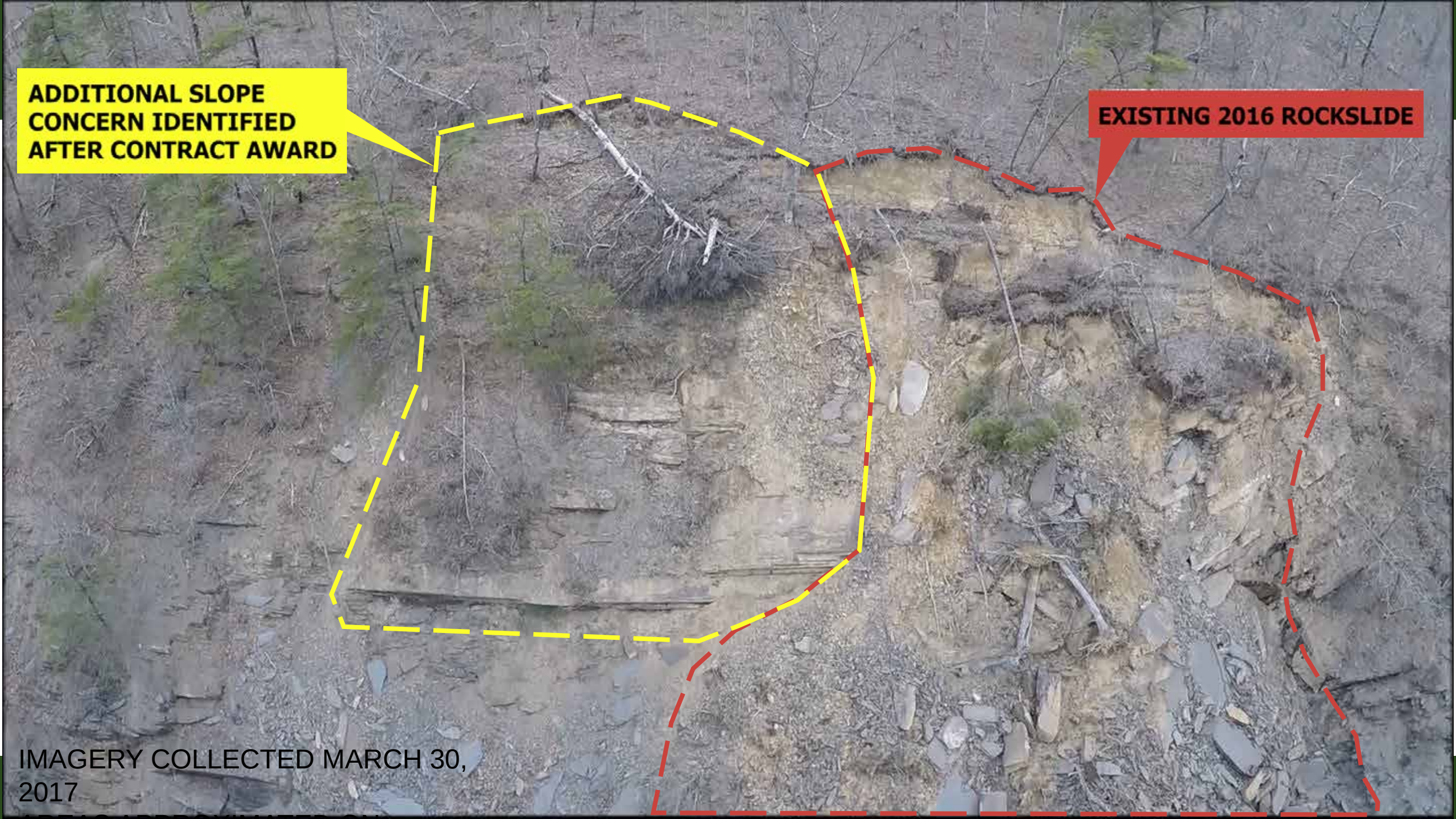


Engineering Geology

Previous Failure

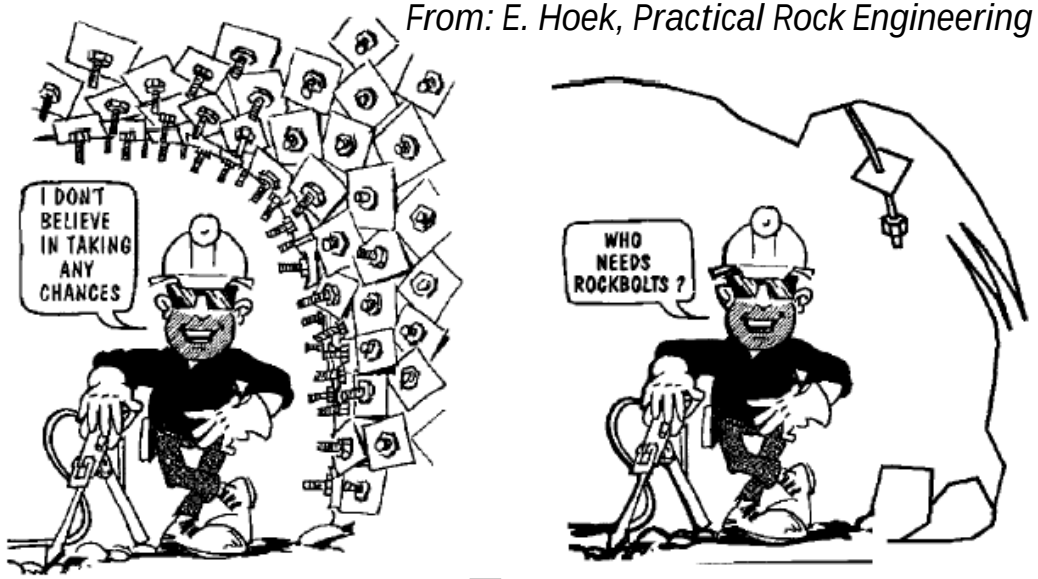
Pre 2016 (www.googleearth.com)

