Upper Mills Dam – Peconic River

Feasibility Study Report: Alternatives for Fish Passage

February 28, 2011

Prepared for:

Town of Riverhead

200 Howell Avenue

Riverhead, NY 11901

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BACKGROUND

Inter-Fluve was contracted by the Town of Riverhead, NY to conduct an analysis of fish passage alternatives for the Upper Mills Dam on the Peconic River. The Peconic River flows through Riverhead from its source on the property of the Brookhaven National Lab to its mouth in Flanders Bay. It is the largest river on Long Island and, until recently, had six dams along its length that prevented river herring and American eels from migrating up and downstream. A fish ladder installed annually at the Grangebel Park North spillway provides passage during migratory periods and last year a permanent fish passageway was built around the Grangebel Park South spillway, opening up an additional 25 acres of spawning and maturation habitat. The Upper Mills Dam and a US Geological Survey (USGS) gaging weir 250 ft downstream are the next fish passage barriers on the Peconic River, followed by dams at Forge Road, Edwards Avenue, and Connecticut Avenue, which are 1.5, 3.5, and 5.5 miles upstream from Upper Mills Dam, respectively. Providing fish passage at Upper Mills Dam would open 40 acres of habitat and is the next step in a goal to restore over 300 acres of habitat along the Peconic River with passage around the remaining dams.

Prior to this analysis, American Rivers provided conceptual ideas for fish passage alternatives at Upper Mills Dam. For this study, Inter-Fluve completed a topographic survey of the dam, river, and USGS weir and completed a hydraulic analysis to help identify an alternative that was feasible from a hydrologic, geomorphic, biologic, and social perspective. With the Long Island Power Authority (LIPA) substation adjacent to the dam, many utility lines cross the river, both above ground and under the river and dam. The road over the dam must be able to withstand traffic from large trucks carrying very heavy equipment to and from this substation. The preferred alternative must also account for various complicated hydrologic issues:

- No drop in normal pond elevation to retain recreation and aesthetics for residents
- No increase in pond flood elevations to prevent increased flooding of property
- Appropriate flow velocity and depth for passage of target fish species

Therefore, the goals of this project were to evaluate each alternative, identify potential problems or opportunities, and identify and describe the preferred alternative that will provide fish passage while maintaining water levels in the pond and not disturbing the utility lines and pipes crossing the river.

This report summarizes our feasibility analysis for fish passage by describing the hydrologic and hydraulic analyses completed, discussing the alternatives for fish passage, and explaining the reasons for choosing the preferred alternative, a new fishway and integrated culvert on the south end of the existing dam.

Figure 1. Upper Mills Dam is located on the Peconic River in the Town of Riverhead, which is located near the eastern end of Long Island, NY. All images are USGS maps.

EXISTING CONDITIONS

Site Description

Upper Mills Dam is approximately 2.9 miles from the mouth of the Peconic River in Flanders Bay (Figure 1). The northern banks of the Peconic River at this location are in the Town of Riverhead, while the southern banks are in Southampton. The Upper Mills Dam is an earthen embankment with an asphalt/concrete road on top and two parallel spillways (Figures 2 and 3): (1) a 6-ft reinforced concrete pipe with an upstream concrete spillway box and timber flashboards; and (2) a 4-ft corrugated metal pipe that has been compressed to a slightly elliptical shape over time. The dam was built in the late 1800s, but the flooding and erosion in early 2005 forced an emergency replacement of a corrugated metal pipe for the 6-ft reinforced concrete pipe mentioned above (Dunn Engineering, 2005). The dam is currently owned by LIPA but is maintained by the Town of Riverhead. The paved road on top of the dam primarily services the LIPA substation located south of the dam (Figure 3).

Figure 2. (Top) Looking upstream at the Upper Mills Dam and the downstream outlets of the two culverts; (middle) looking north along the paved road on top of the dam; (bottom) looking north at the USGS gaging weir downstream from the dam.

The USGS maintains a concrete weir 250 ft downstream of the dam in order to measure the stage and discharge of the Peconic River (Figures 2 and 3). This gaging station (#01304500) has been active since 1942. The structural height of the weir is approximately 2.5 ft and its length is 52 ft. A concrete apron on the downstream end is 0.5 ft tall and 6 ft wide. The weir is a fish passage barrier through much of the year but may pass some fish during higher water flows when the drop in water elevation over the weir is decreased (B. Young, pers. comm.). In addition to providing passage around Upper Mills Dam, alternatives for passage over the weir are analyzed below.

The Peconic River watershed upstream of Upper Mills Dam is approximately 75 square miles. Much of the watershed is forested, but the land use is mixed with residential, agricultural, commercial, and industrial areas as well as the US Reservation Brookhaven National Laboratory and Peconic Airport (Figure 4).

