Presentation for Pawtuxet River Stabilization Project

Rebuilding After the Flood: A Holistic Approach to Preserving History while Enhancing Flood Resiliency

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Agenda

Rebuilding After the Flood – Pawtuxet River Stabilization Project

- **Project Introduction and Purpose (8 min.)**
  - Project Location and Site History
  - Overview of March 2010 Flood Impacts /Post-Flood Project Conditions
  - Project Purpose and Funding
- **Resilient Design Solutions (12 min.)**
  - Structural/Infrastructure Stabilization Solutions
  - River Channel Stabilization Solutions
- **Construction Challenges (4 min.)**
- **Pre- Versus Post-Construction Photographs (1 min.)**
- **Questions and Discussion (5 min.)**

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Project Introduction and Purpose

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Project Location and Site History

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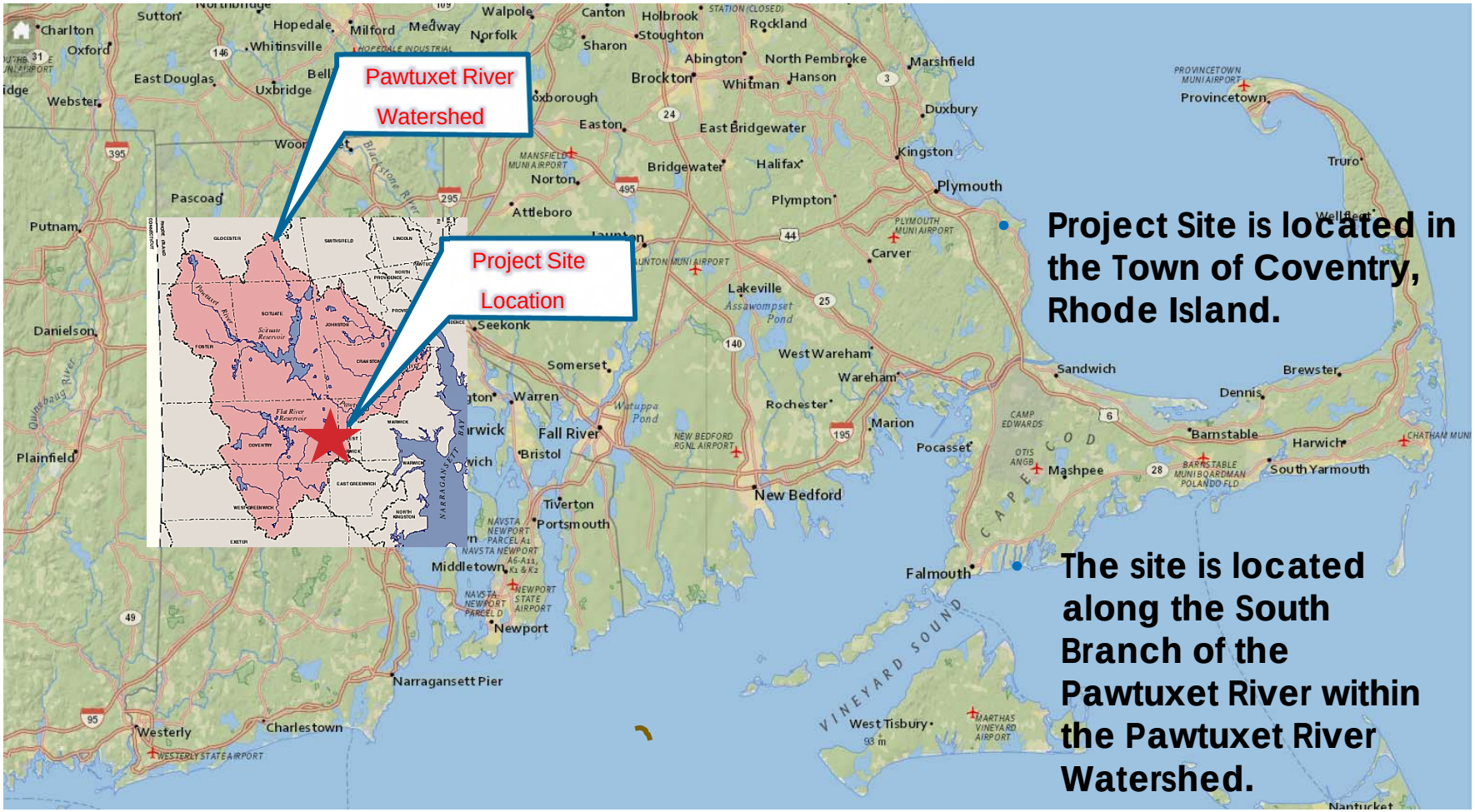

- The Pawtuxet River Watershed, located in central-western Rhode Island, is the largest watershed in the State. The River flows in an easterly direction and discharges to the Providence River / Narragansett Bay.

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Project Location

- **The River flows between two economically productive, privately-owned historic, multi-level mill buildings.**

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Site History

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Project Site History:

- 1920 : Concordia founded as manufacturer of silk yarns. Since 1920, the business has become a leading producer of synthetic/engineered yarns and threads as well as advanced composite materials and fibers for aerospace, filtration media, power transmission belts, etc. Today, it is still an active business and the facility holds over 40 employees.

- 1873 : Anthony Mills was constructed to manufacture cotton products. Today the structure is referred to as "The Lofts at Anthony Mill." It is home to over 122 newly renovated residential apartment units.

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Site History

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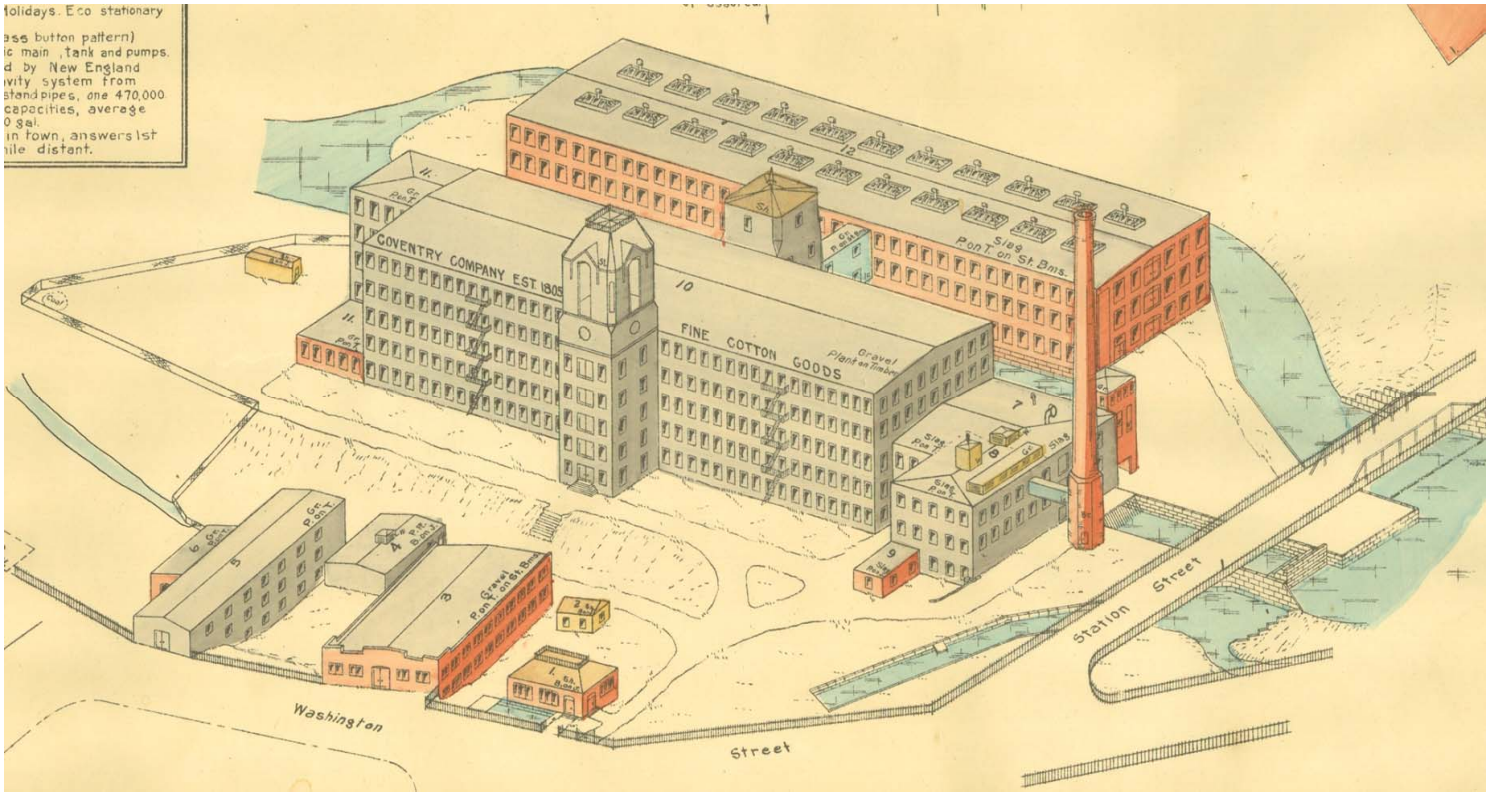

Obtained from October 3, 1928 and May 12, 1941 Architectural Drawings

- Channel Realignment shortened channel length by approximately 110 feet leading to an increase in channel slope/gradient.
- Channel realignment also resulted in a narrower channel by approximately 43%.

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Site History

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Project Site History:

- Prior to March 2010, the river flowed between two mill buildings with a concrete wall primarily defining the southern edge of the river and a combination of concrete and granite block walls defining the northern edge of the river.
- A concrete buttress also existed along the foundation of the Tower that was apparently installed subsequent to original construction.

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March 2010 Flood

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- Between March 29 and April 1, 2010, 8.8 inches of rain fell on the Pawtuxet River watershed in Rhode Island.
- 11.3 inches of rain fell over the previous 35 days (Category III Antecedent Moisture Conditions).
- Coupled with the level of development/impervious area in the Watershed, this resulted in a flooding event with a 0.2% annual exceedance probability or greater.
- On the Pawtuxet River, this flooding exceeded the previous flood stage record by about 6.3 feet.

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March 2010 Flood

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March 2010 Impacts at Project Site:

- High flow and flow velocities resulted in substantial scour along the river channel bottom and banks.
- This led to the failure of the river channel bottom, river walls, and adjacent up-gradient river bank areas.

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March 2010 Impacts at Project Site:

- This ultimately resulted in the collapse of the corner of the Concordia structure and the undermining of Anthony Mill's historic six-story stair tower.