2016 Failure.....


ADDITIONAL SLOPE CONCERN IDENTIFIED AFTER CONTRACT AWARD
EXISTING 2016 ROCKSLIDE
IMAGERY COLLECTED MARCH 30, 2017

Slope Stabilization

From: E. Hoek, Practical Rock Engineering

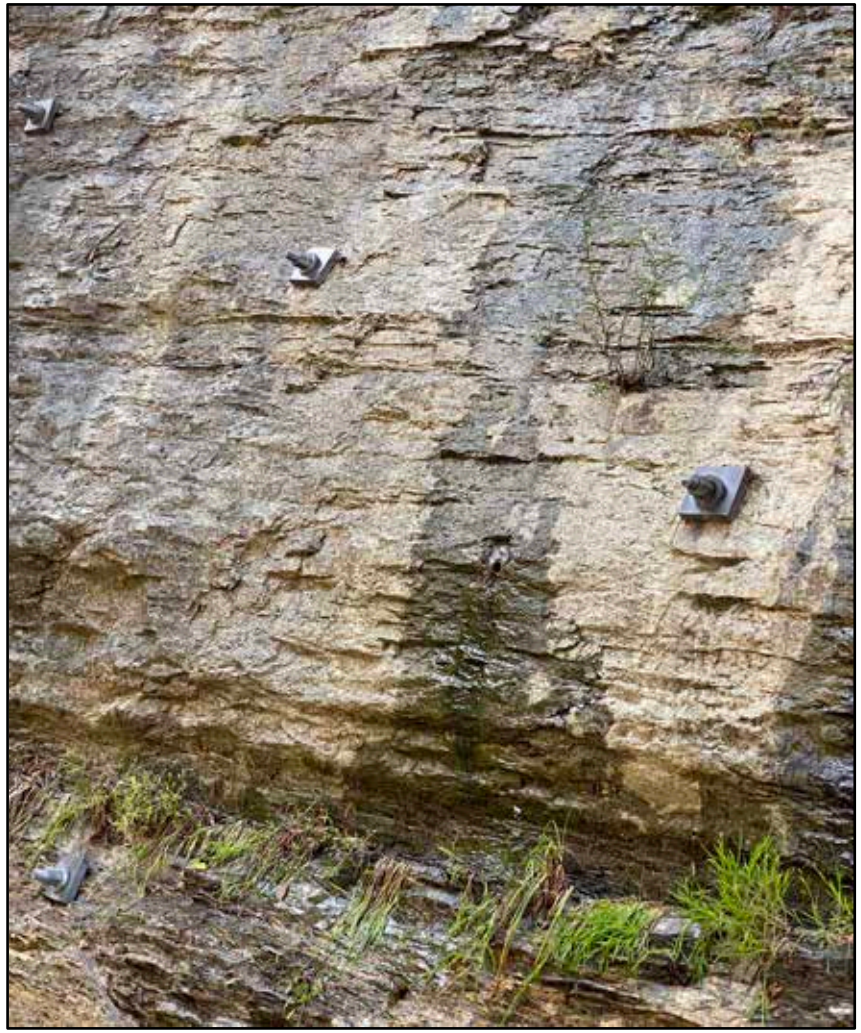


Goal: Stabilize the slopes, but preserve the historic features and natural appearance of the landscape.

Avoid impacts to natural and cultural resources, if possible, mitigate if avoidance is not possible!

The National Park Service preserves unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations. The National Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.

