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# Stream Crossings I: Engineering and Design Approaches to Provide Fish Passage at Culvert Slipline Projects in Connecticut

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# Culvert Sliplining

**Definition:** Smaller culvert or sleeve is installed or slipped within an existing culvert barrel and stabilized.

## Advantages:

- Does not require any excavation of existing culverts or roadway fill.
- No disruption to traffic.
- Cheap, cost effective and reduces overall construction time period.

## Disadvantages:

- Several Potential Obstacles to Upstream Fish Passage
  - Perched culverts at outlet
  - Shallow water depth
  - Increased water velocities
  - Culvert length/slope
  - Smaller diameter collects debris

# Three Examples of Culvert Slipline Projects and approaches to provide upstream fish passage

- Tributary Lyman Brook, Marlborough

  Outlet pool/weir fishway and culvert baffles

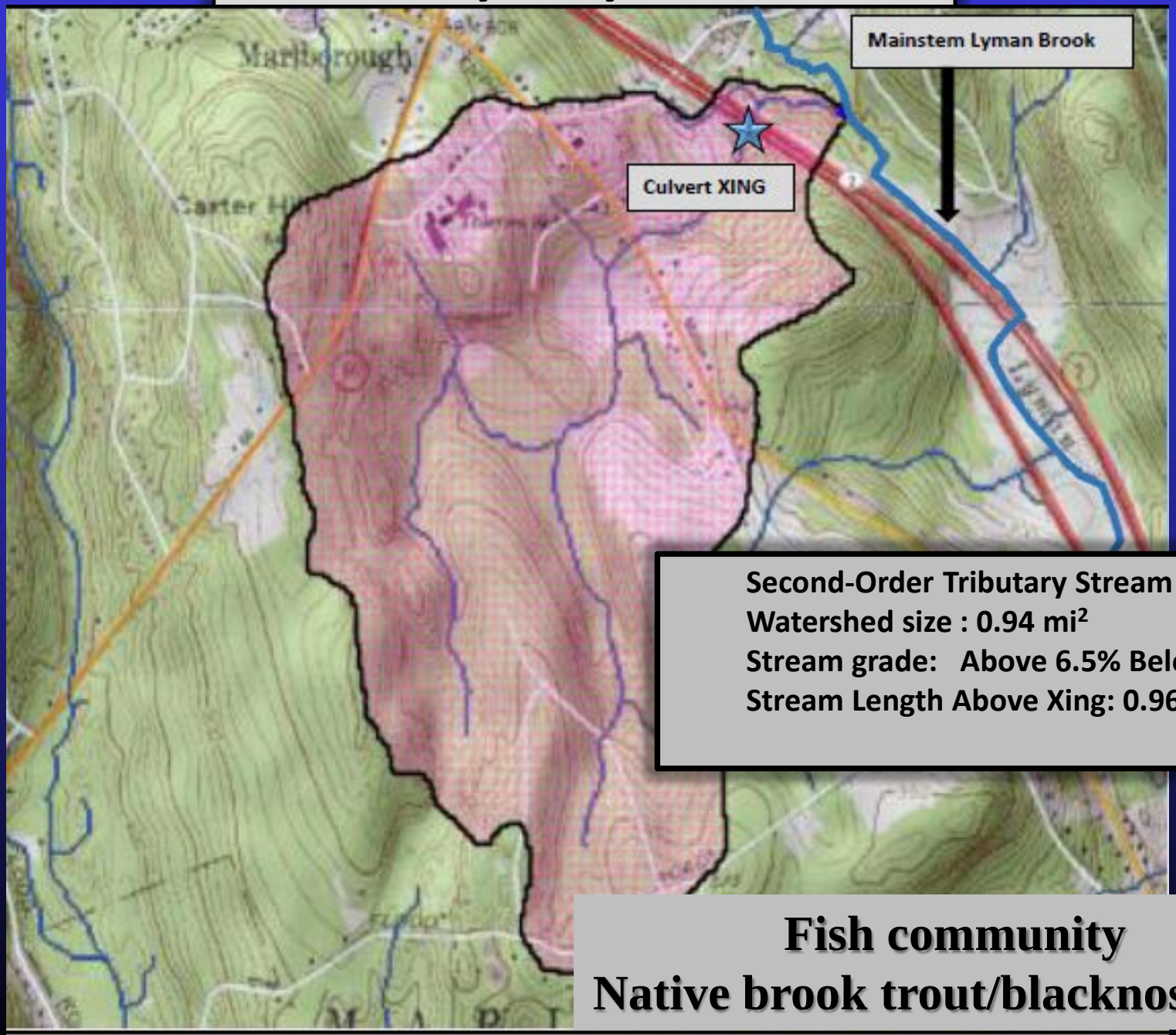
- Tributary Hubbard Brook, Middletown

  PreFab Concrete Fishway and culvert baffles

- Great Brook, Chester

  Concrete Inlet Weirs and Outlet Rock Weirs

# Tributary to Lyman Brook




Second-Order Tributary Stream
Watershed size : 0.94 $mi^2$
Stream grade: Above 6.5% Below: 2 %
Stream Length Above Xing: 0.96 miles