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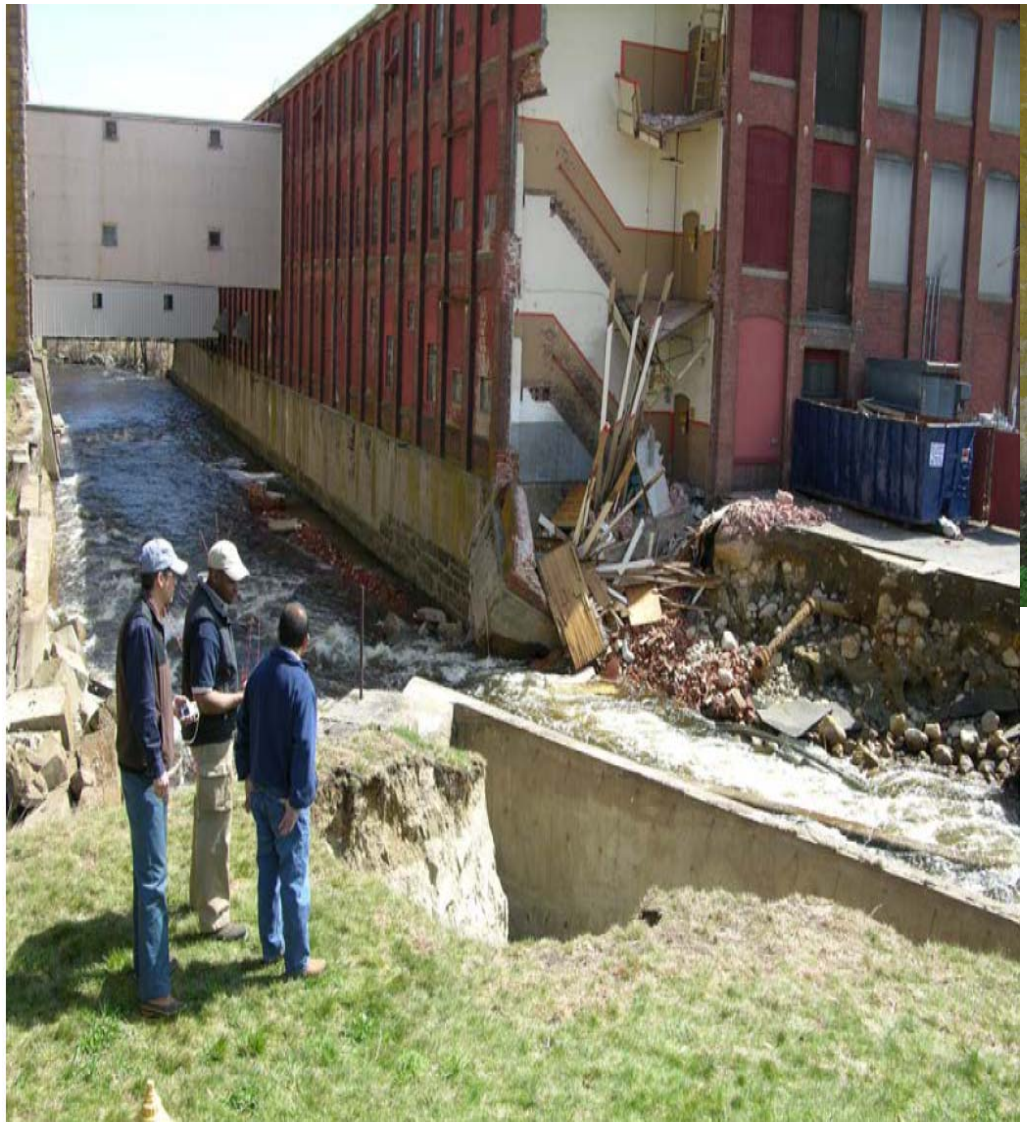
Post-Flood March 2010 Impacts at Project Site:



Project Purpose

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Thus, the purpose of Project was to:

- Reconstruct the failed river channel bottom, walls, and bank areas that protect the two historic mill buidings.
- Stabilize the Six-Story Anthony Mill Stair Tower.

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Project Purpose

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- Given the high-risk environment of the structures and potential for increased intensification of future storms (due to climate change), it was critical that the improvements proposed would be resilient to future extreme flood events and changing conditions in the river system.

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Project Funding

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In response to the flooding and damage at the Project Site, an Emergency Watershed Program (EWP) agreement was reached between the Town of Coventry and NRCS for:

- removal and reconstruction of damaged embankment walls
- reconstruction of riverbed
- riverbank stabilization (behind walls)
- stabilization of Anthony Mill Stair Tower

Total Project Cost – $3.6 million

- NRCS Contributed - $3.3 million (90%)
- Building Owners Only Had to Contribute - $323,000

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Resilient Design Solutions

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Structural / Infrastructure Stabilization Solutions

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Stair Tower Structural Impacts

- Undermining and voids beneath structure
- Horizontal movement of Structure (separation from main building)

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Retaining Walls

- Severe undermining
- Loss of backfill
- Failure/collapse in several locations

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March 2010 Flood

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STRUCTURAL OBJECTIVES

- Stabilize and protect tower
- Reconstruct river walls (tie into bridge)

STRUCTURAL CHALLENGES

- Work within fixed budget – major decision driver
- Uncertain subsurface conditions
- Historic and inhabited/active structures
  - Minimize disturbance
- Limited work area

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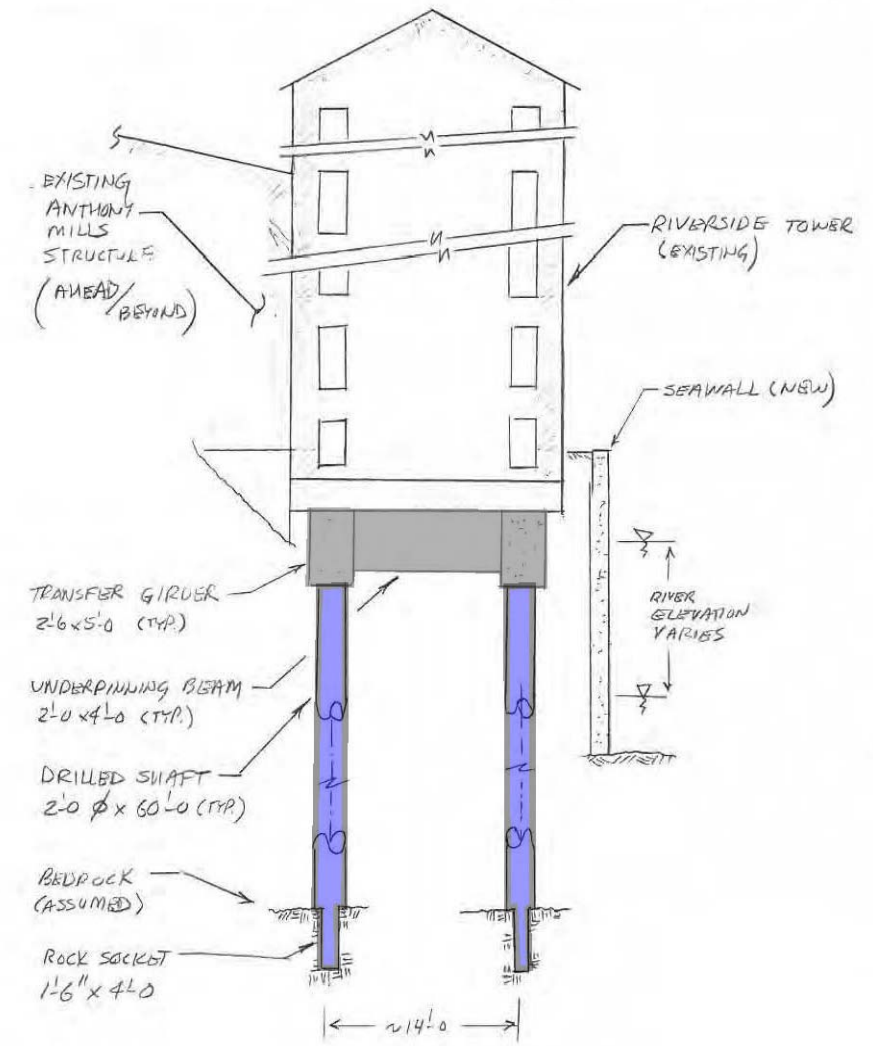
Tower Stabilization

- Original Concept
  - Traditional underpinning with concrete framing on drilled shafts
  - Would be difficult and expensive
  - Would require temporary support
  - Would risk the destabilization of stone foundation



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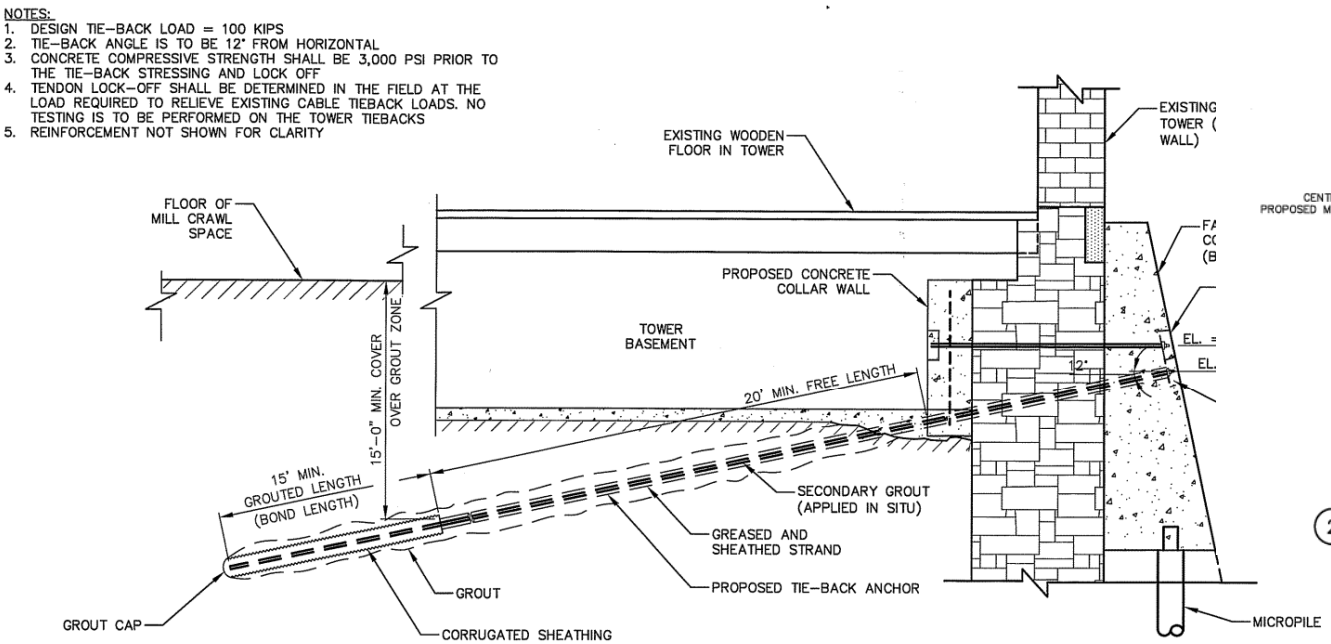
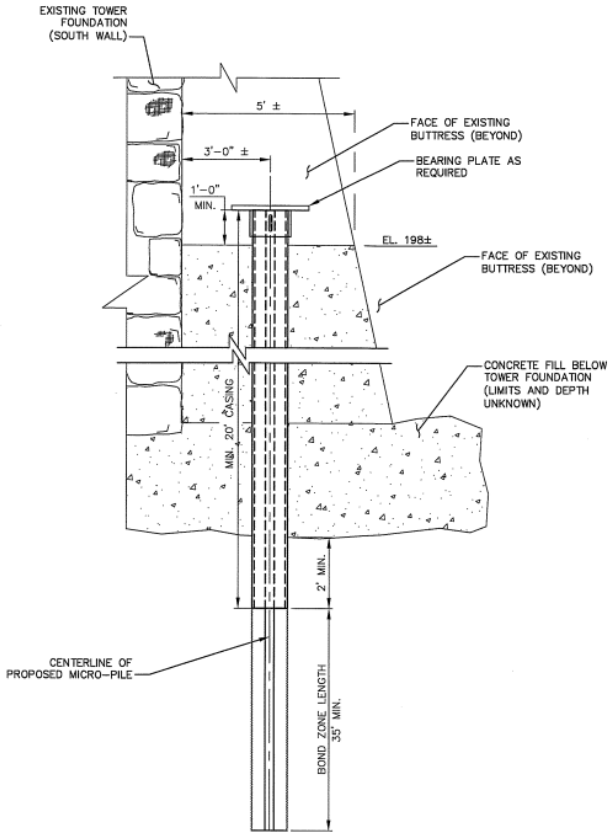
Tower Stabilization

