Jun 20th, 4:45 PM - 5:00 PM

Dam Removal II: No Longer Caught Up in that Old Race: Successful Velocity Barrier Elimination for Anadromous Fish

Sean D. Arruda
Fuss & O'Neill, Inc.

Follow this and additional works at: https://scholarworks.umass.edu/fishpassage_conference

Arruda, Sean D., 'Dam Removal II: No Longer Caught Up in that Old Race: Successful Velocity Barrier Elimination for Anadromous Fish' (2016). International Conference on Engineering and Ecohydrology for Fish Passage. 7.
https://scholarworks.umass.edu/fishpassage_conference/2016/June20/7
Presentation for Fish Passage Conference 2016

No Longer Caught Up In That Old Race
Successful Velocity Barrier Elimination For Anadromous Fish

Sean D. Arruda, P.E., CFM, Fuss & O’Neill, Inc., Providence, RI

June 20, 2016
Agenda
No Longer Caught Up In That Old Race – Velocity Barrier Elimination

• Project Introduction and Purpose (4 min.)
  • Project Location and Dam History
  • Project Purpose
  • Project Funding and Permit Agency Coordination

• Project Highlights, Design Considerations, and Challenges (8 min.)

• Questions and Discussion
Project Introduction and Purpose
Watershed is 317± Square Miles

Pawcatuck River is over 30 miles long

Originates at Worden’s Pond

Empties into Little Narragansett Bay / Long Island Sound

Prior to 2010, eight dams existed throughout the Pawcatuck River.
The White Rock Dam was a low-head, run-of-river structure that was considered to be in poor condition.
Project Background

No Longer Caught Up In That Old Race - Velocity Barrier Elimination

Dam History:

• 1770: First Dam Constructed at this location.

• 1849: Dam was reconstructed as a stone crib dam used to divert flow through an adjacent mill race channel. The flow in the channel was used to power a nearby cotton mill.

• 1940: In the wake of the Hurricane of 1938, the Dam was reinforced with a concrete spillway (to its Current Configuration)
INSTALLATION OF DAM RESULTED IN AN IMPACT TO THE NATURAL FLOW OF THE RIVER AND AQUATIC PASSAGE CONNECTIVITY!
Spillway Crest set 3.8 feet above invert of millrace channel.

Breach in millrace channel (approx. 1,300 feet downstream of the Dam) became location for attraction flow.

Width of millrace (58 feet) approx. 1/2 of width of natural river channel (119 feet).
Project Background

No Longer Caught Up In That Old Race - Velocity Barrier Elimination

The Dam Under Varying Flow Conditions
Flow Diversion and Impact to Natural Flow of River

• Although the increased flow velocities and relatively steep hydraulic gradient have made it an impediment to fish passage, these flow characteristics have made the millrace an attraction for avid paddlers. This section of the millrace channel became known locally as the “White Rock Playpark.”
Project Background
No Longer Caught Up In That Old Race - Velocity Barrier Elimination

- In 2011, USACE published a “Pawcatuck River Flood Damage Reduction” Study noting that removal of White Rock Dam would reduce flood levels upstream.

- USFWS published an evaluation in July 2014 identifying the Dam as a barrier to fish passage. Results indicated that flow velocities in the bypass channel did not facilitate passage of alewife and significantly limited passage by shad during upstream migration period.
Thus, purpose of Project was to remove the Dam.

This would:

• Reduce Upstream Flood Elevations
• Improve River Connectivity for All Aquatic Species
• Improve Flow Conditions for Migratory Fish at this location:
  • Target species included American shad (Alosa sapidissima), alewife (Alosa pseudoharengus), blueback herring, (Alosa aestivalis), and American eel (Anguilla rostrata).
Project Funding & Permit Agency Coordination
No Longer Caught Up In That Old Race – Velocity Barrier Elimination

- The Dam and River spans across two states.
- The Project required coordination not only with the RI permitting agencies...but also CT.
Project Funding & Permit Agency Coordination
No Longer Caught Up In That Old Race – Velocity Barrier Elimination

It only took 13 months from Start to Substantial Completion!

• Permitting Agencies involved included CTDEEP, USACE (Category II), RIDEM, RIHPHC/ACHP (Section 106).