**Fish community**
**Native brook trout/blacknose dace**

# Potpourri of Fish Passage Issues!

Twin 6 ft. dia. corrugated metal: 262 ft. length at 4.5% slope

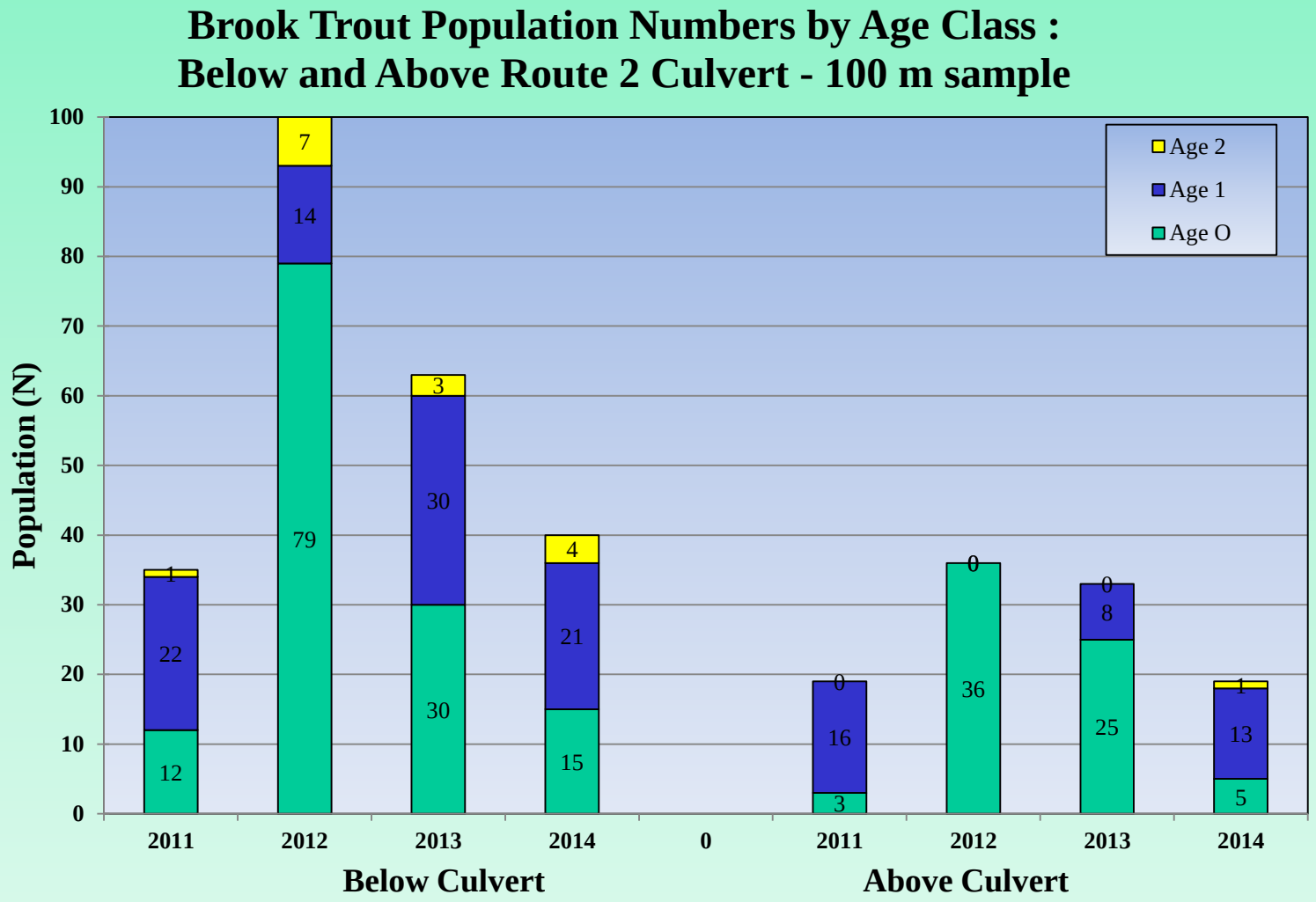


Outlet: Barrier due to drop/perch of 1.5 ft. in height.

Inlet: Prone to clogging with woody debris.

Various within culvert issues: Seasonal excessive water velocities, shallow water, lack roughness & velocity refugia.

# Population Data Confirms Fish Passage Issues!



# Fish Passage Design Features Target Species Native Brook Trout

Literature Review and FishXing Software

- Prolonged Swim Speed: 1. 3 ft/sec
- Burst Swim Speed: 3.1 ft/sec.
- Minimum water depth: 0.5 ft.

# Design Feature: Outlet Cast-in-Place Pool/Weir Fishway

- 6 pools/weirs at 4 inch drop per pool
- Three inch backwater into culvert
- Weirs notched (2 x 1 ft.) with weirboard slots

- Diversion wall at west culvert
- Boulder grade control holding pool below fishway