- Selected Alternative needed to:
  - Stabilize existing foundation in place; while
  - minimizing excavation, undermining and risk of damage
- As a result, the following structural measures were implemented
  - Micro-piles
  - Tie-backs
  - Concrete collar to encompass stone masonry foundation



1 PERMANENT GROUTED TIE–BACK ANCHOR
SCALE: 1/4"= 1'– 0"



2 MICRO–PILE
SCALE: 1/2"= 1'– 0"

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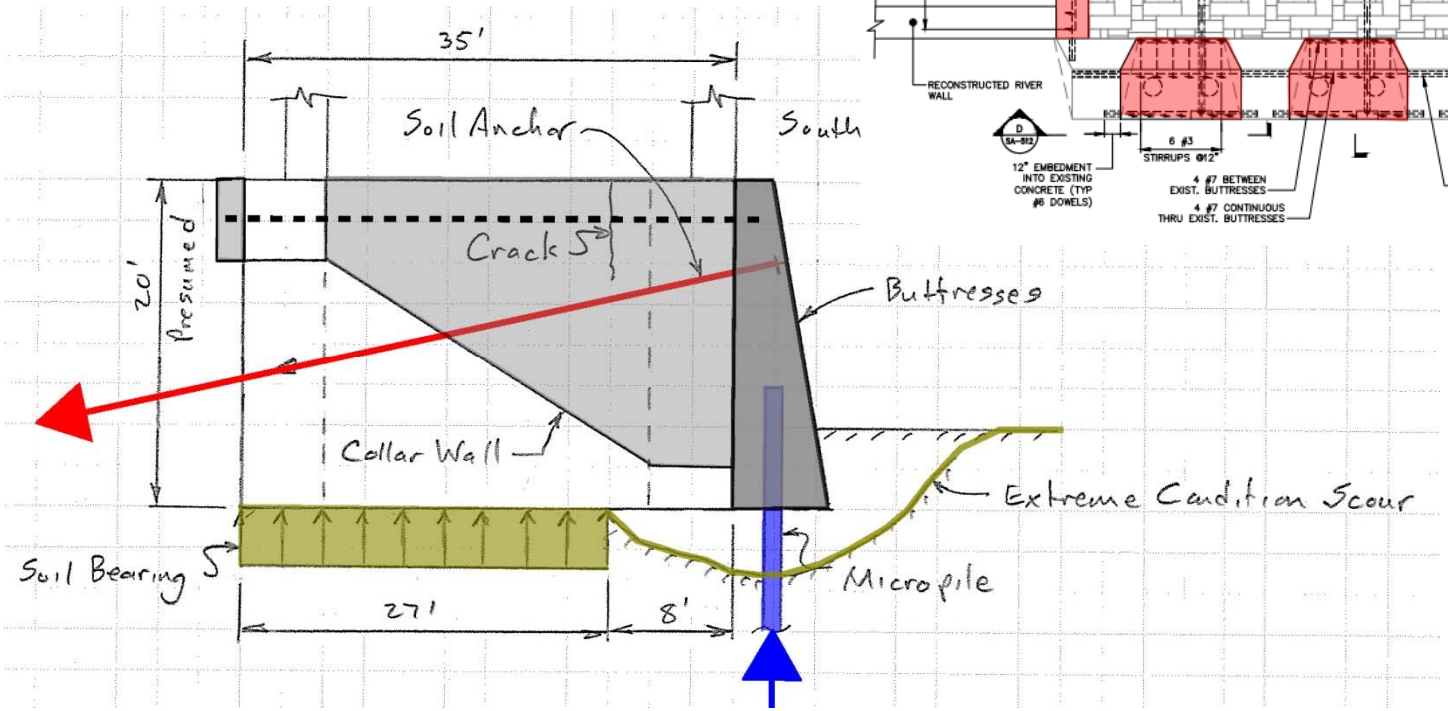

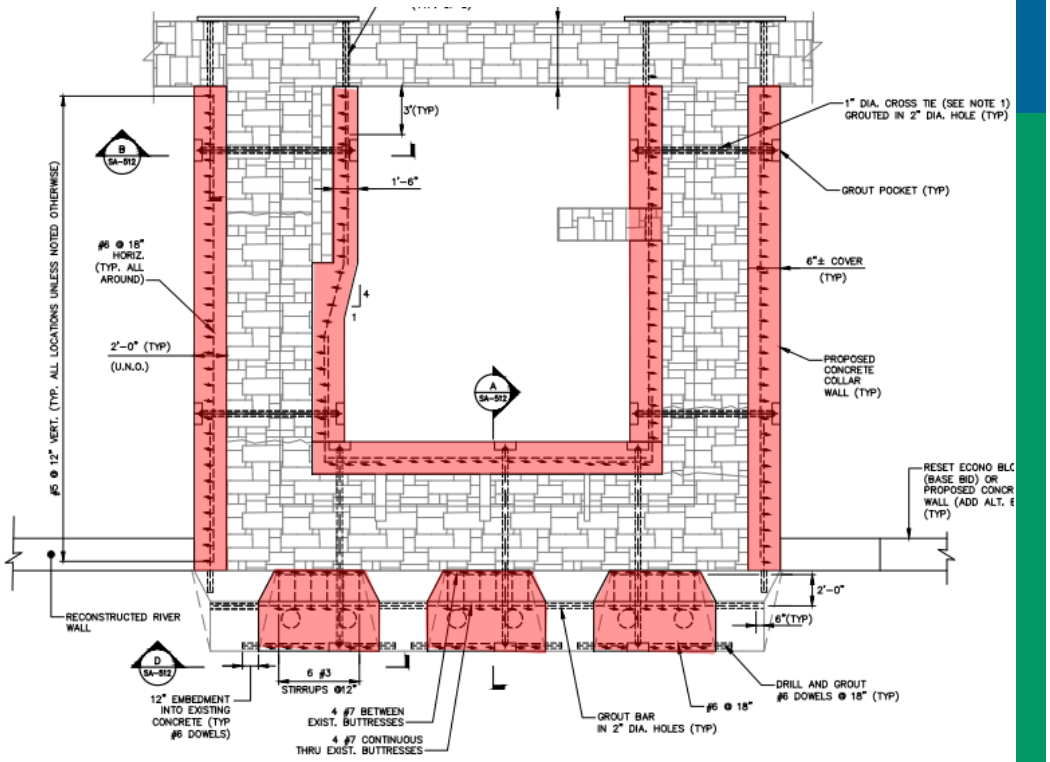

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March 2010 Flood

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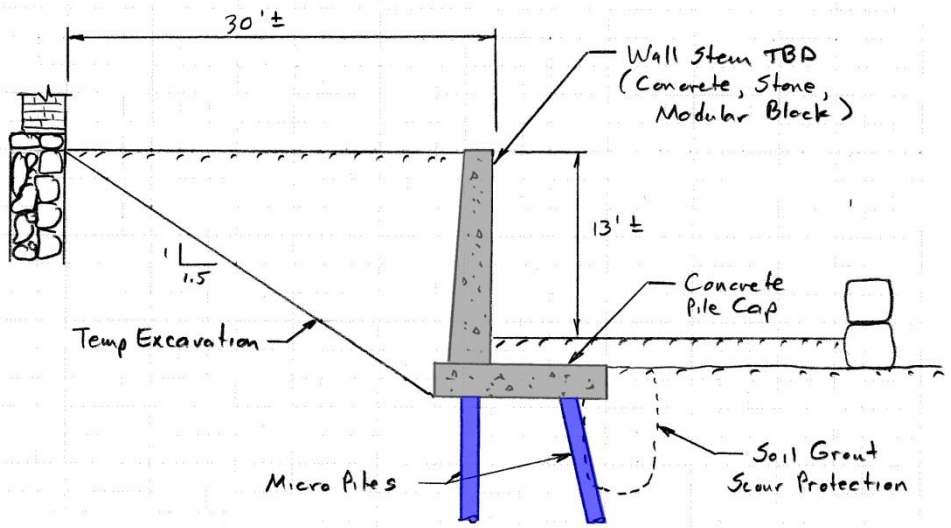
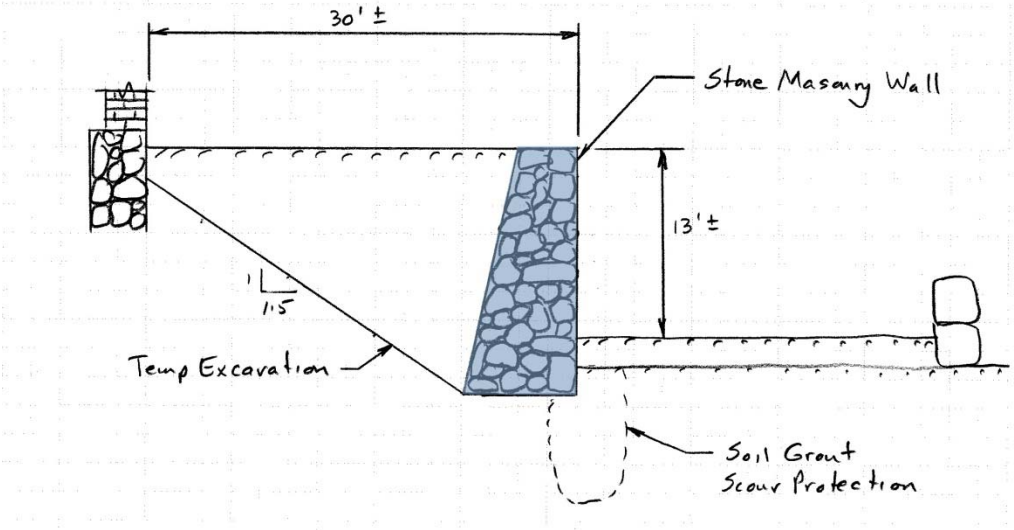
Bank Stabilization / Wall Repair Alternative

- Selected Alternative needed to:
  - Minimize excavation
  - Have a limited construction footprint
  - Eliminate the necessity for shoring which was risky & relatively expensive



Concrete Cantilever



Stone Gravity

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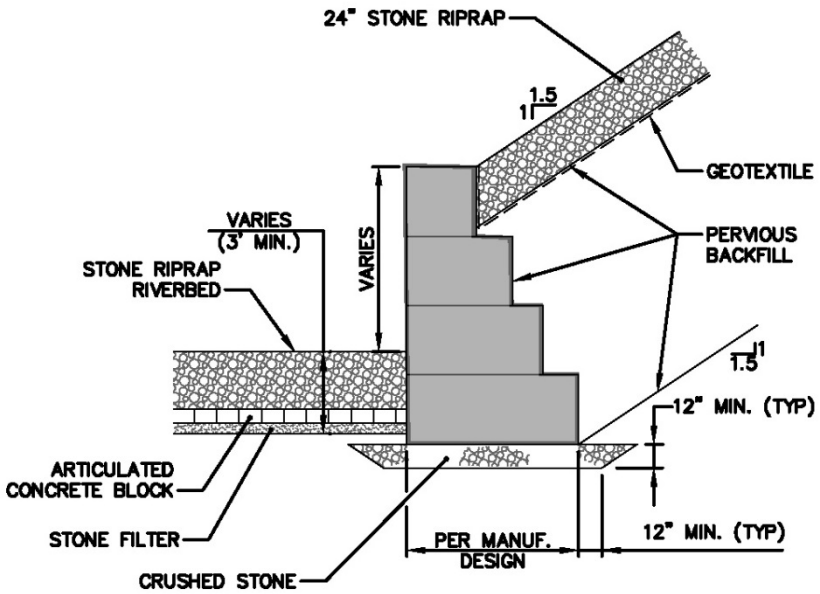
Selected Bank Stabilization / Wall Repair Alternative

- As a result, the following structural measures were implemented:
  - Pre-fabricated modular blocks selected for economy
  - Reduced wall height
  - Stone slope stabilization
- This was a cost-effective approach that allowed us to protect the river banks up to the 100-year flood while keeping the project within the construction budget.