• Key to Success - Creating Team atmosphere with project partners from the start.
  o Multiple Partner Meetings were conducted throughout the design process. RIDEM (Wetland and Fisheries), CTDEEP (Wetlands and Fisheries), USFWS, NOAA, WPWA, TNC (RI and CT Divisions) were in attendance and had input throughout the design process.
  o This resulted in mutually agreed upon design prior to actual submission to the permitting agencies.
Project Design Considerations and Challenges
**Project Highlights**

No Longer Caught Up In That Old Race - Velocity Barrier Elimination

**Project Highlights/Summary:**

- Construction of Millrace Earthen Barrier (Bankfull)
- Excavation of fish passage resting areas
- Installation of boulder clusters and riverbank stabilization measures

- Dam Removal
- Excavation of sediment from river channel in targeted locations

**Map Diagram:**

- Streambank Stabilization
- Boulder Clusters
- Fish Passage Resting Pools (Typ.)
- Millrace Earthen Barrier
- Sediment Excavation in Key Locations (Typ.)
**First Challenge** - Divert flow from millrace channel to natural river channel while avoiding increases in BFEs

- Designed an earthen barrier at upstream end of millrace to divert flow during the fish passage season through the natural river channel; but still allow flood flows through the mill race. This was achieved using HEC-RAS.
- Only selected areas of sediment build-up that had the greatest impact on flood elevations were removed.
• HEC-RAS was utilized to determine the elevation to set the crest of the raceway channel’s upstream earthen barrier to eliminate flow through the channel during the upstream migratory period.

• The crest elevation also had to be set to an elevation that would still allow flood flows to pass in order to avoid increases in BFEs in Natural River Channel during flood events. Sediment in selected locations in main channel also had to be removed to further avoid BFE increases.
### Project Design Considerations & Challenges

**No Longer Caught Up In That Old Race - Velocity Barrier Elimination**

#### Post-Dam Removal Flow Distribution - Elimination of Flow through Raceway/Bypass Channel during Upstream Migratory Fish Passage Season

<table>
<thead>
<tr>
<th>Flow Event</th>
<th>Total Flow Upstream and Downstream of River and Bypass Channel Confluence Points</th>
<th>Natural River Channel Flow (cfs)</th>
<th>Bypass Channel Flow (cfs)</th>
<th>Percentage of Total Flow Conveyed by Bypass Channel (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Flow Conditions</td>
<td>235 cfs</td>
<td>235 cfs</td>
<td>0 cfs</td>
<td>0%</td>
</tr>
<tr>
<td>Min. Operating Conditions</td>
<td>381 cfs</td>
<td>381 cfs</td>
<td>0 cfs</td>
<td>0%</td>
</tr>
<tr>
<td>Normal Operating Conditions</td>
<td>849 cfs</td>
<td>848 cfs</td>
<td>1 cfs</td>
<td>0%</td>
</tr>
<tr>
<td>Max. Operating Conditions</td>
<td>2,091 cfs</td>
<td>2,090 cfs</td>
<td>1 cfs</td>
<td>0%</td>
</tr>
<tr>
<td>1-Year</td>
<td>1,265 cfs</td>
<td>1,264 cfs</td>
<td>1 cfs</td>
<td>0%</td>
</tr>
<tr>
<td>2-Year</td>
<td>2,300 cfs</td>
<td>2,288 cfs</td>
<td>12 cfs</td>
<td>1%</td>
</tr>
<tr>
<td>10-Year</td>
<td>4,090 cfs</td>
<td>3,510 cfs</td>
<td>580 cfs</td>
<td>14%</td>
</tr>
<tr>
<td>25-Year</td>
<td>5,290 cfs</td>
<td>4,310 cfs</td>
<td>980 cfs</td>
<td>19%</td>
</tr>
<tr>
<td>50-Year</td>
<td>6,320 cfs</td>
<td>4,972 cfs</td>
<td>1,348 cfs</td>
<td>21%</td>
</tr>
<tr>
<td>100-Year</td>
<td>7,480 cfs</td>
<td>5,715 cfs</td>
<td>1,765 cfs</td>
<td>24%</td>
</tr>
<tr>
<td>500-Year</td>
<td>10,500 cfs</td>
<td>7,601 cfs</td>
<td>2,899 cfs</td>
<td>28%</td>
</tr>
</tbody>
</table>