# Design Feature: Culvert Corner Baffle System

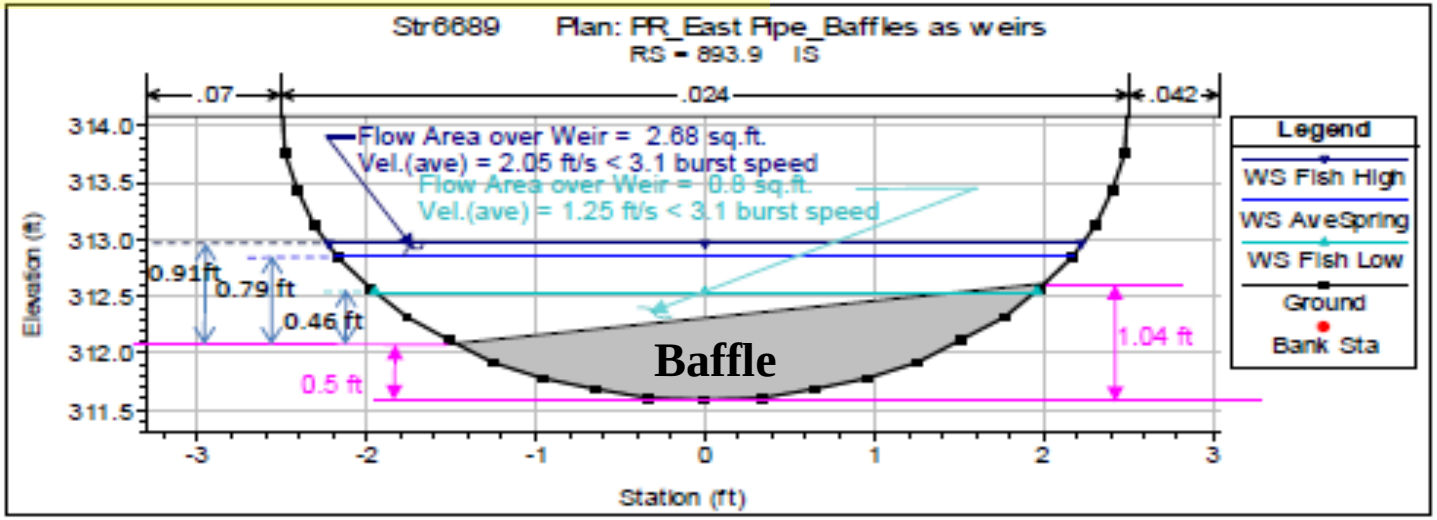
# Inlet Trash Rack and Diversion Wall

Hybrid Deflect and Collect Trash Rack to Minimize Debris & Maintenance in Baffled Culvert

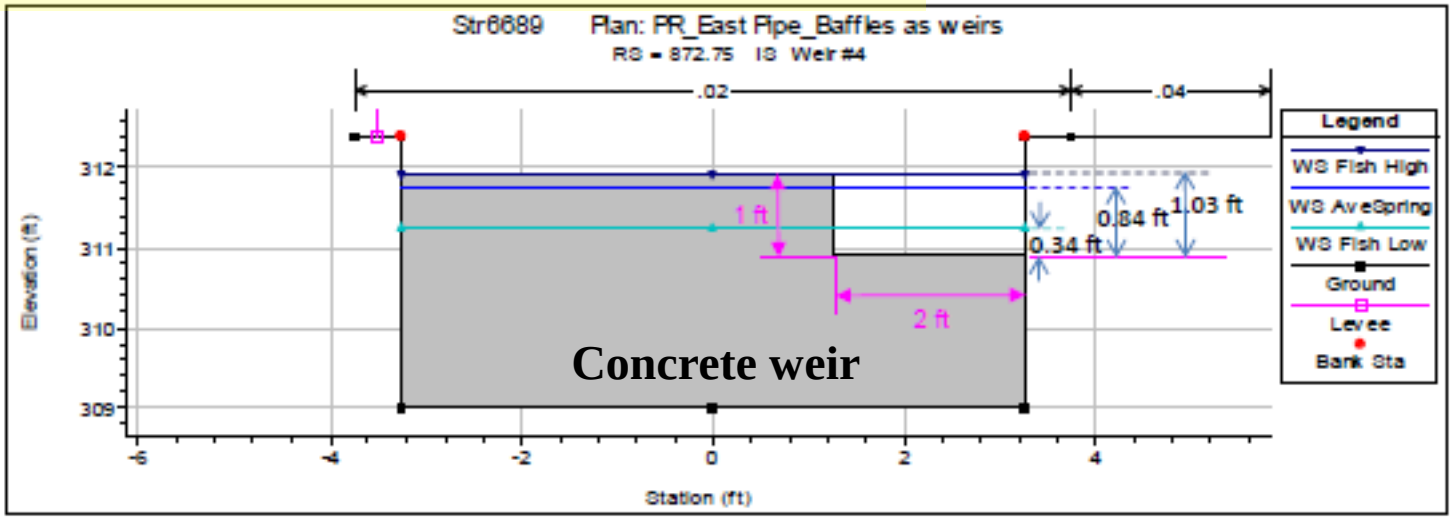

Diversion wall: average daily flows directed into baffled culvert. Flood flows conveyed into both culverts.

# Fish Passage Hydraulic Analysis (HEC RAS)

Typical Cross Section at A Baffle Inside The Culvert




Cross Section at Weir #4 (Typical Hyd. Condition for All Weirs)