Prefabricated Modular Concrete Blocks

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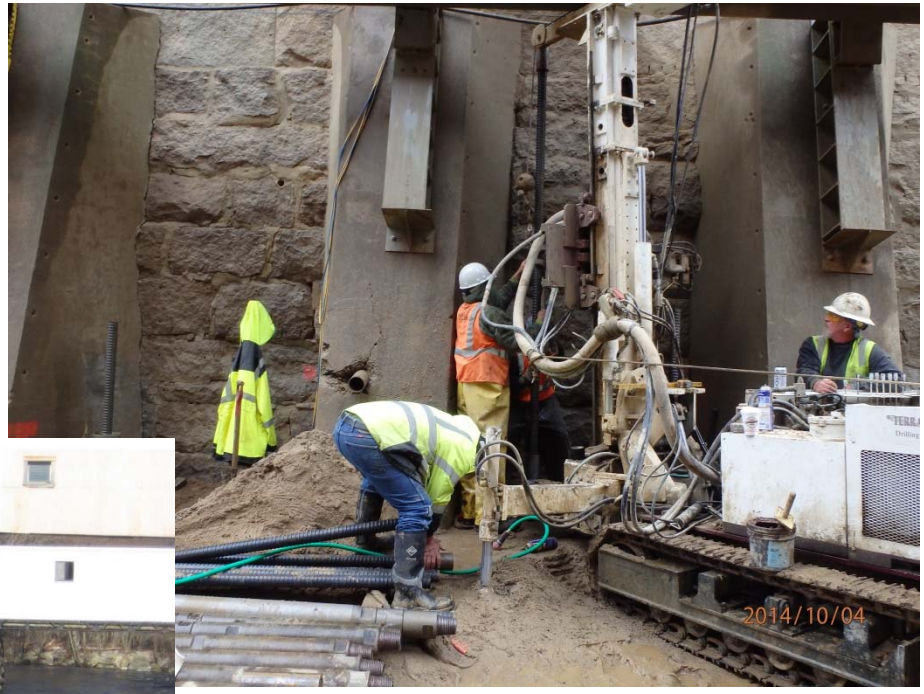
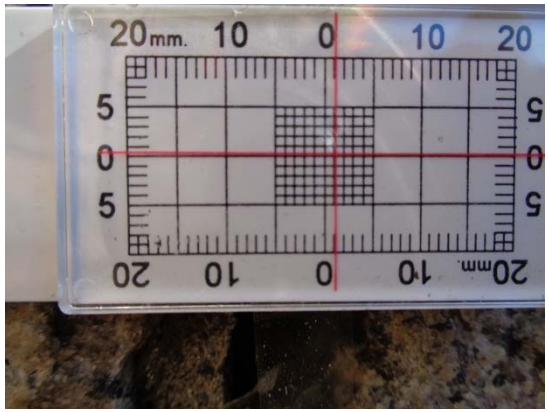
Rebuilding After the Flood – Pawtuxet River Stabilization Project

Sequence

1. Micropile Installation to stabilize buttress foundation





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March 2010 Flood

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Sequence

2. Buttress Further Reinforced

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Sequence

3. Tie-Back Installation

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Sequence

4. Reinforced Concrete Collar Walls Constructed Around Existing Masonry Foundation

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March 2010 Flood

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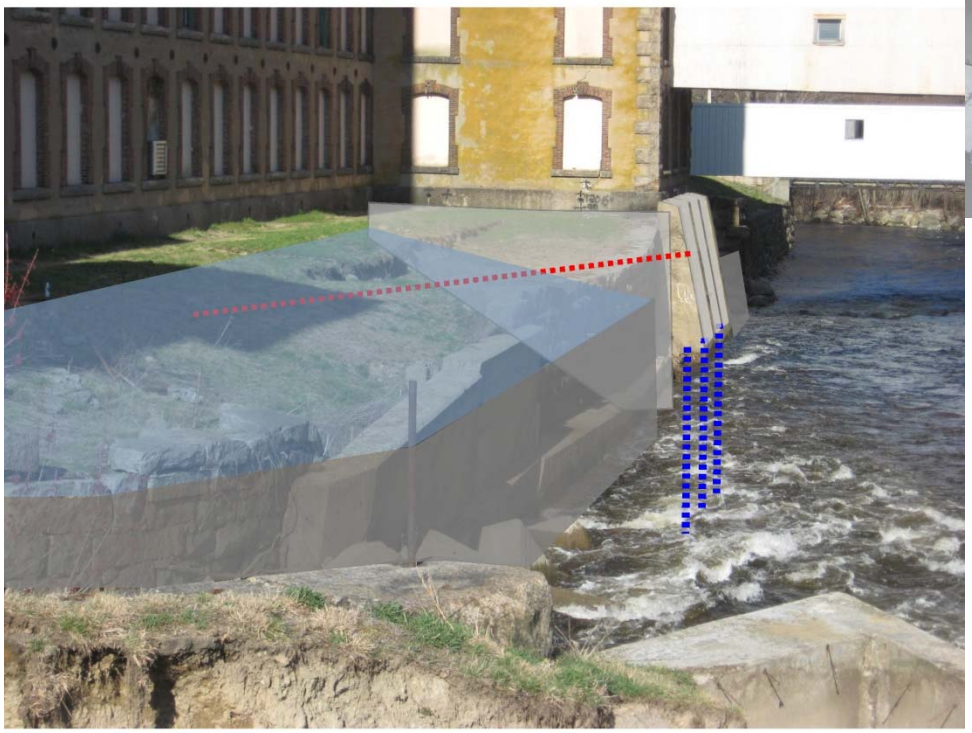
Sequence

5. Modular Block Retaining Walls Were Constructed Along Riverbanks



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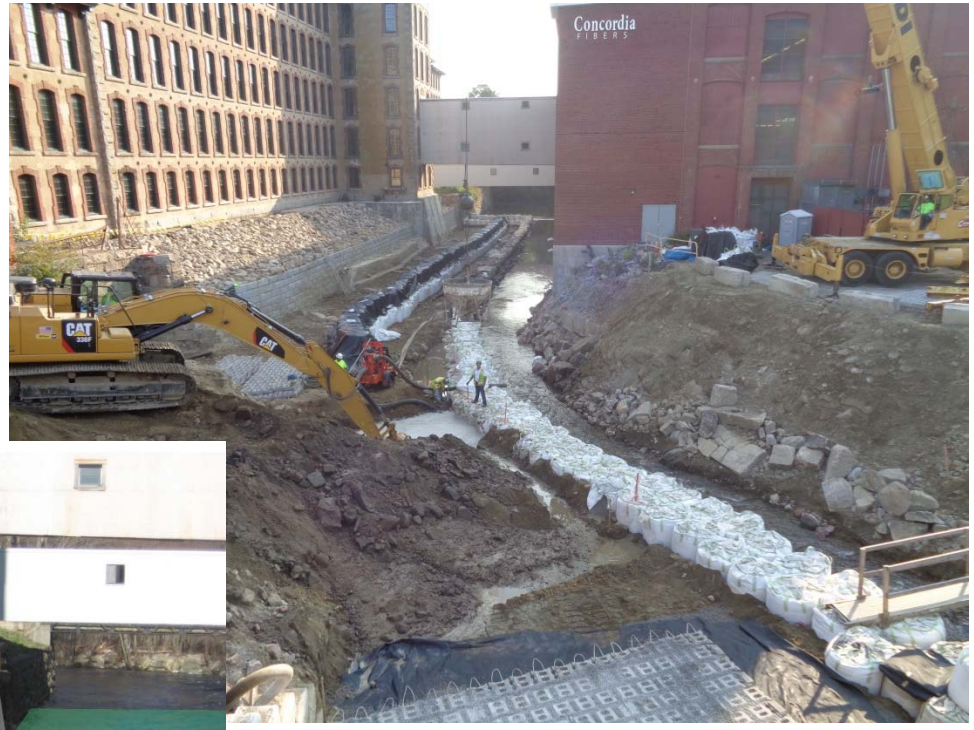
March 2010 Flood

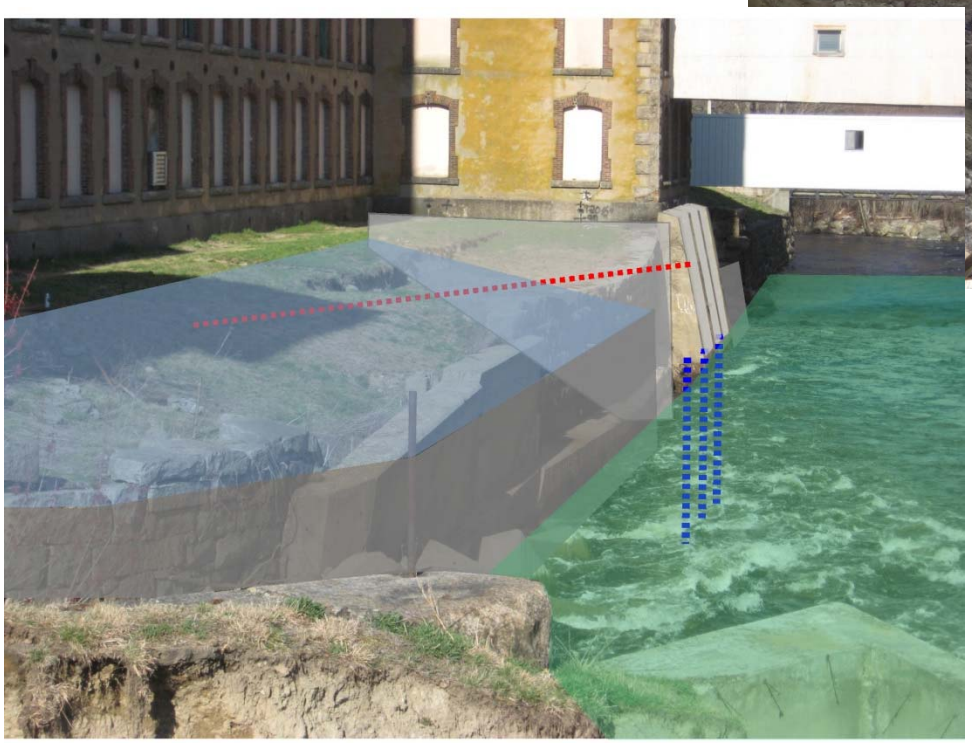
Rebuilding After the Flood – Pawtuxet River Stabilization Project

Sequence

6. Upper Banks of River Stabilized with Stone Slope Protection

River Channel Stabilization Measures were then installed!