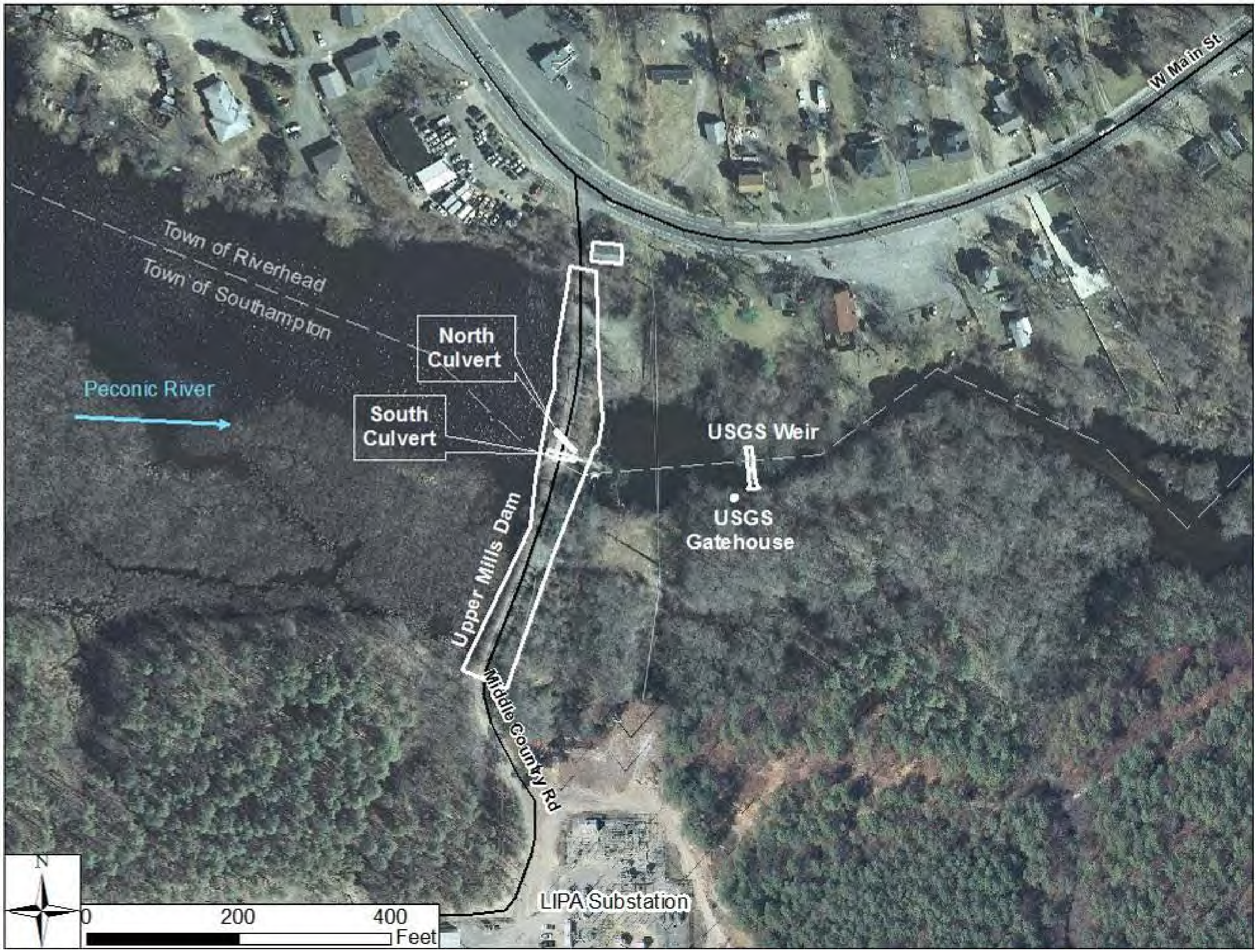

Figure 3. Air photo of study site with Upper Mills Dam, the USGS weir, and other structures identified.