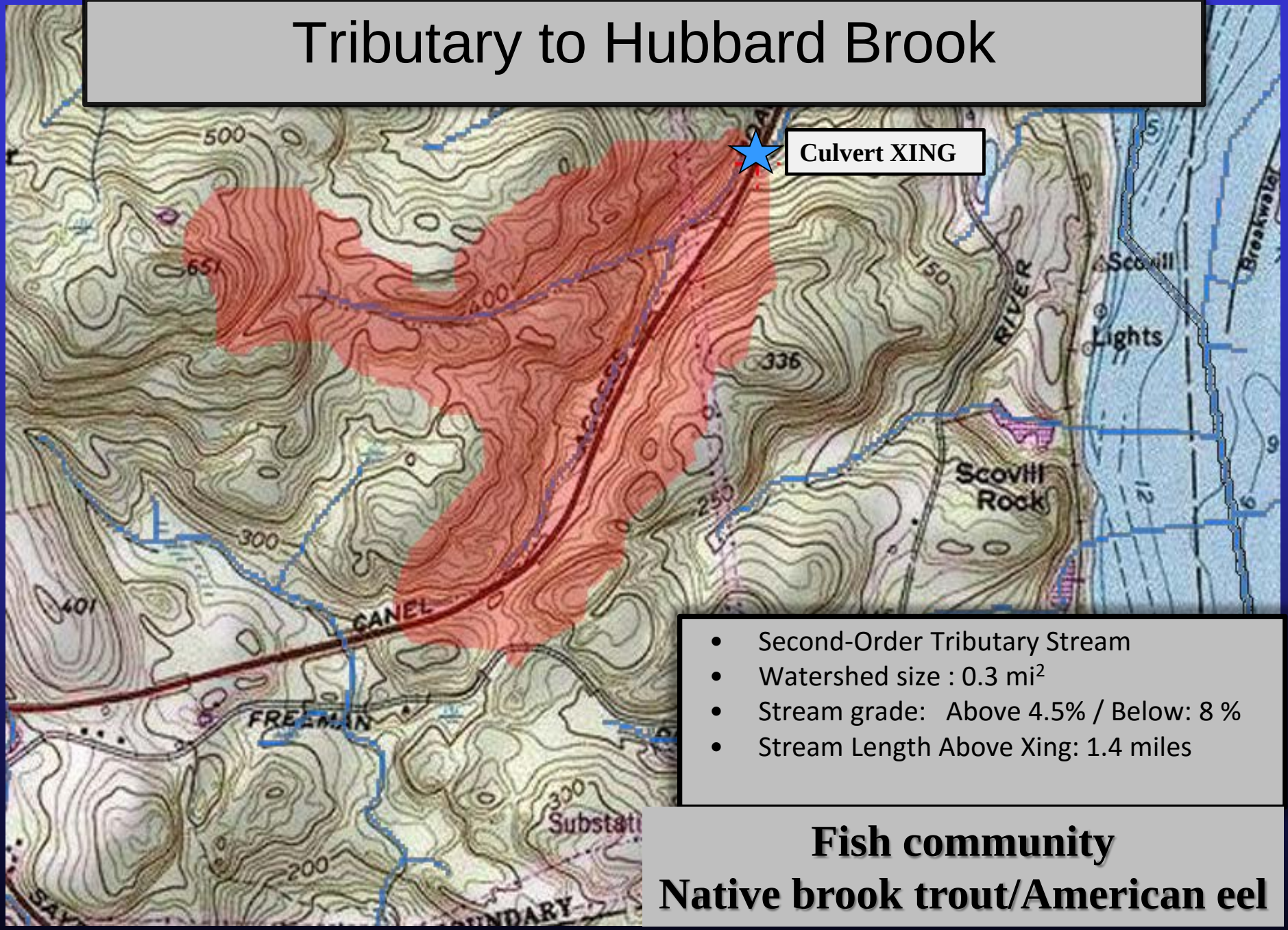
# Summary Fish Passage Hydraulic Analysis by Bioperiod

| | | BIOPERIODS | | |
|---|---|---|---|---|
| **Hydraulic Conditions** | **Habitat Forming** (March-AprilQ50) **4.0 CFS** | **Resident Spawning** (June Q75) **0.4 CFS** | **Rearing & Growth** (July-OctoberQ75) **0.1 CFS** | **Salmonid Spawning** (NovemberQ75) **0.5 CFS** |
| **Between Culvert Baffles** | | | | |
| Mean Depth (ft.) | 1.2 | 0.7 | 0.5 | 0.7 |
| Mean Velocity (ft./s) | 1.1 | 0.3 | 0.1 | 0.3 |
| **Over Culvert Baffles** | | | | |
| Mean (Max.) Depth (ft.) | 0.5 (0.8) | 0.2 (0.3) | 0.1 (0.2) | 0.2 (0.4) |
| Mean Velocity (ft,/s) | 1.8 | 1.0 | 0.8 | 1.1 |
| **Over Fishway Weir Notch** | | | | |
| Mean (Max.) Depth (ft.) | 0.8(0.8) | 0.2 (0.2) | 0.1 (0.1) | 0.2 (0.2) |
| Mean Velocity (ft./s) | 2.4 | 1.1 | 0.7 | 1.2 |
| **Upstream Channel** | | | | |
| Mean Depth (ft.) | 0.8 | 0.5 | 0.4 | 0.5 |
| Mean Velocity (ft/s) | 1.8 | 0.6 | 0.4 | 0.7 |

# Fish Passage Demonstration Site

- **Evaluate fish passage performance using passive integrated transponder (PIT) tag monitoring (2016-2018).**
- **Inland Fisheries Staff conduct study.**
  - **Equipment funded by CTDOT**
- **Utilize study findings to facilitate fish passage design for future culvert sliplining or culvert modification projects.**