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River Channel Stabilization Solutions

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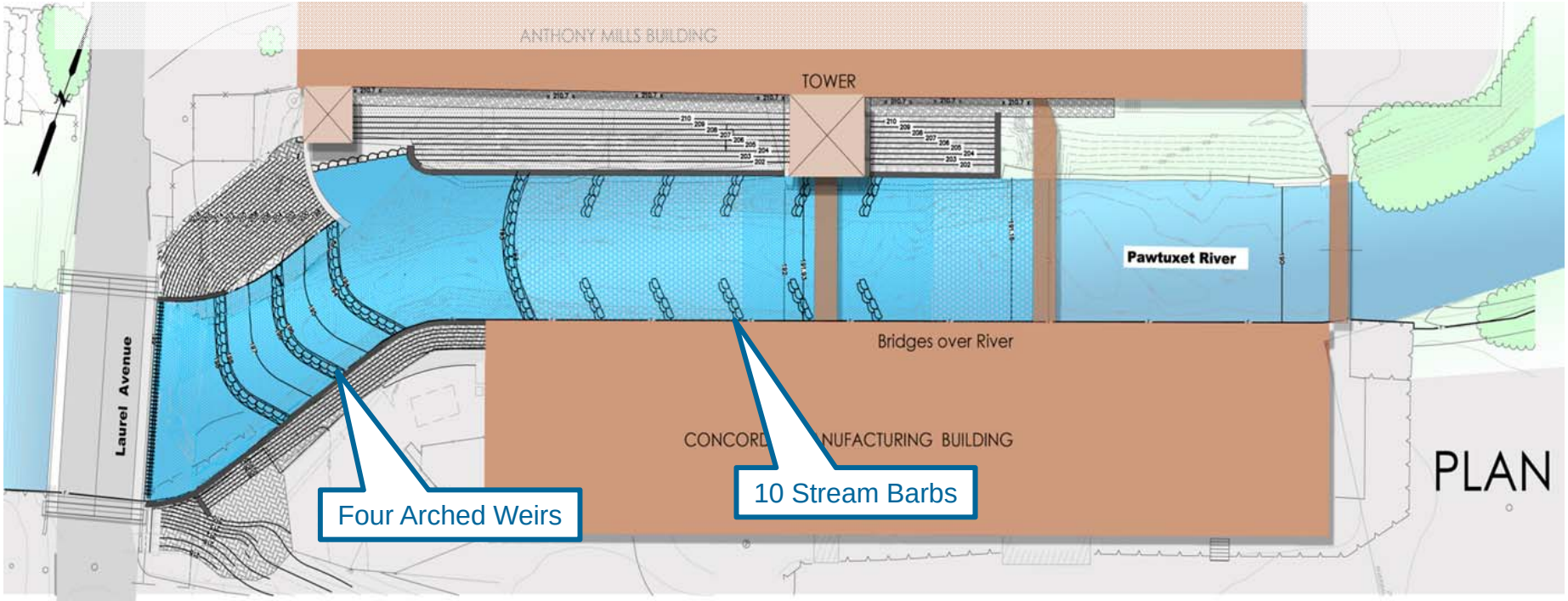
River Channel Stabilization Solutions

Rebuilding After the Flood – Pawtuxet River Stabilization Project

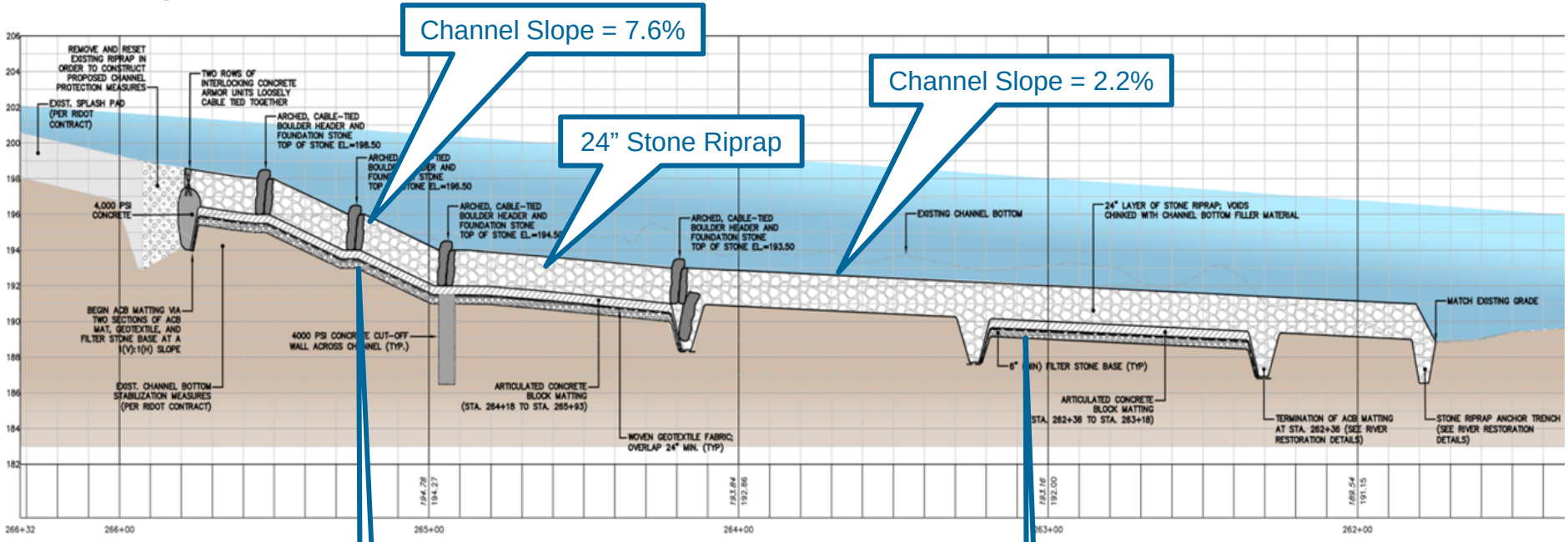
- Major channel and riverbank stabilization solutions included:
  - Two-Tiered Channel Bottom Scour Control System
  - Stream Barbs and Stone Arch Weirs
  - Pre-Fabricated River Walls and Stone Slope Protection



River Channel Stabilization Solutions

Rebuilding After the Flood – Pawtuxet River Stabilization Project

- Two-Tiered Channel Bottom Scour Control System in locations where scour anticipated to be the greatest



ACB Matting in Steep Portion of Channel and Where Scour was computed to be greatest

ACB Matting in Location of Channel Constriction

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- Two-Tiered Channel Bottom Scour Control System

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- Two-Tiered Channel Bottom Scour Control System

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- Two-Tiered Channel Bottom Scour Control System

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River Channel Stabilization Solutions

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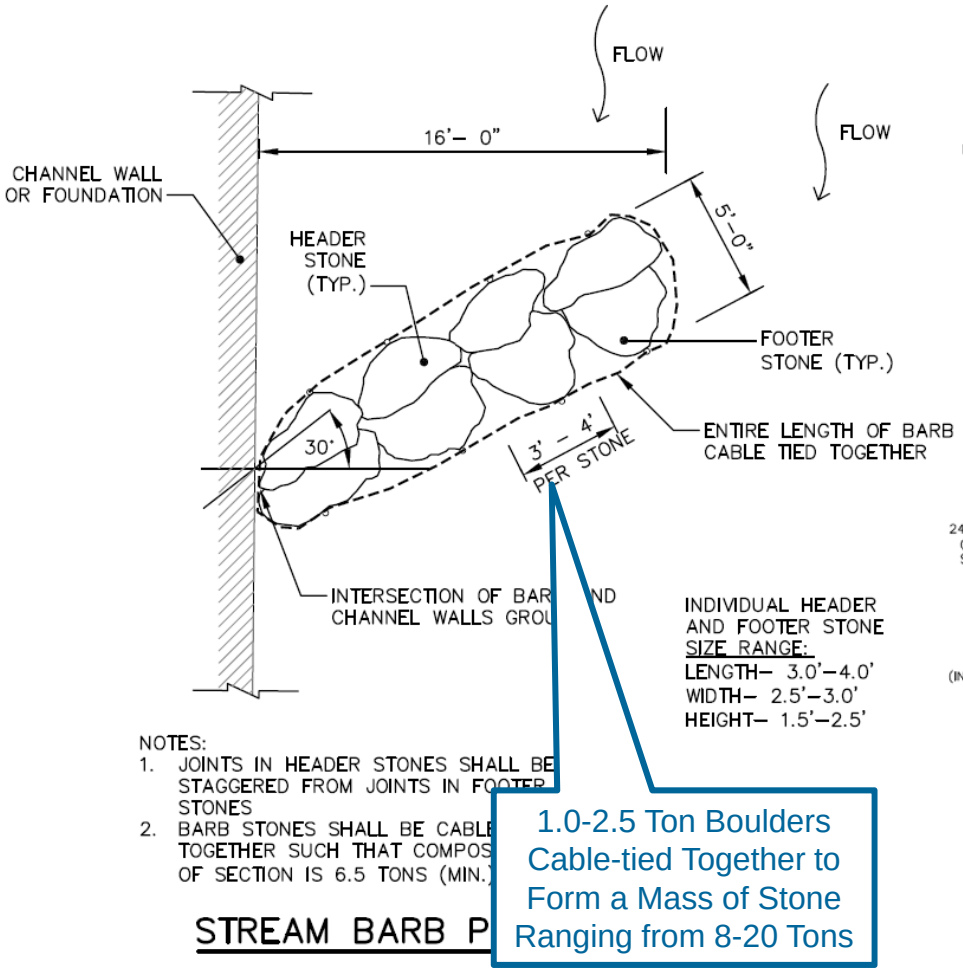
- Stream Barbs and Stone Arch Weirs proposed for energy dissipation and to divert energy/flow away from river walls

Stream barbs also provide pool habitat for fish.