**Notes:**

1. Includes the installation of a fish passage berm/barrier installed at the upstream entrance to the bypass channel with a crest elevation of El. 16.5+ designed to prevent flow during the upstream fish passage migration period from entering the bypass channel and contributing to false attraction flows at the downstream confluence between the bypass channel and natural river channel.
Project Design Considerations and Challenges
No Longer Caught Up In That Old Race - Velocity Barrier Elimination

- Earthen Barrier constructed of soil-filled stone underlain by an impermeable liner.
- A grouted stone cutoff was also provided.
Project Design Considerations and Challenges

No Longer Caught Up In That Old Race - Velocity Barrier Elimination
• **Second Challenge** - Design and incorporate fish passage improvements in locations where anticipated flow velocities exceeded the swimming speed of the target species.
• HEC-RAS also used to determine locations where resting pools were required.

• Locations where flow velocities exceeded the cruising speed of the target species were identified. Quiescent pools were added on river left to provide areas for resting. Excluding the American eel, the most restrictive burst speed of the target species is approximately 5.5 feet per second (for alewife).

• Since it is expected that a burst speed can be maintained by a particular fish species for only up to 20 seconds (based on fatigue time), Fuss & O’Neill used 110 feet as a parameter for distance between resting pools/areas in locations where velocities exceeded 2.8 feet per second.
Project Design Considerations & Challenges
No Longer Caught Up In That Old Race - Velocity Barrier Elimination
Third Challenge - Assess streambank locations most susceptible to erosion and provide natural bank stabilization.
Log Jam Structures and Tree Revetment Protection.

Boulders and stone line upstream river right. However, lower river right was determined to be susceptible. Engineered log jams and tree revetments proposed to prevent erosion while simultaneously improving aquatic habitat.
Log Jam Structures and Tree Revetment Protection.

Boulders and stone line upstream river right. However, lower river right was determined to be susceptible. Engineered log jams and tree revetments proposed to prevent erosion while simultaneously improving aquatic habitat.
• Log Jam Structures and Tree Revetment Protection.

• Boulders and stone line upstream river right. However, lower river right was determined to be susceptible. Engineered log jams and tree revetments proposed to prevent erosion while simultaneously improving aquatic habitat.
Project Design Considerations & Challenges
No Longer Caught Up In That Old Race - Velocity Barrier Elimination

• **Fourth Challenge** - Develop a water control approach that would be sensitive to aquatic habitat (i.e. mussel relocation).
Project Design Considerations and Challenges
No Longer Caught Up In That Old Race - Velocity Barrier Elimination
Approximately 2,300 to 2,400 mussels were collected (mostly from the upstream dewatered area) and transplanted to the lower Shunock River just downstream of Route 49.

Relocated mussels consisted of a five different species of mussel including the endangered eastern pearlshell. Most, however, were of the Elliptio species.
Project Design Considerations & Challenges
No Longer Caught Up In That Old Race - Velocity Barrier Elimination

- Pre-Construction View of Dam and Millrace Channel Inlet (as viewed looking downstream)

- Post-Construction View of Dam and Millrace Channel Inlet (as viewed looking downstream)
Project Design Considerations and Challenges
No Longer Caught Up In That Old Race - Velocity Barrier Elimination

- Natural flow regime restored to River in this location after over 240 years of impact!
Illustration 16: Hydraulic cross-sections downstream of White Rock Dam.
Table 1

Migratory Periods for the Target Species in the Pawcatuck River

<table>
<thead>
<tr>
<th>Species, life stage</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alewife, adult</td>
<td>U</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>American shad, adult</td>
<td>U</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Blueback herring, adult</td>
<td>U</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

In Rhode Island, river herring (alewife and blueback herrings are collectively referred to as river herring) tend to undertake upstream migration between March 1st and June 1st, peaking in April. Shad typically migrate between April 1st and July 1st, peaking in May. As a result, the extent of the upstream migration season for the project’s target species is March 1st to July 1st. For purposes of this project’s analysis and design (as a conservative approach), the upstream migration period used for evaluation of river channel flows was taken from March 15th through May 15th per guidance from RIDEM Division of Fish and Wildlife (DFW) and USFWS staff.
HEC-RAS confirmed that flow velocities in by-pass channel exceeded cruising speed of target species over extended distances during the upstream fish passage migration period (March 15th through May 15th).

The Team agreed to use 2.8 fps as the cruising speed for the Target Species for design purposes.
Pre-Dam Removal Flow Distribution - Most flow through Raceway/Bypass Channel during Upstream Migratory Fish Passage Season