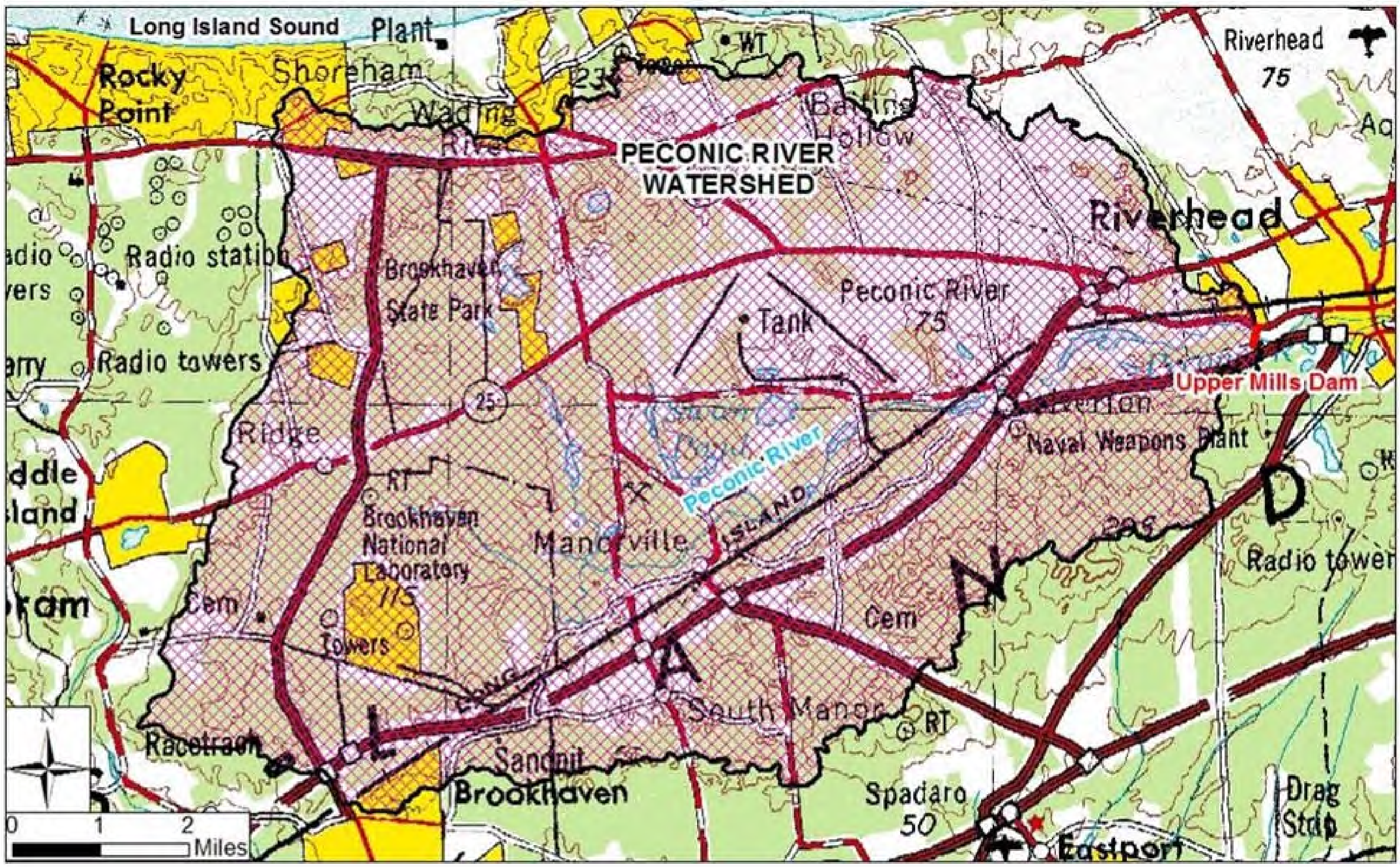

Figure 4. Peconic River watershed upstream of Upper Mills Dam. Map from the USGS.

On-Site Utilities

As mentioned above, the road on top of Upper Mills Dam primarily serves the LIPA substation to the south of the dam. High voltage utility lines lie under the road and overhead carrying electricity to and from this substation (Figure 5). The road has been designed to withstand the use of heavy utility vehicles while protecting the utility lines beneath. The utility lines are within conduits buried between the bottom of the road and the top of the culverts. Additional overhead utility lines are above the road and above the river downstream. A gas line lies beneath the river between the dam and the weir as well and is identified by yellow signs and a mowed strip of vegetation.

These utilities present challenges for the completion of fish passage alternatives involving the construction of new culverts through the dam and any excavation or construction between the dam and the USGS weir. The overhead utility lines are generally high enough not to be impacted by construction vehicles. Care will need to be taken, however, to ensure the utilities under the road are not damaged during any construction relating to the fishway alternatives involving a new culvert. The emergency culvert replacement in 2005 provides a template for what to expect during any future construction. A conversation with representatives at Dunn Engineering, who designed and oversaw the construction in 2005, provided valuable information regarding the utilities. During that culvert replacement, the heavy, reinforced concrete slab on top of the culvert was saw-cut and removed. The utilities were located within one or two conduits directly below this concrete slab and only inches above the culvert. The conduits were kept in place during construction to maintain continuous flow of electricity. The old culvert was pulled out and the new one was slipped underneath the conduits. Fill was then placed around the culvert and the conduits and a concrete slab placed on top. A similar sequence is likely to occur for any construction relating to the fishway alternatives involving a new culvert. Assistance from the utility company would be desirable, as was provided during the emergency culvert replacement.