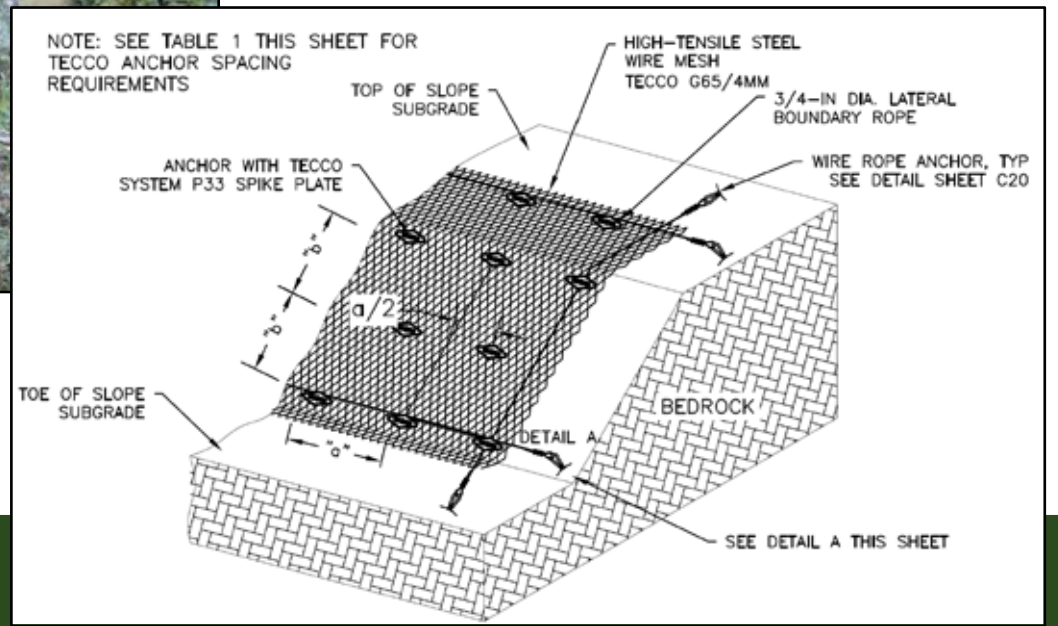
Slope Stabilization – Rock Anchors



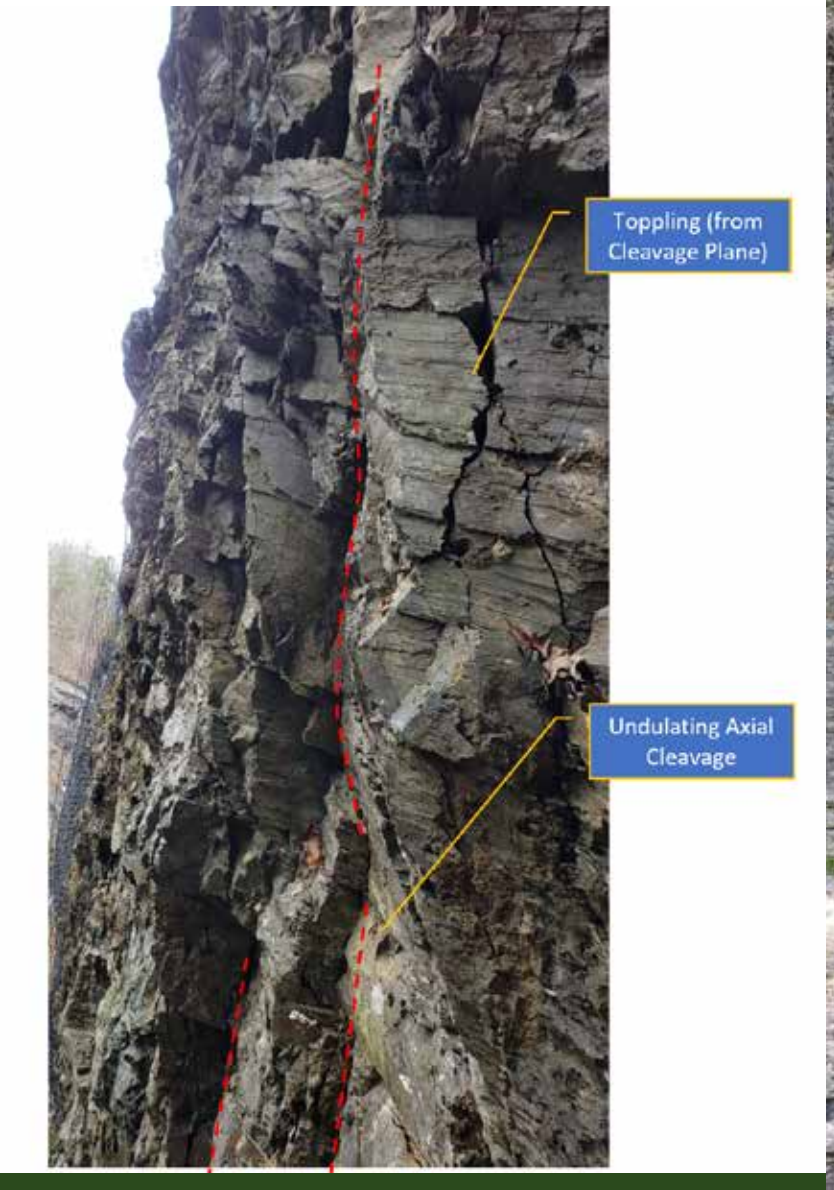

Active Slide
Previous Slide