# Tributary to Hubbard Brook



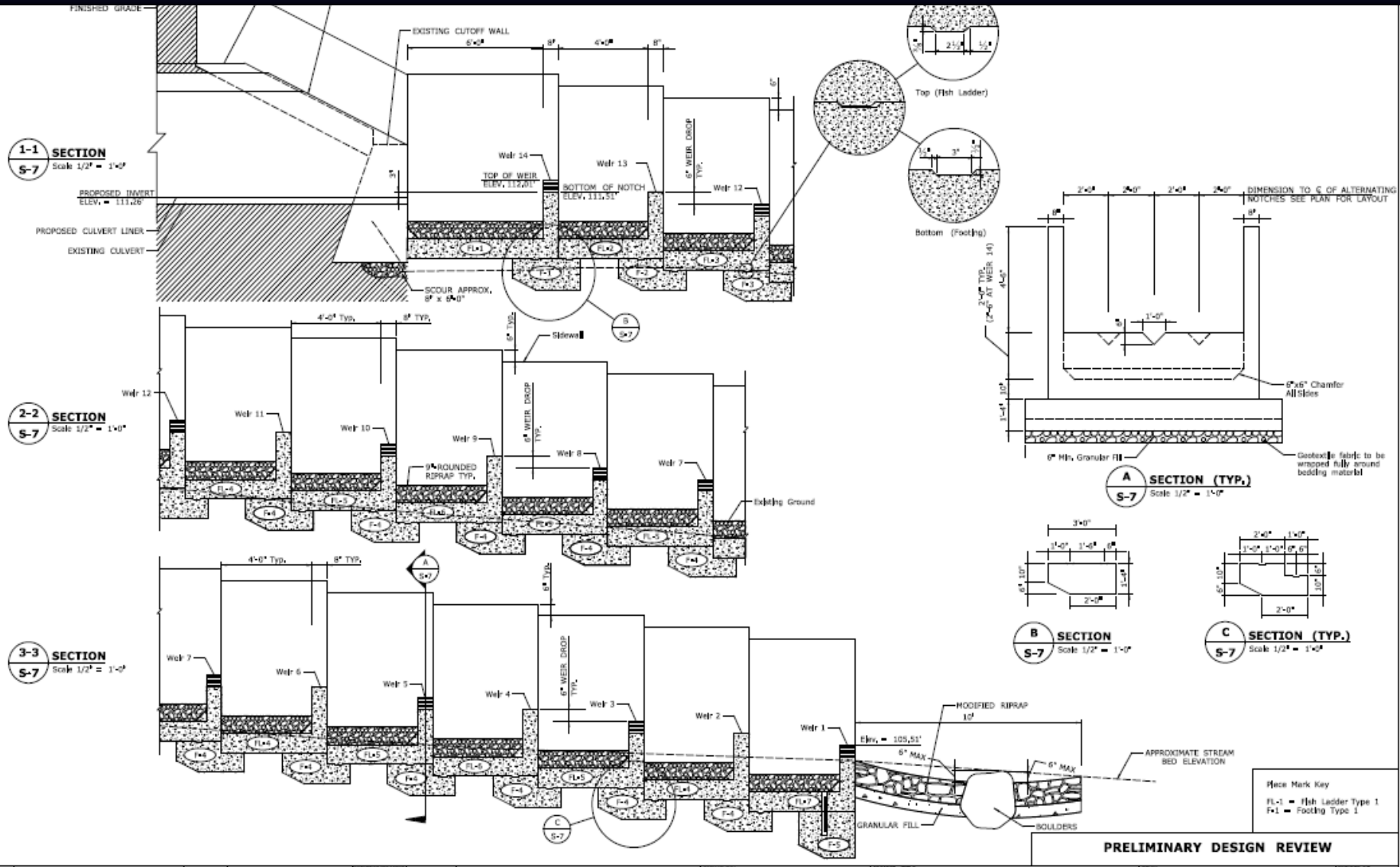

- Second-Order Tributary Stream
- Watershed size : 0.3 $mi^2$
- Stream grade: Above 4.5% / Below: 8 %
- Stream Length Above Xing: 1.4 miles