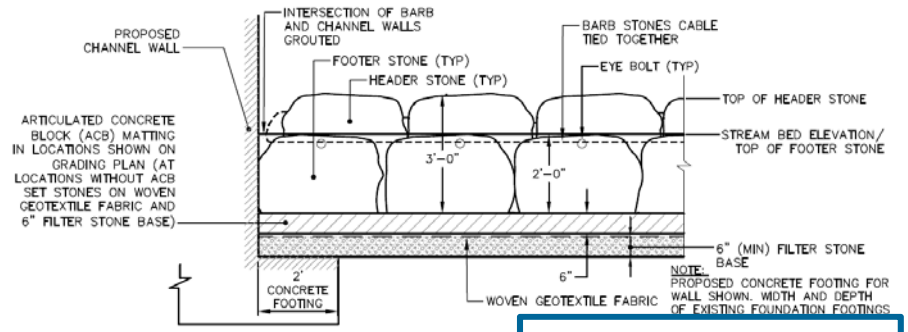
River Channel Stabilization Solutions

Rebuilding After the Flood – Pawtuxet River Stabilization Project

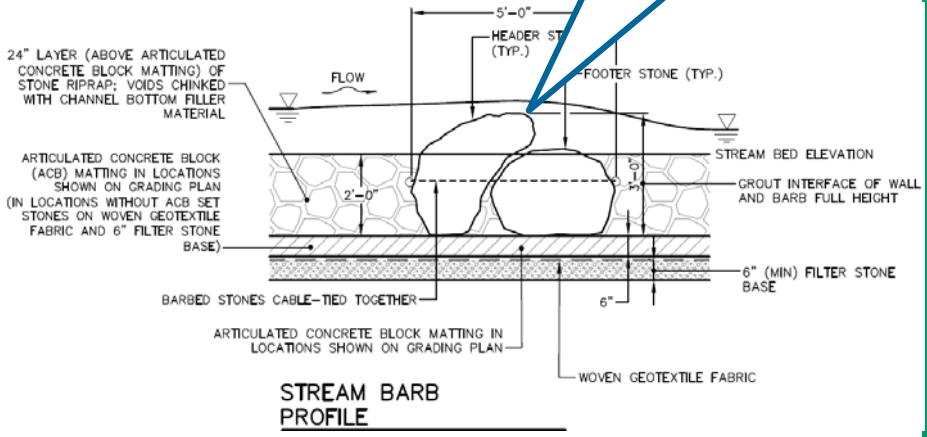
What are Stream Barbs?



1.0-2.5 Ton Boulders Cable-tied Together to Form a Mass of Stone Ranging from 8-20 Tons



Top of Header Stones Set 12-Inches Above Stream Bed Elevation



Stream barbs also provide pool habitat for fish.

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River Channel Stabilization Solutions

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- Stream Barb Construction

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Rebuilding After the Flood – Pawtuxet River Stabilization Project

- Stream Barb Construction

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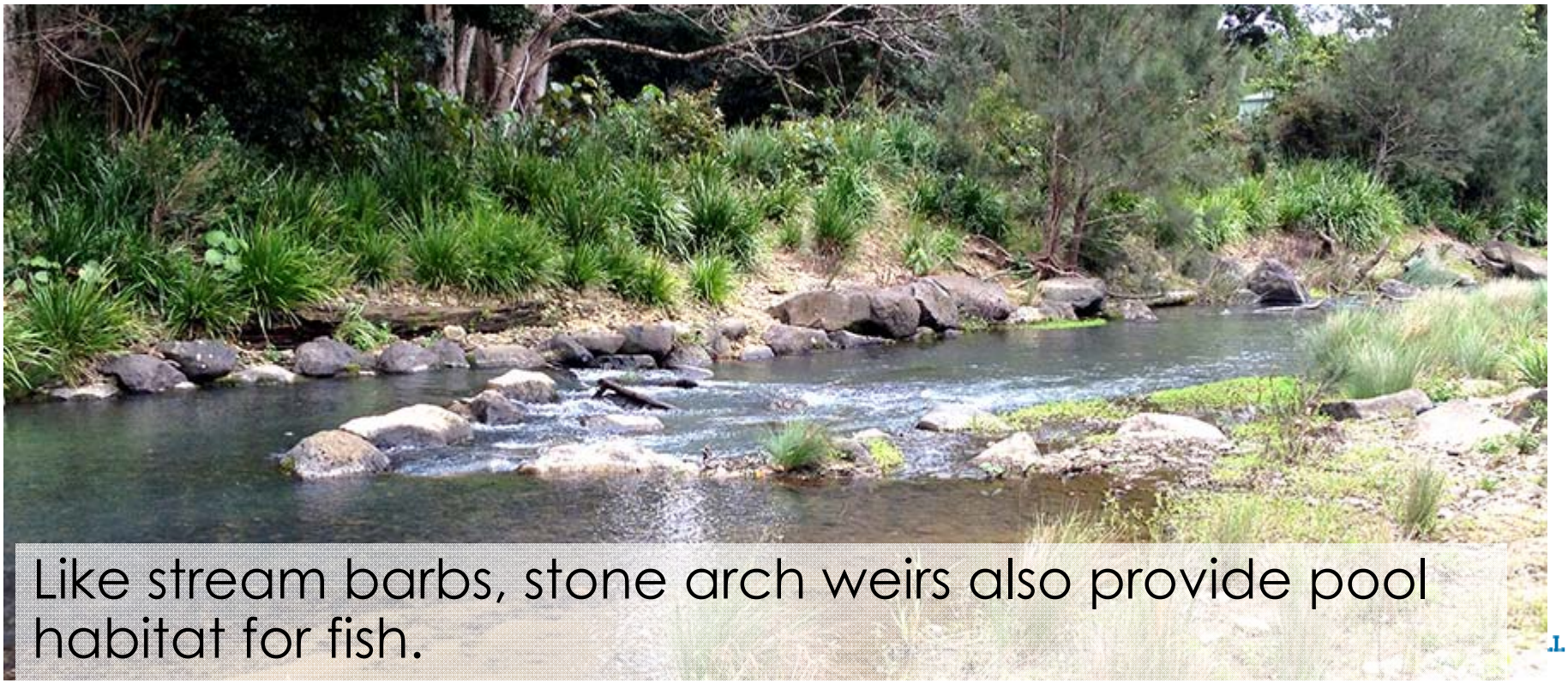
Rebuilding After the Flood – Pawtuxet River Stabilization Project

- What are stone arch weirs?

Stone arch weirs are grade control structures that decrease near-bank shear stress, velocity and stream power, while redirecting the energy to the center of the channel.

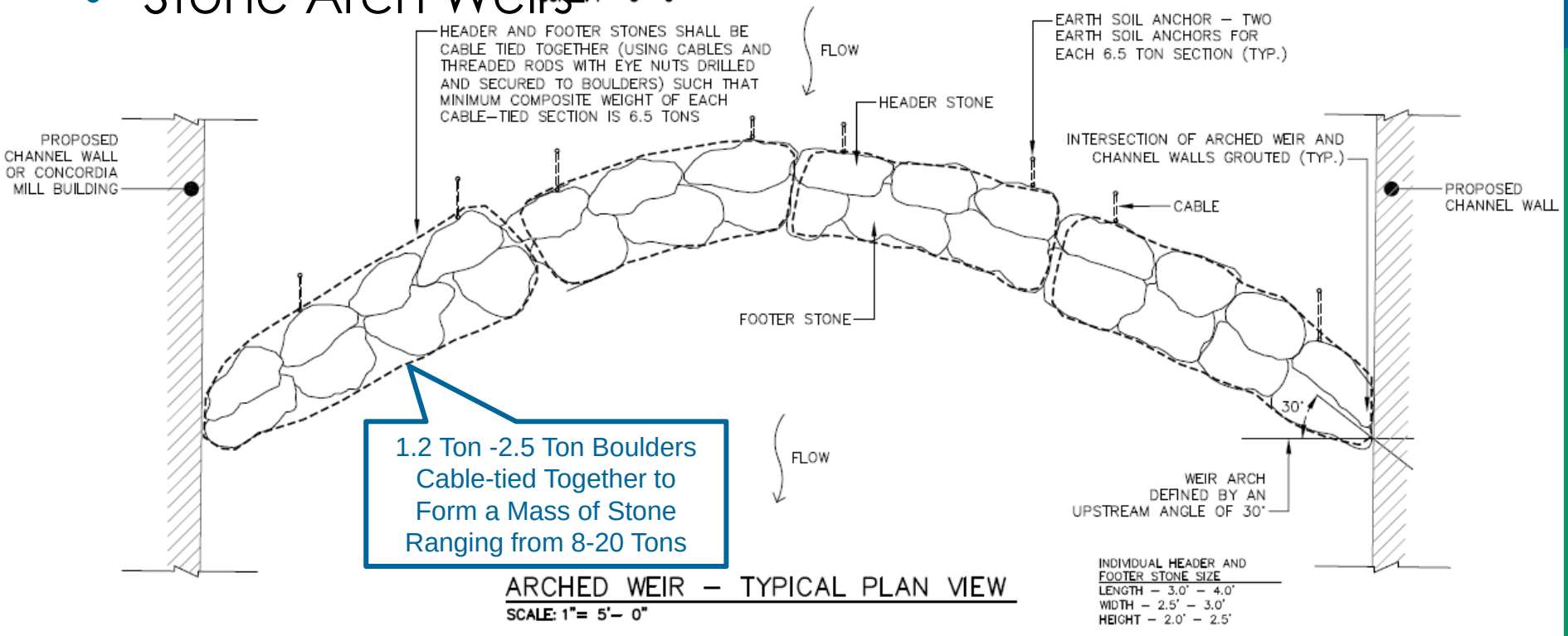


Like stream barbs, stone arch weirs also provide pool habitat for fish.

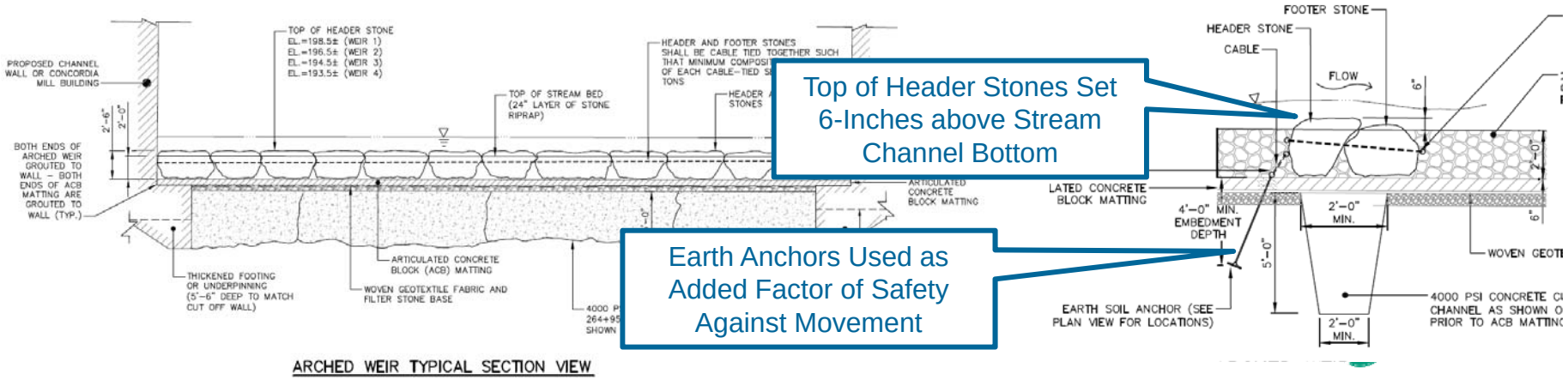
River Channel Stabilization Solutions

Rebuilding After the Flood – Pawtuxet River Stabilization Project

- Stone Arch Weirs



1.2 Ton -2.5 Ton Boulders Cable-tied Together to Form a Mass of Stone Ranging from 8-20 Tons



Top of Header Stones Set 6-Inches above Stream Channel Bottom

Earth Anchors Used as Added Factor of Safety Against Movement

River Channel Stabilization Solutions

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- Stone Arch Weir Construction