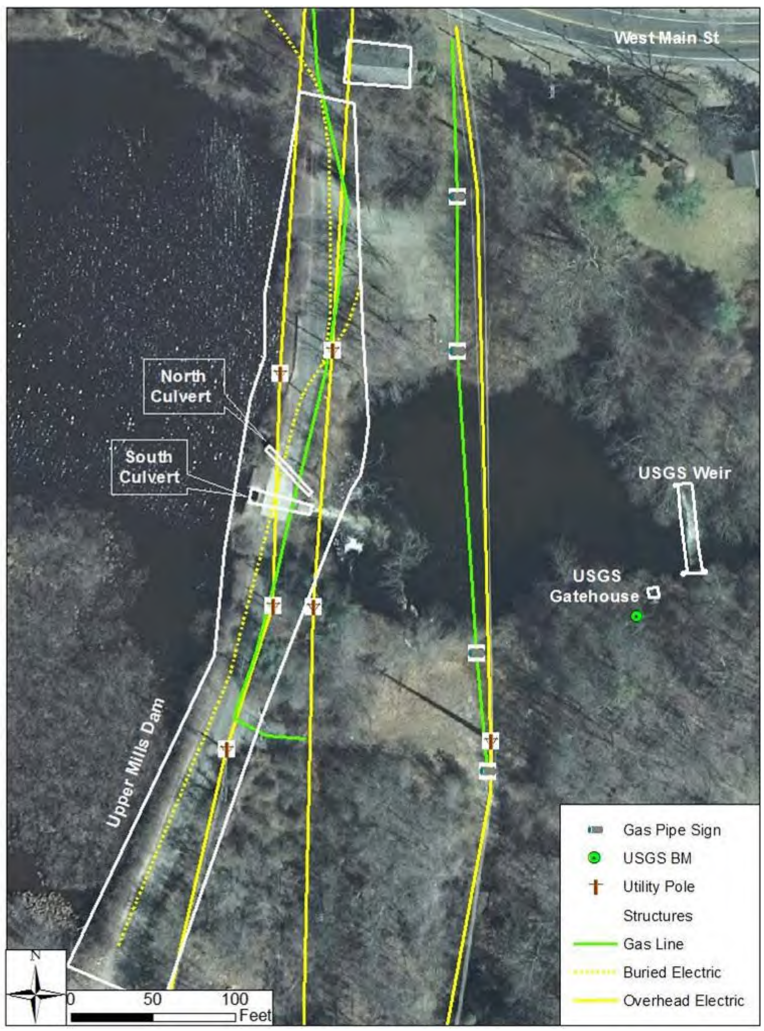

Figure 5. Utilities, structures, and other site features near the Upper Mills Dam.

The gas line underneath the Peconic River between the Upper Mills Dam and the USGS weir is clearly marked on both shores by yellow gas signs. While attempts have been made to obtain information from National Grid, the depth of the line is unknown at this time. Although the line is likely buried well below the channel bed, the elevation will need to be determined before any excavation commences and before construction vehicles drive over the pipe location.

Geology

The bedrock underlying most of Long Island, including the area around Upper Mills Dam, is crystalline metamorphic material, or gneisses and schists, created from Precambrian granite or sandstone more than 400 million years ago. The surficial geology consists of outwash sand and coarse to fine gravel that is well-rounded and stratified. This coarse material provides a medium that induces very fast rates of infiltration throughout Long Island. Consequently, 90% of the annual flow in the Peconic River is derived from base flow (groundwater discharge) and only 10% from precipitation runoff (Scorca et al. 1999). In fact, the highest recorded discharge at the Riverhead gage (#01304500) occurred without any precipitation during the day of the flow and the three days preceding it (225 cfs on January 30, 1978) (Dunn Engineering Associates 2005). Because of the composition of the surficial geology, the channel substrate of the Peconic River is primarily gravel and sand. The gravel and sand are the preferred spawning substrate for alewife and blueback herring that spawn in the Peconic River. This variable substrate is also important for creating geomorphic complexity with coarse-grained riffles and finer-grained pools that provide variable habitat for macro invertebrates, fish, and other aquatic organisms.

Fisheries

Historically, the Peconic River likely supported large populations of native diadromous fish species. In its natural form, the river would have provided variable sand and gravel substrate, copious canopy cover, and sufficient in-stream habitat with large woody debris, deep pools, and riffles. With the many dams built on the river, fish passage problems have limited the ability of these fish species to access this habitat. Today, alewife and American eel spawn and mature in the Peconic River downstream of Upper Mills Dam with the recent completion of the rock ramp at Grangebel Park. In addition, blueback herring have been observed in the system (B. Young, pers. comm), though not in significant numbers. A volunteer monitoring program was organized by the Peconic River Fish Restoration Commission in 2010 following the completion of the rock ramp. This monitoring suggests that the rock ramp was successful as a minimum of 24,000 alewives (and as much as 40-50 thousand) entered the Peconic River to spawn in the spring of 2010 (Young, 2010).

Hydrology

Hydrologic characteristics of the Peconic River at Upper Mills Dam were analyzed to provide input for existing and proposed hydraulic conditions. Data from the USGS streamflow gage (#01304500) located approximately 250 feet downstream from the dam was used for analysis. The 67 year flow record (operating since 1942) was sufficiently long to describe average flow and peak flows below the dam. Despite the long gaging record, flow data before 1972 was disregarded due to a shift in discharge pattern that occurred at this time. Specifically, the standard deviation of the peak discharges before 1972 was 23 cubic feet per second (cfs), whereas afterward it almost doubled to 44 cfs (Figure 6). This change reflected a shift in precipitation variability. Drought conditions prevailed prior to 1972, resulting in low variability in peak discharges. After 1972, annual average precipitation and its variability increased (Ron Busciolano, personal communication, 2011). These shifts are indicative of hydrologic patterns found throughout the region. Collins (2009) suggests omitting discharge data before 1970 for New England rivers due to a step-like increase in precipitation and flood flows. Although the Upper Mills Dam is not in New England, its proximity suggests it is generally governed by the same climatological processes. Collins (2009) also suggests that these trends are representative of the entire Northeastern U.S.