Slope Stabilization – Previous, Existing Slide

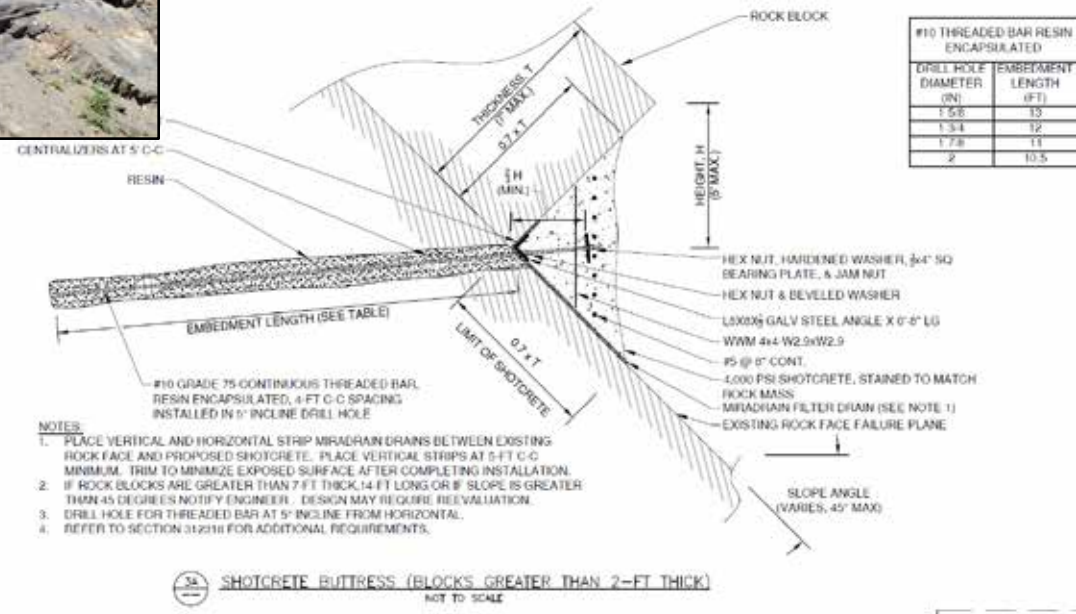
Slope Stabilization – Pinned Mesh



Slope Stabilization – Pinned Mesh



Slope Stabilization - Buttress