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- Stone Arch Weir Construction

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River Channel Stabilization Solutions

Rebuilding After the Flood – Pawtuxet River Stabilization Project

- Stone Arch Weir Construction

- **Hydraulic modeling confirmed that the arched weirs reduced the energy grade line in steep section of reach from 7.6% to 1.6%.**

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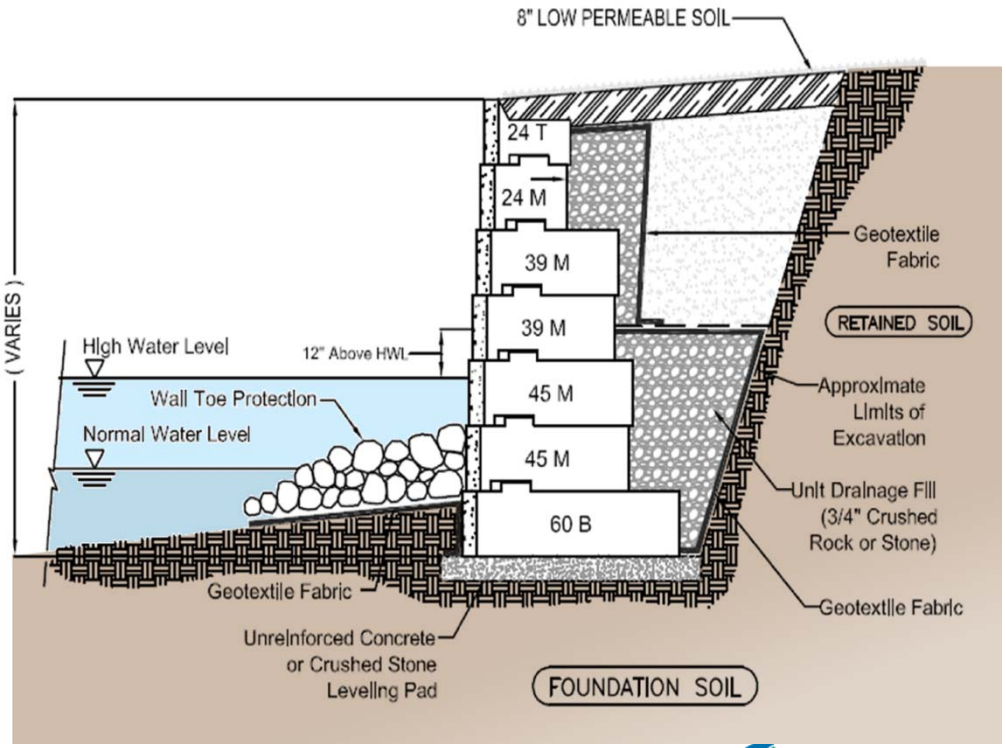
River Channel Stabilization Solutions

Rebuilding After the Flood – Pawtuxet River Stabilization Project

- Pre-Fabricated River Walls and Stone Slope Protection
  - Pre-Fabricated River Walls were proposed to save project costs and stay within allotted funding
  - Finish of walls were consistent with granite appearance



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River Channel Stabilization Solutions

Rebuilding After the Flood – Pawtuxet River Stabilization Project

- Pre-Fabricated River Wall System

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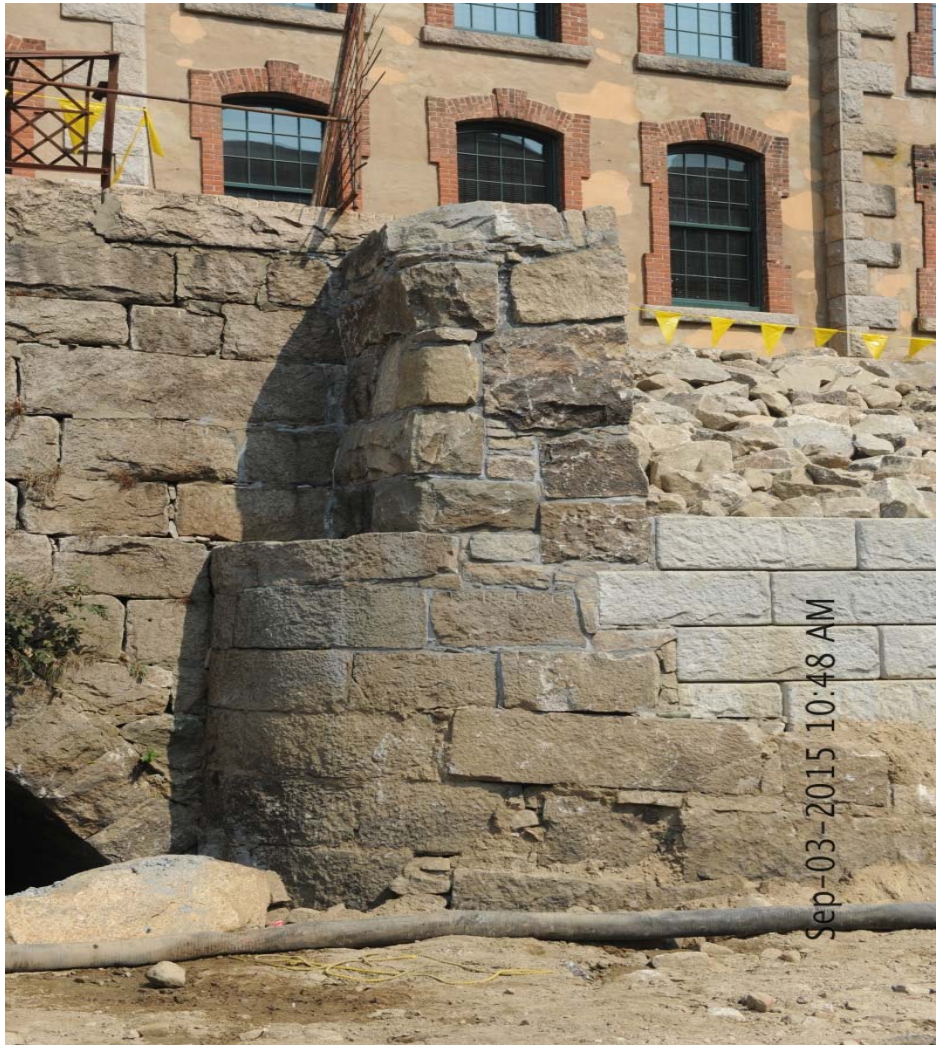
River Channel Stabilization Solutions

Rebuilding After the Flood – Pawtuxet River Stabilization Project

- Pre-Fabricate River Wall System Connect to Exist. Granite Walls



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Rebuilding After the Flood – Pawtuxet River Stabilization Project

- Pre-Fabricated River Walls and Stone Slope Protection

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River Channel Stabilization Solutions

Rebuilding After the Flood – Pawtuxet River Stabilization Project

- As a result of the river channel stabilization improvements, flow velocities during the 100-year flood event were reduced from 14.0 fps to less than 10.0 fps.
- The river channel cross-section was widened and the geometry around the bend was improved.
- The channel bottom was protected against future scour.
- Energy through the river system was reduced and high flow velocities were redirected from the river channel walls (edges) towards the center of the river.
- These benefits were achieved without any adverse to existing upstream and downstream floodplain elevations.

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Pre- Versus Post-Project Comparison

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Construction Challenges

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Construction Challenges

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- Poor construction access and limited work space.
  - Temporary Soil Nail Walls required to construct river wall system near bridge
  - Smaller Drilling Equipment required for Micropile Installation

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Construction Challenges

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- Temporary Bridge necessary to gain access to north side of river due to limited construction access

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Construction Challenges

Rebuilding After the Flood – Pawtuxet River Stabilization Project

- Work within an active business zone and residential complex.
  - Dust Control (especially during summer months)
  - Vibration and Crack Monitoring

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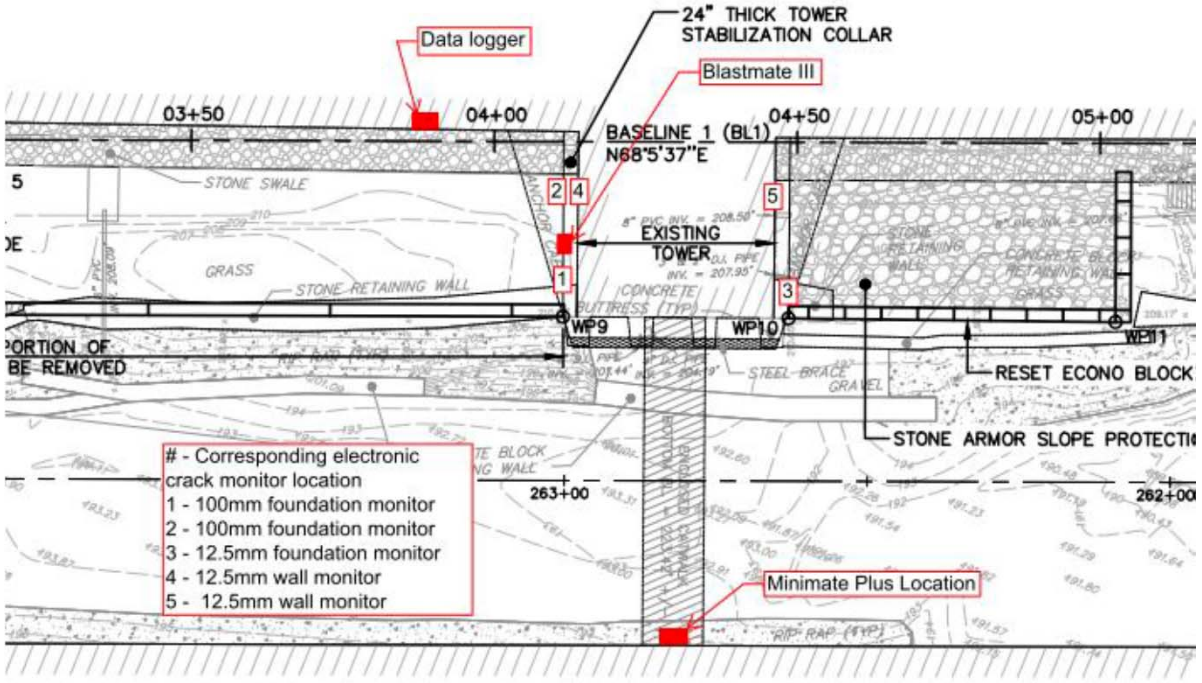
Construction Challenges

Rebuilding After the Flood – Pawtuxet River Stabilization Project

- Crack and Vibration Monitoring – 24 hours/day
- 2 Seismographs (Transient Vibration Threshold at 0.25 in./sec. which is considered Distinctly Perceptible to Humans) – Trigger set at 0.05 in./sec.
- 5 Electronic Crack Meters and 6 Analog Crack Gauges