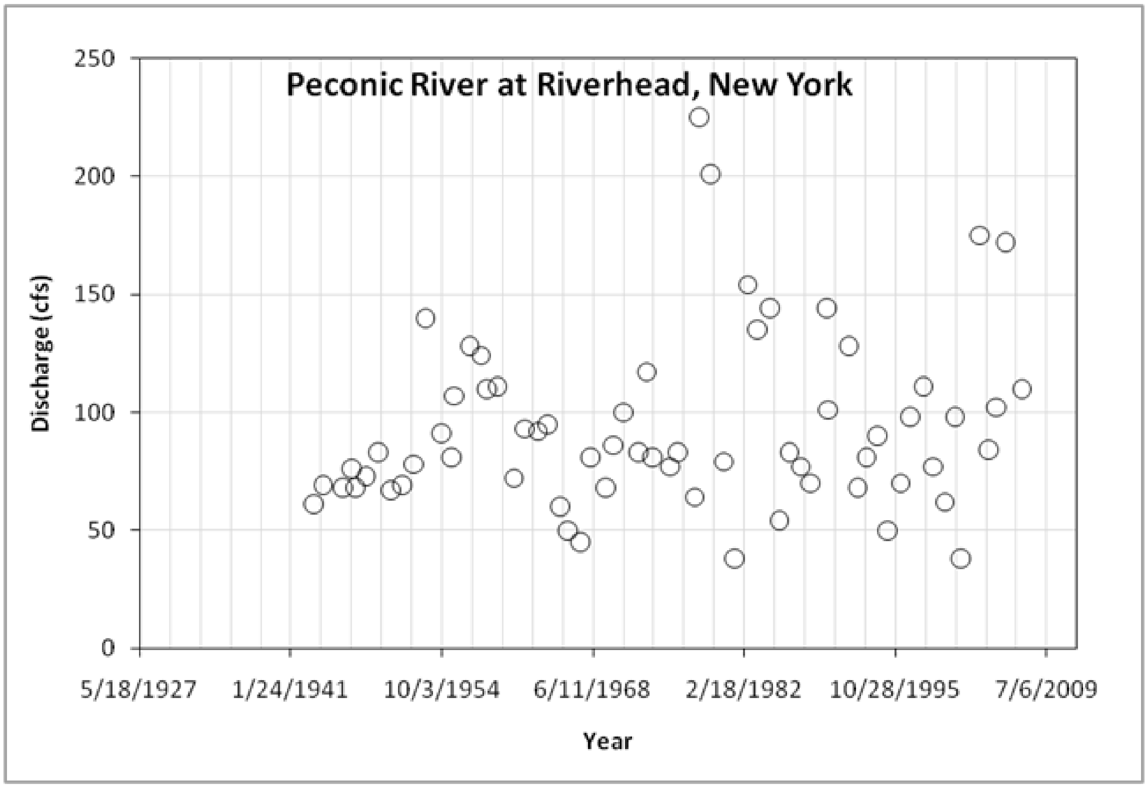

Figure 6. Peak discharges at the Upper Mills Dam between 1943 and 2007 (USGS Gage #01304500).

It is unknown if the flashboards in the south culvert of the dam are managed in any way to regulate pond elevations. The flow data from the gage does not seem indicative of a regulated system. For this study and for the hydraulics analysis, it was assumed that the boards remain in place at the surveyed elevation and are not removed during higher flows to increase hydraulic capacity.

Flow characteristics during the spring are most critical since this is the time period that alewives are migrating upstream to spawn. Spawning runs typically start in early April and end in May (Scott and Crossman 1973). Actual spawning run observations in the spring of 2010 were provided by Young (2010) for the Peconic River at the new rock ramp fish passage at Grangebel Park, approximately 1.2 miles downstream of the Upper Mills Dam. The observed peak in alewife numbers occurred between April 5th and May 1st in 2010. This range falls within that provided by Scott and Crossman (1973). Nevertheless, a longer time period was analyzed between March 15th and June 15th to account for yearly variation in temperatures that induce spawning. The 90%, 50% and 10% exceedance probability discharges (the percentage of time a specific flow was equaled or exceeded) were calculated for this period (Table 1).

Table 1. Water flow for specific exceedance probabilities during the spawning period.

	Discharge for Specific Exceedance Probability (cfs)		
Date Range	90%	50%	10%
March 15-30	27.7	46.3	70.6
April 1-30	27.6	50.6	75.9
May 1-31	30.1	55.3	82.3
June 1-15	26.6	51.7	79.0
Average	28.0	51.0	77.0

Flow variability during the spawning period could aid fish passage. Alewives may delay passage until higher flows recede and lower velocities are present in the culverts to migrate upstream. Nevertheless, periods of high flows typically persist throughout the spawning period rather than increasing for a shorter time period of a couple days or less before receding again. For instance, during the spawning period when the highest recorded flow occurred in 1978, discharges remained above 60 cfs throughout all of April and May. Thus, weaker alewives may not have been able to migrate through the Upper Mills spillway for the entire spawning season.