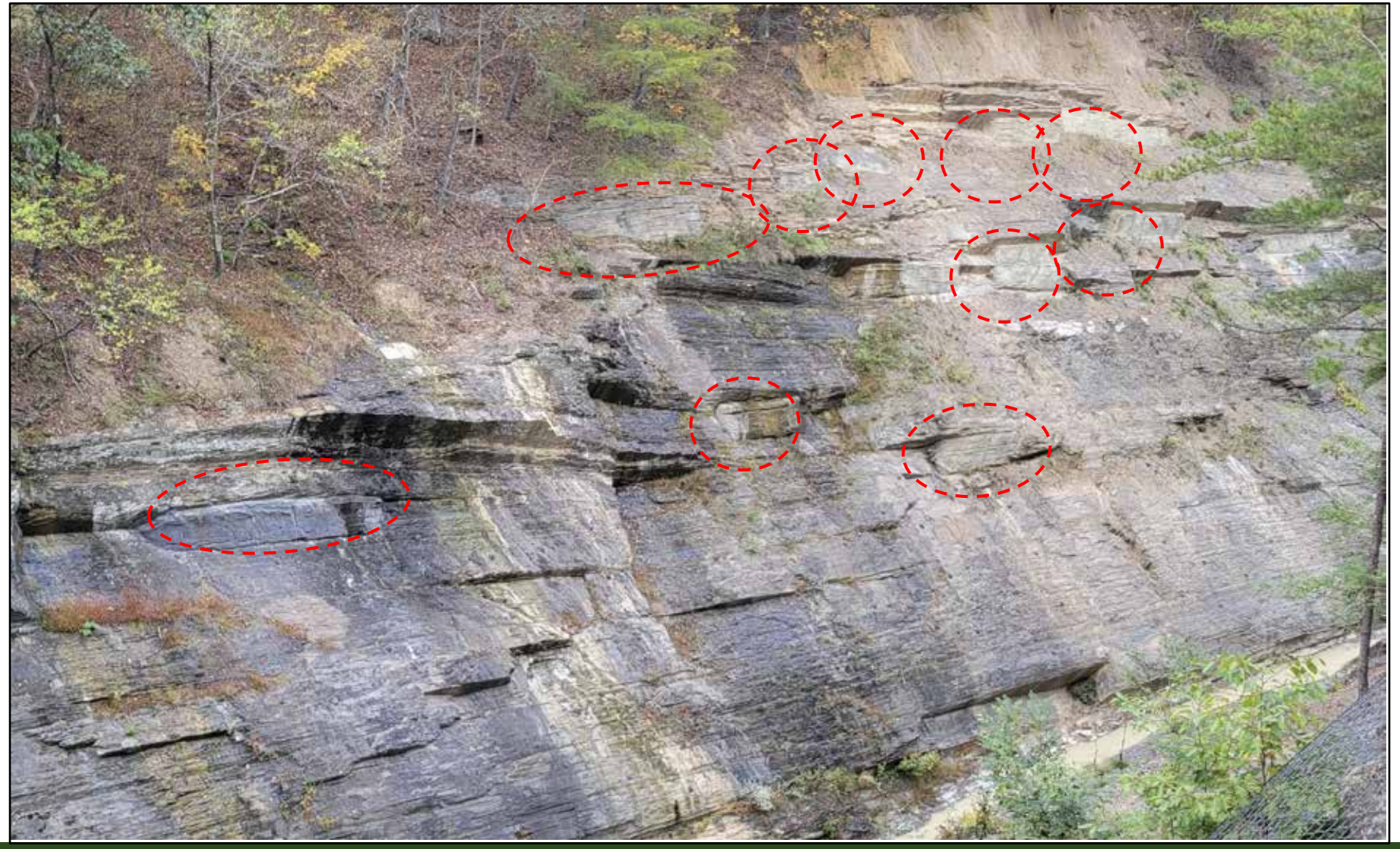
#10 THREADED BAR RESIN ENCAPSULATED	
DRILL HOLE DIAMETER (IN)	EMBEDMENT LENGTH (FT)
1 5/8	13
1 3/4	12
1 7/8	11
2	10.5