**Fish community**
**Native brook trout/American eel**

# Fish Passage Barrier

**Single 5.5 x 8 ft. Corrugated Metal Arch Culvert / 165 ft. length at 4.0% slope**

# Design Feature: PreFabricated Concrete Fishway
# 14 units/0.5 ft drop



# Installation of PreFab Units

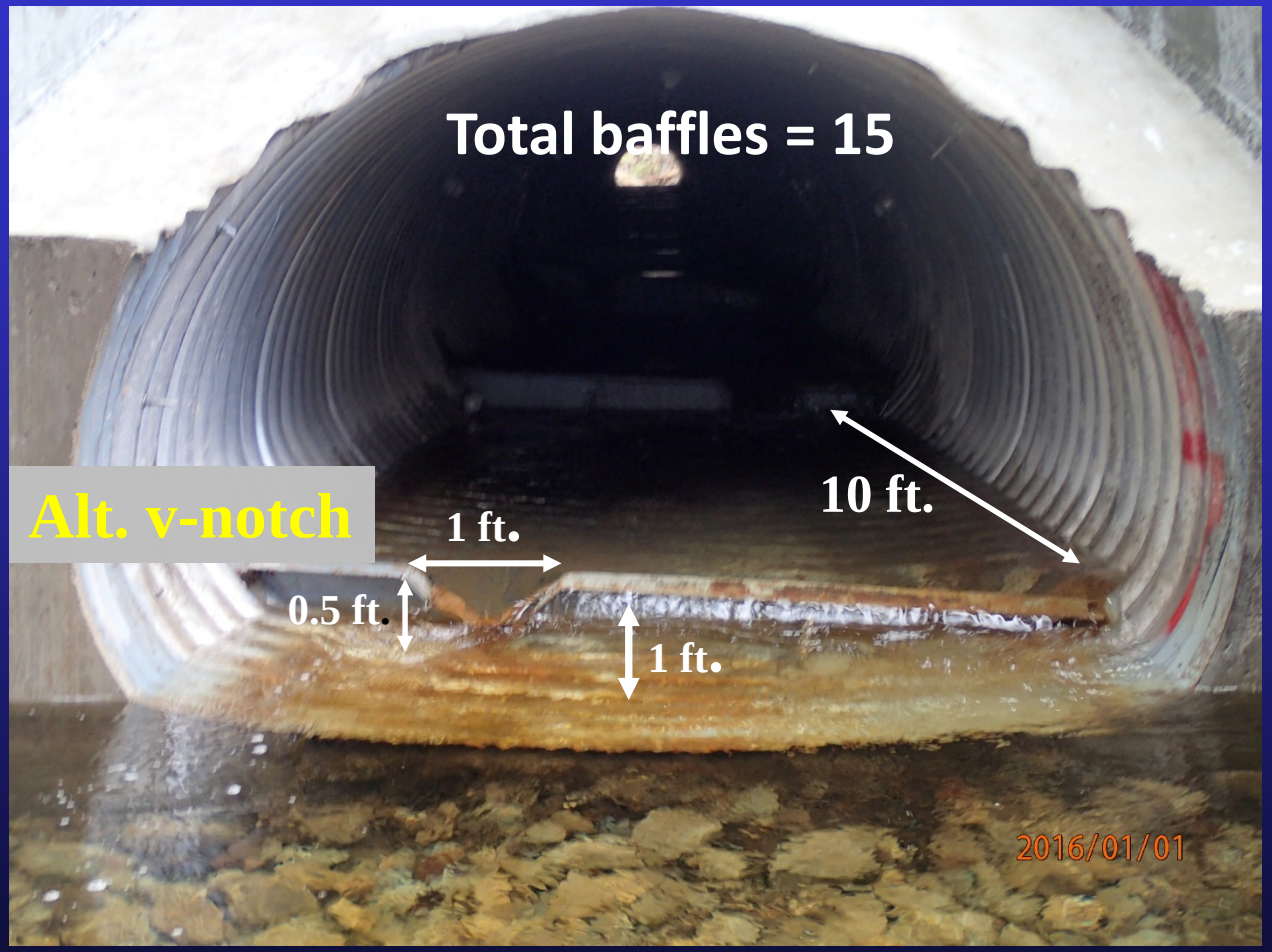



# Design Feature: PreFabricated Concrete Fishway

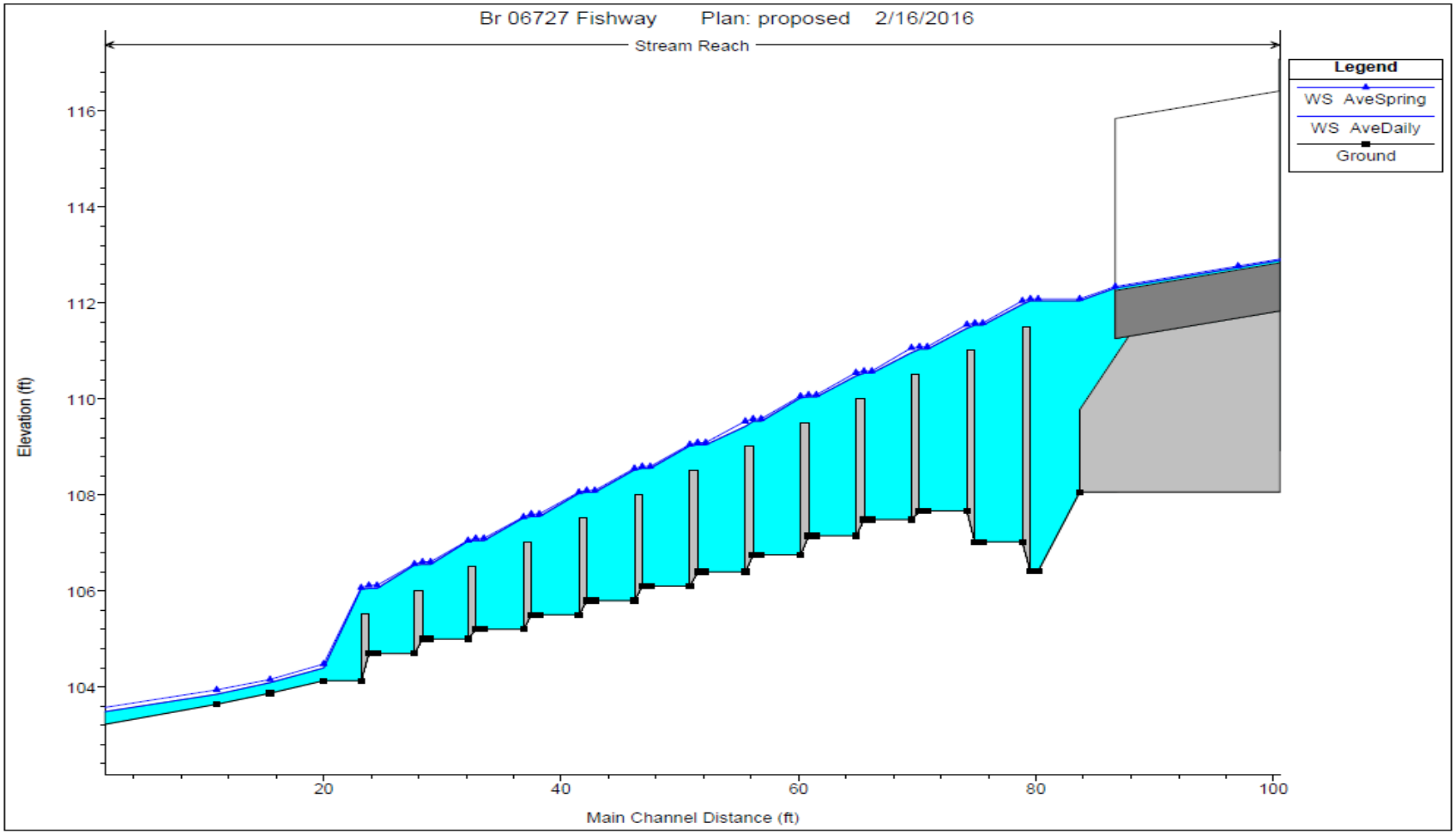
## Fishway Metrics

- Total length : 67 ft.
- 14 pools/weirs at 0.5 ft. elevation drop per pool
- V-Notch Weir (1 ft. x 0.5 ft.)
- Backwater depth into culvert : 0.25 ft.
- Boulder grade control holding pool below fishway

# Design Feature : V-Notch Culvert Baffle System



# Fish Passage Hydraulic Analysis (HEC RAS)




Downstream Channel Profile