Although minimum depth and velocity requirements dictate fish passage, it is also important to understand the hydraulics associated with peak flows to ensure the dam embankment will not overtop, shear stresses through the potential fishway will not cause failure, and upstream flood water surface elevations will not increase. The Log-Pearson Type III (LP3) method was used to complete a flood frequency analysis and calculate the discharge during certain recurrence intervals (Interagency Advisory Committee on Water Data, 1982; Figure 7, Table 2).

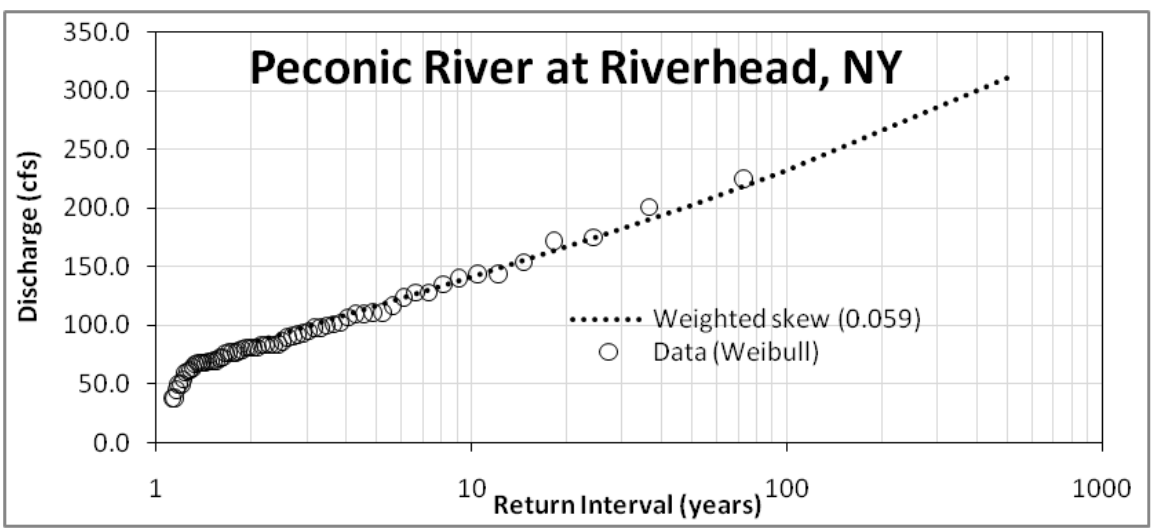

Figure 7. Plot of the measured discharges at the USGS Gaging Station #01304500 using a Weibull plotting position compared with the calculated LP3 peak flow distribution.

Table 2. Calculated flood flows of various recurrence intervals using the LP3 method.

Return Interval (yrs)	2	5	10	25	50	100
Discharge (cfs)	89.3	132.8	162.0	201.3	232.2	264.4

Hydraulics

A hydraulic model of the current dam configuration was completed to determine the fish passage capability under existing and proposed conditions. The discharges from the hydrologic analysis were applied to a one-dimensional, steady-state HEC-RAS hydraulic model. As described above, long-term USGS gage data was used to complete the hydrologic analysis, but the gage was not working properly between May and September 2010 (Figure 8). Because of this, modeled low flows cannot be calibrated with the discharge during the survey. The USGS is actively trying to fix this data and may have it published this year, allowing the low flows to be calibrated. In addition, although FEMA flood data is available on the NY GIS clearinghouse website, the data are only approximate (in some locations, the 100-yr flood line is inside the normal pool elevation of the pond at Upper Mills Dam) as no hydraulic model for the Peconic River has been completed for FEMA mapping. Therefore, the model developed for this study is useful for comparing existing and proposed conditions relative to one another but should not be used for other purposes until properly calibrated.