NOTES:
1. PLACE VERTICAL AND HORIZONTAL STRIP MIRADRAIN DRAINS BETWEEN EXISTING ROCK FACE AND PROPOSED SHOTCRETE. PLACE VERTICAL STRIPS AT 5-FT C-C MINIMUM. TRIM TO MINIMIZE EXPOSED SURFACE AFTER COMPLETING INSTALLATION.
2. IF ROCK BLOCKS ARE GREATER THAN 7 FT THICK,14 FT LONG OR IF SLOPE IS GREATER THAN 45 DEGREES NOTIFY ENGINEER. DESIGN MAY REQUIRE REEVALUATION.
3. DRILL HOLE FOR THREADED BAR AT 5° INCLINE FROM HORIZONTAL.
4. REFER TO SECTION 312316 FOR ADDITIONAL REQUIREMENTS.

34 SHOTCRETE BUTTRESS (BLOCKS GREATER THAN 2-FT THICK)
NOT TO SCALE

Slope Stabilization - Buttress

Slope Stabilization - Buttress



Design Build Execution – Shear Blocks

Design Build Execution - Boardwalk

Conclusion

Conclusion

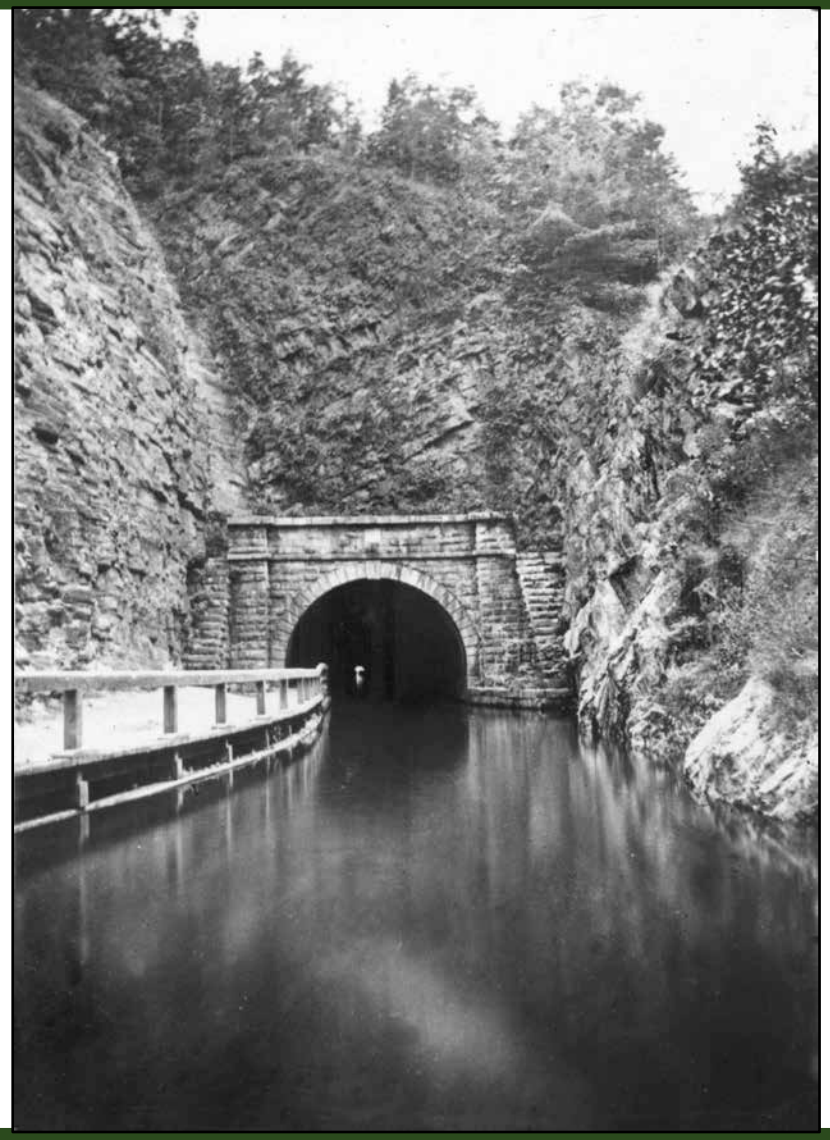
Conclusion

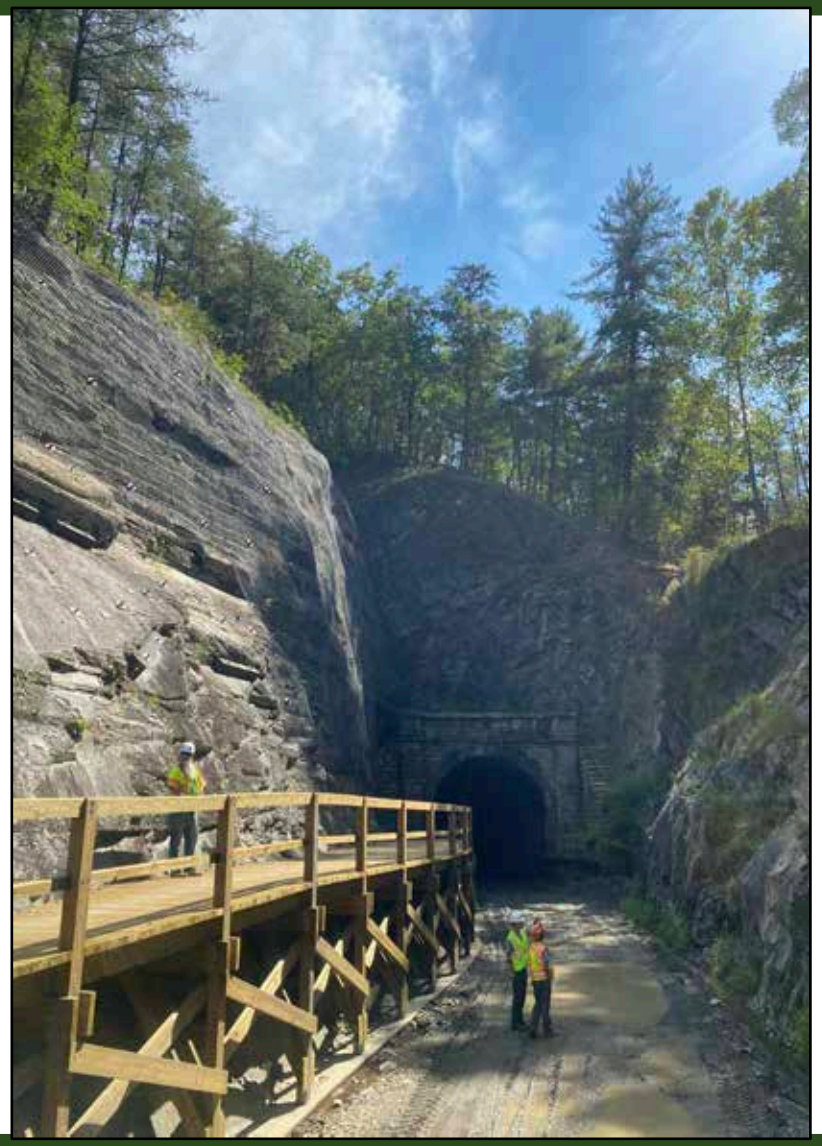
Conclusion

Conclusion

Conclusion

Conclusion





Thank You!

QUESTIONS?

Contact:

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E-mail: joseph_reed@nps.gov