# Summary Fish Passage Hydraulic Analysis

## Target Species Native Brook Trout

2. Result of analysis for fish passage:

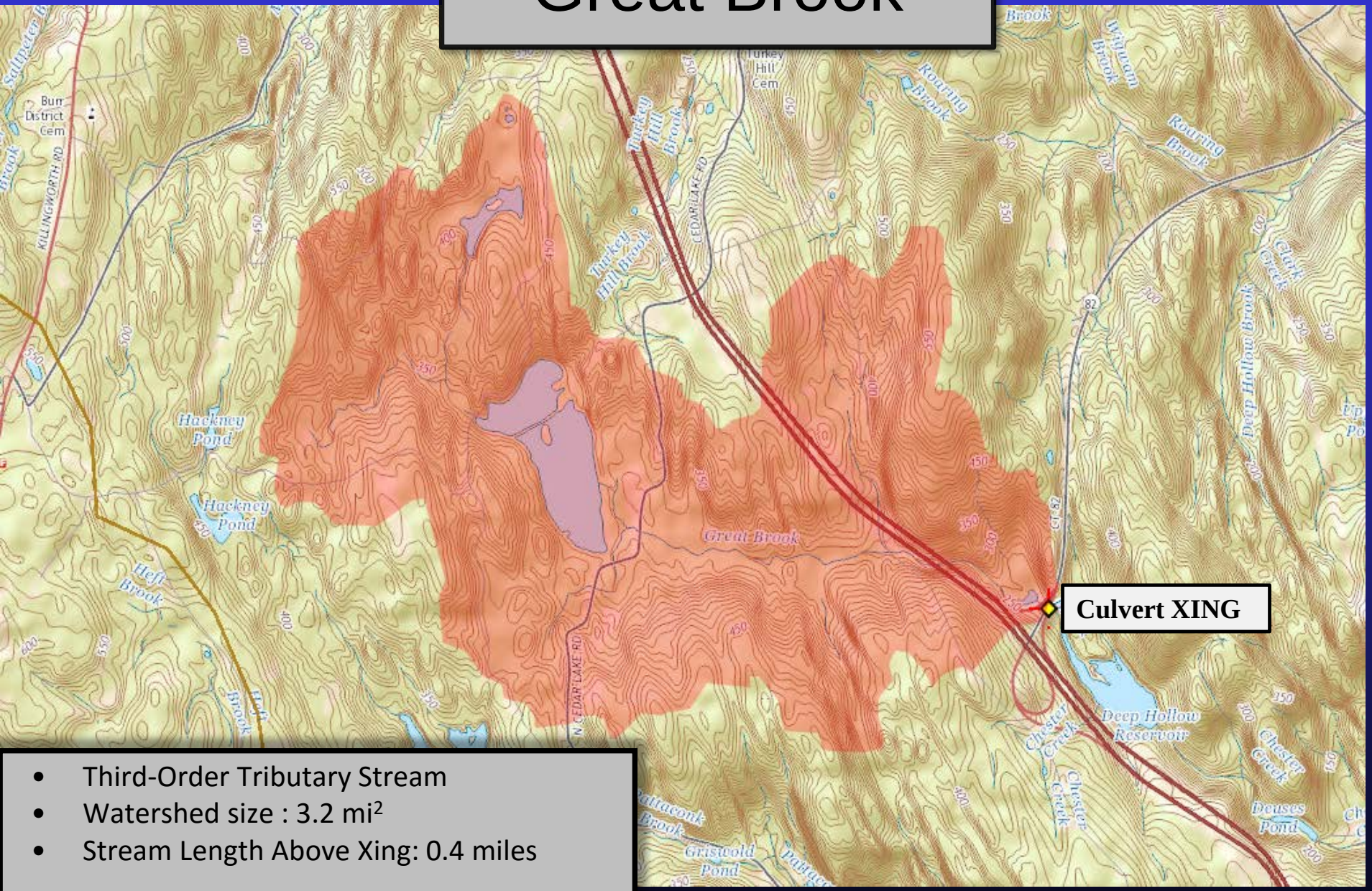
a. The following table indicates the result of the analysis using the following flows for the drainage area of 205 acres:

| | Q (cfs) | Pipe with Baffles | | Channel with Weirs | |
|---|---|---|---|---|---|
| | | Water Depth (inch) | Velocity (fps) | Water Depth (inch) | Velocity (fps) |
| Ave. Spring/Fall | 1.2 | 6.8 | 0.30 | 6.5 | 0.34 |
| Ave. Daily/Summer | 0.6 | 6.0 | 0.16 | 6.2 | 0.20 |

b. Weir type:
V-notch 90 degrees, top opening length is 1 ft. long by 0.5 ft. high.

c. Fish Baffles:
The height of the baffle is 1 ft. with the same V-notch type as above. Install the baffles in the pipe every 10 ft. It is recommended that the upstream baffle should be placed at least 5 ft. downstream of the inlet.