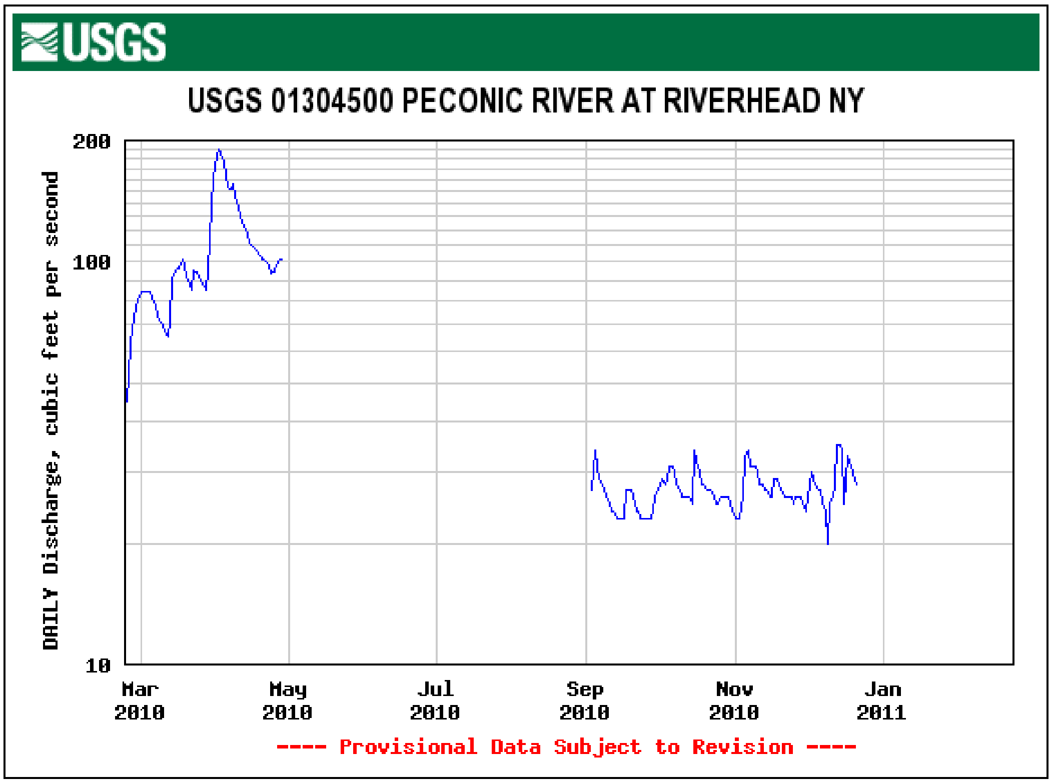

Figure 8. Mean daily discharge at USGS gage #01304500, immediately downstream of Upper Mills Dam, showing the gap in data collection between May and September 2010.

In HEC-RAS, two parallel reaches were modeled to simulate the split flow between the two existing culverts. The north culvert is a 4-ft corrugated metal pipe slightly compressed into an elliptical shape (Figure 9). Both ends of the culvert project from the road embankment without wingwalls that typically help prevent erosion and reduce entrance and exit energy losses. Vegetation is growing at the inlet of this culvert, however, and erosion does not appear to be impacting the integrity of the dam or culvert. The slope of this culvert is 0.119 (ft/ft). The south culvert is a 6-ft diameter concrete pipe that was installed in 2005 (Figure 9). Stop logs are used at the upstream end of the south culvert to keep the reservoir levels at the desired elevation. As mentioned in the hydrology section above, however, it is unknown if these stop logs are actively managed to regulate flows. The structure appears to be in a stable working condition. The slope of this culvert is 0.053 (ft/ft). Average flow velocities along the length of the culvert, and specifically at the entrance and outlet, indicate conditions are difficult for most fish to negotiate during passage. Flow velocities, as determined with the HEC-RAS model are greater than 3 feet per second (ft/s) in the north culvert and 5 ft/s in the south culvert (Table 3)

Table 3. Average modeled velocities through the existing culverts during the migratory period (flows used for application in Haro et al.'s (2004) model are in bold).

	Exceedance probability	Flow (cfs)	North culvert			South culvert		
			Entrance	Exit	Average	Entrance	Exit	Average
Average velocities (ft/sec)	10%	77.0	4.72	10.19	**7.64**	7.17	12.77	**10.17**
	50%	51.0	4.15	8.85	**6.67**	6.34	11.84	**9.28**
	90%	28.0	3.59	7.49	**5.58**	5.49	10.73	**7.52**

Existing Fish Passage

To analyze the existing fish passage potential, velocities were compared with a model from Haro et al. (2004) ('Haro model' henceforth). Haro's model was the result of flume experiments where alewives were presented with different velocities, and their corresponding maximum sprinting distances were tracked. A gamma distribution, with independent variables of swimming distance and velocity, was fit to the data after applying a regression to predict the proportion of fish capable of passing a velocity barrier. Temperature, fork length and sex were also measured, but no significant statistical relationship was found. The authors, however, suggest that this is due to low variability in alewife size distributions, and because sprinting is an anaerobic process that is not dependent on temperature (Haro et al. 2004). The Haro model was applicable to this feasibility study since it addresses velocity barrier issues, which is a limiting variable that prevents the upstream migration of alewives at Upper Mills Dam.

Figure 9. (Top) Looking downstream at the north culvert; (bottom) looking downstream at the south culvert with stop logs in place.

North Culvert – To implement the model, the average velocities of the entrance and exit at the north culvert were calculated during the 10%, 50% and 90% exceedance probability discharges over the spawning period (Table 3). The resulting proportions of alewives that could pass through the length of the culvert (40.9 ft) were 17%, 32% and 46% for the 10%, 50% and 90% exceedance probability flows, respectively.

These results suggest that, while some passage is possible, at least half of the migrating alewives are not likely to traverse the dam spillway through the north culvert. Factors limiting passage include water velocity, culvert length, and water depth. Fish have the ability to swim at moderate speeds for long periods of time (sustained speed) or quickly for short periods of time (burst speed). A 40-ft culvert is not too long for alewives at sustained speeds, but due to the slope of the culvert and the water velocity, burst speed would be necessary and alewives generally have difficulty sustaining their burst speed for 40 ft. If the culvert provided resting places (behind boulders, baffles, etc.), alewives would have a higher likelihood of passing through the entire culvert. In a theoretical run of the model using a hypothetical 5-ft culvert length (representing the distance between resting places throughout a longer culvert), alewives passed through the hypothetical culvert at an 84%, 87% and 90% rate during the 10%, 50% and 90% exceedance probability flows, respectively. Without opportunities to rest, water velocity and culvert length will continue to limit fish passage at the dam.