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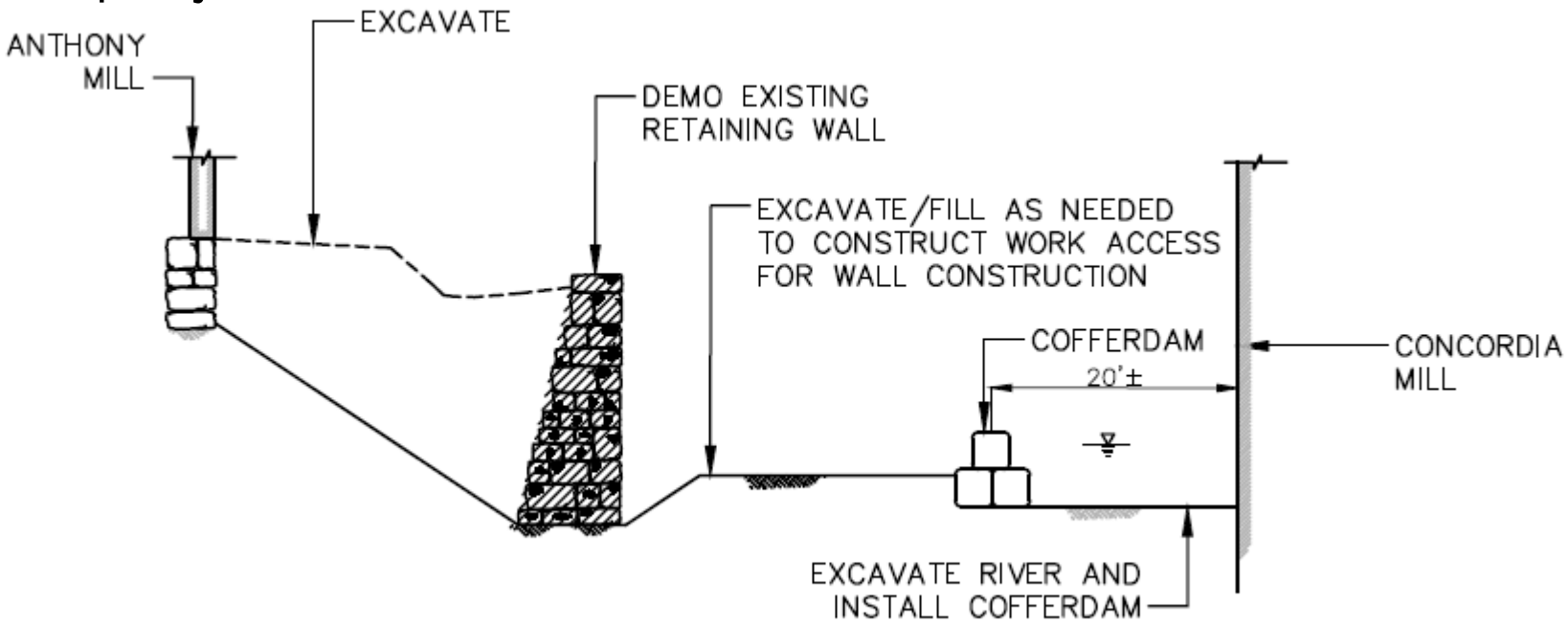
Construction Challenges

Rebuilding After the Flood – Pawtuxet River Stabilization Project

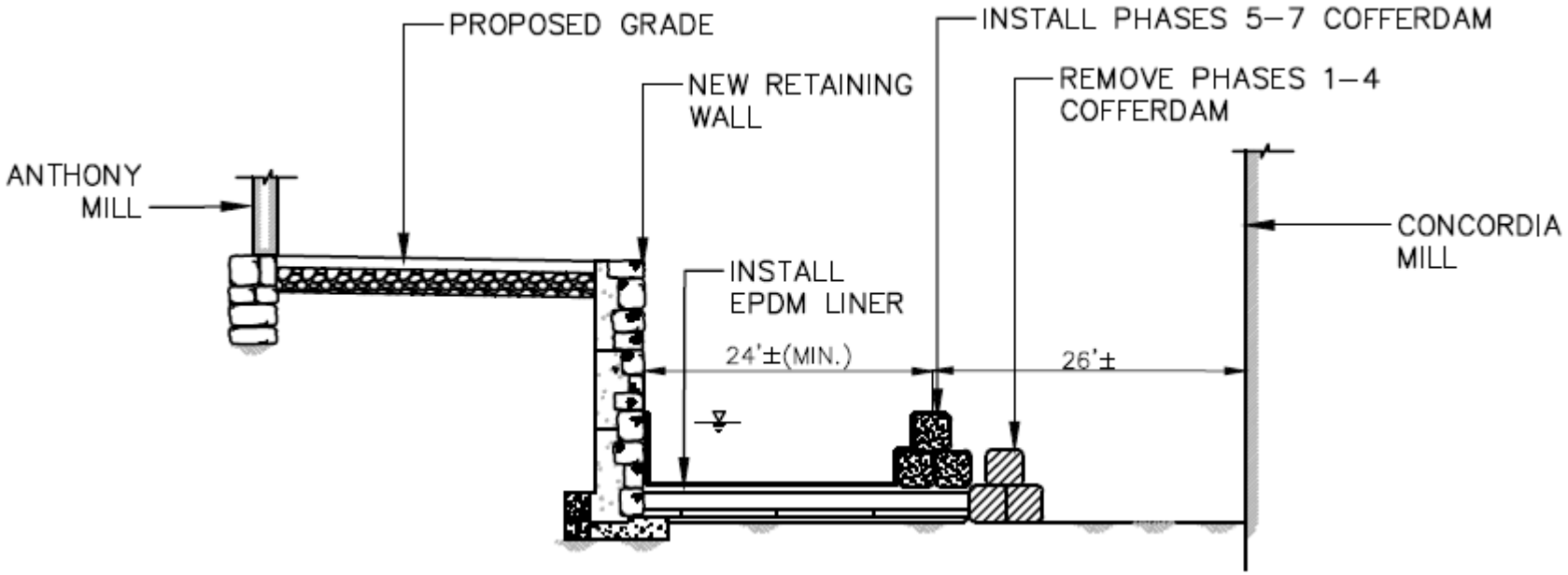
- Another big challenge - Water Control (Phasing)
  - The fact that the project was located within a floodway of a major river was a challenge. Water control was an integral part of the project.



Initial major phase of water control was to divert flow to southern side of river.

Construction Challenges

Rebuilding After the Flood – Pawtuxet River Stabilization Project



Second major phase of water control was to divert flow to northern side of river.

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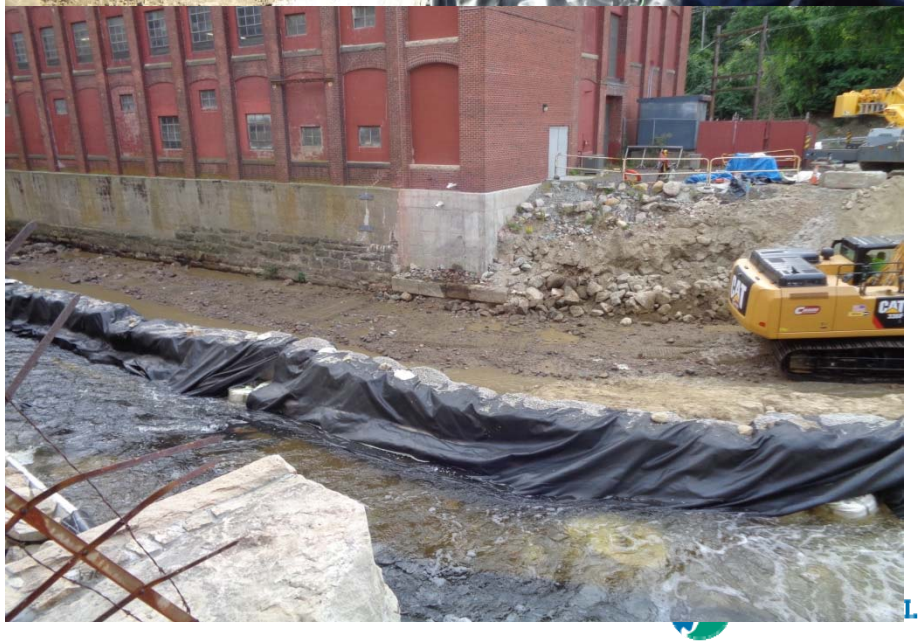
Construction Challenges

Rebuilding After the Flood – Pawtuxet River Stabilization Project



Construction Challenges

Rebuilding After the Flood – Pawtuxet River Stabilization Project

- Despite the challenges, substantial completion was achieved in December of 2015 (after approximately 18 months of construction).

Jan. 2016: The ribbon cutting celebration was held on Jan. 15, 2016 and included several partners along with U.S. Senator Whitehouse, U.S. Congressman Langevin, and U.S. Senator Reed.

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Pre- Versus Post-Project Comparison

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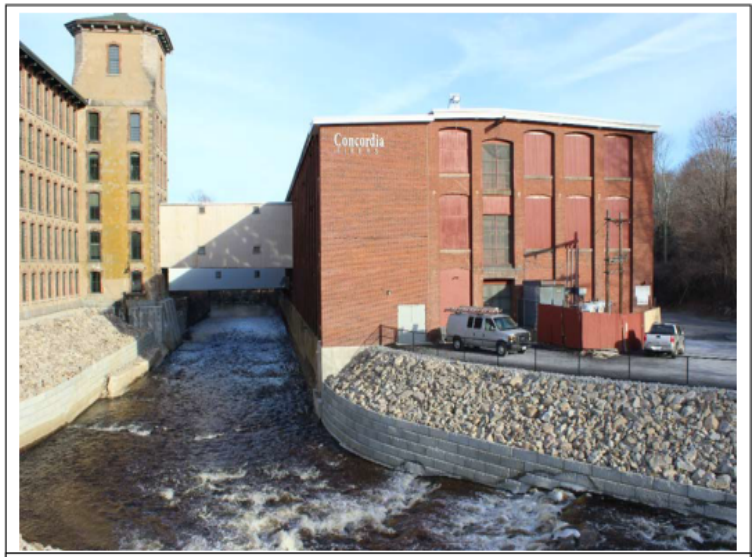
Pre- Versus Post-Project Comparison

Rebuilding After the Flood – Pawtuxet River Stabilization Project

March 2010: Peak flood flows in the Pawtuxet River during the historic storm event. The riverbank is eroded but the building at Concordia Manufacturing is still intact.

March 2010: Flood flows cause severe erosion of the riverbank. This led to a partial collapse of the Concordia Manufacturing building. As a result, the building was uninhabitable.



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Pre- Versus Post-Project Comparison

Rebuilding After the Flood – Pawtuxet River Stabilization Project

April 2010: Riverbank failure below Laurel Avenue Bridge in Coventry, RI; residents and property downstream need to be protected. The retaining wall collapses into the river.

April 2010: Severe erosion has jeopardized the local businesses adjacent to the river, permanent repairs are necessary to ensure employment security and protect critical infrastructure.

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June 2010: NRCS emergency repairs included providing rock rip rap and concrete armor along the toe of the severely eroded riverbank.

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Questions

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Project Video

(from Channel 12 News Report)

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Introductory Project Video

Rebuilding After the Flood – Pawtuxet River Stabilization Project

Pawtuxet River Restoration Project Completed in Coventry

Source: http://wpri.com/2016/01/15/pawtuxet-river-restoration-project-completed-in-coventry/

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