# Great Brook




- Third-Order Tributary Stream
- Watershed size : 3.2 $mi^2$
- Stream Length Above Xing: 0.4 miles

# Fish Passage Barriers

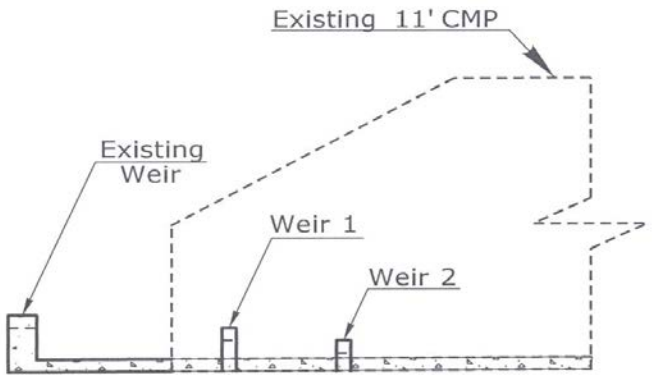
Inlet concrete weir 2 ft. in height forming 0.7 acre pond/wetlands

Fish community:
fallfish/white sucker


Cascade perched outlet
Seasonal barrier

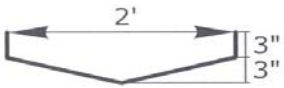
**Single 11 ft. Corrugated Metal Culvert / 144 ft. length at 0.5 % slope**
**Retrofit with concrete liner (6 inch thick along corrosion line)**

# Design Feature: Inlet weirs passage into pond




Inlet Weir Profile

| Location | Approx. dist. from intlet | Weir ℄ elevation |
|---|---|---|
| Weir Ex. | n/a | 244.4 |
| Weir 1 | 2' | 243.9 |
| Weir 2 | 6' | 243.4 |

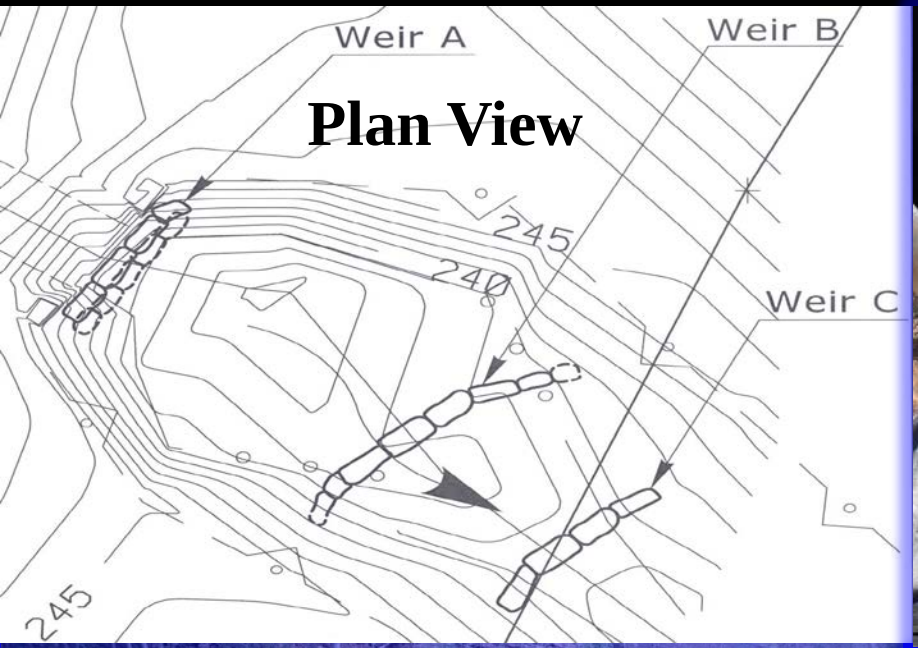



Detail A - Weir Notch

NOTE:

1. The e
during th

# Design Feature: Three boulder weirs/pools at outlet





# Project Construction Costs

| Project | Fish Passage Features | Estimated Cost |
|---|---|---|
| Tributary Lyman Brook | Outlet cast in place pool/weir fishway and culvert baffles | $245,000 |
| Tributary Hubbard Brook | PreFab Concrete Fishway and culvert baffles | $264,000 |
| Great Brook | Inlet Weirs and Outlet Rock Weirs | $10,000 |

# Conclusions/Future Efforts

- **Site specific fish passage designs required.**
- **Designs not passable for all stream species; bias towards strong swimming species.**
- **PIT tag evaluation will help guide the development and design of fish passage features at future sliplining projects.**
- **If culvert modifications cannot successfully pass fish, future sliplining projects may be “red-flagged” as not being able to provide fish passage, subsequently requiring offsite mitigation.**

# Acknowledgements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