An additional limiting variable is water depth. Water depth within the culvert is 0.59 ft, 0.48 ft and 0.36 ft for the modeled 10%, 50% and 90% exceedance probability flows, respectively. Considering that alewife need to be submerged to generate maximum swimming speeds, and the approximate depth of female alewives in the Peconic River is 0.27 ft (Young 2010) (average length multiplied by the average body depth [including dorsal fin height] [Scott and Crossman 1973]), the 0.36 foot depth is on the edge of being too shallow for passage. Even with full coverage, low water depth can result in portions of the body of the fish coming into contact with the culvert (losing energy due to friction) and the turbulent wake behind them minimizing the force with which their tails can power them upstream. As a result, the predicted 46% of fish that are able to pass during the 90% exceedance probability flow is likely an overestimate. Water depth may impede passage for some of the larger alewives in the Peconic River during lower discharges.

Together, the limiting variables of high velocities, a long culvert, and shallow depths result in few alewives that are able to reach upstream areas relative to the number that approach the dam (Table 4).

Table 4. Fish passage characteristics for the existing north culvert.

Exceedance Prob.	*Avg. velocity (ft/s)*	*Depth (ft)*	*% passing*
10%	7.64	0.59	17%
50%	6.67	0.48	32%
90%	5.58	0.36	46%

South culvert – The south culvert presents a more significant barrier for migrating fish. Applying the Haro model yields a 1%, 9% and 34% proportion of alewives that are able to migrate upstream during the 10%, 50% and 90% exceedance probability flows, respectively. With the stop logs (which regulate reservoir level) in place at the upstream end, a drop of at least 1 ft would have to be negotiated. Scott and Crossman (1973) claim that alewives avoid leaping to overcome vertical barriers. Coupled with the lack of a plunge pool to develop the vertical speed to attempt a jump, this barrier would likely prevent any fish from passing. Thus, while the north culvert is constrained by velocity, depth and distance, the south culvert presents an additional obstacle with a vertical barrier.

Table 5. Fish passage characteristics for the existing south culvert.

Exceedance Prob.	*Avg. velocity (ft/s)*	*Depth (ft)*	*% passing*
10%	10.17	0.60	1%
50%	9.28	0.48	9%
90%	7.52	0.35	34%

ALTERNATIVES INVESTIGATION

Upper Mills Dam

Four alternatives were considered to improve fish passage at Upper Mills Dam: (1) installing an Alaskan steep pass fish ladder in the north culvert; (2) installing baffles in the north culvert; (3) constructing a new 100 ft long fishway with a new culvert; and (4) constructing a new 200 ft long fishway with a new culvert. Selecting the preferred alternative required satisfying three performance criteria:

- No drop in normal pond (reservoir) elevation to retain recreation and aesthetics for residents
- No increase in pond flood elevations to prevent increased flooding of property
- Appropriate flow velocity and depth for passage of target fish species

Common to all alternatives is easy site access and simple water control. The road over the dam is substantial enough to carry large construction vehicles to the sites of each alternative. Because of the two existing culverts, pumping of water or the use of a gravity-fed water control system is unnecessary. Flows can be diverted through the culvert(s) not affected by construction to provide dry working conditions.

1. *Alaskan Steep Pass Fish Ladder*

The first alternative developed for analysis was the installation of an Alaskan steep pass fish ladder within the existing north culvert. This option was proposed initially as an intended low cost retrofit to an existing structure to accomplish passage. Alaskan steep pass ladders are prefabricated structures with metal pieces extending into the flow of water; these sections of metal disrupt the flow and provide refuge and resting areas behind (Figure 10). The primary benefit of this alternative at this site is that the road surface can remain undisturbed and none of the utilities are exposed or disturbed during construction. The prefabricated fish ladder can be delivered on site, slid into the north culvert, and installed with no surface disruption.

Figure 10. Looking downstream at an Alaskan steep pass fish ladder (photo from NOAA photo library).

Placing a fish ladder that is rectangular in cross section inside of a circular culvert does present challenges. Assuming the ladder is placed in the center of the culvert, water will flow through the ladder as well as in the space between the ladder and the culvert walls. Migrating fish are attracted to swift water and may become confused on the downstream end of the culvert/ladder with flow coming from the ladder and the sides of the culvert. If a solid structure is put into place at the ends of the culvert to prevent flows between the ladder and the culvert, the hydraulic capacity of the culvert will be diminished resulting in increased flood elevations in the pond. Without this type of structure, the hydraulic capacity may be sufficient, but this will not be known until the management of the stop logs in the south culvert is understood. As mentioned in the hydrology section above, we assumed that there is no active management of the stop logs and that the stop logs are not removed during flood flows. If this is the case, installing the ladder within the culvert may be accomplished without significantly increasing pond elevations at flood flows only if the stop logs are removed during these floods to increase capacity (Table 6). A design-level investigation including additional upstream surveying and hydraulic modeling, as well as an understanding of the current management of the stop logs, is necessary to definitively quantify the level of increase, if any, of the pond elevation during flood flows with a fish ladder installed in the north culvert.

Another challenge presented by this alternative is its location. All of the Peconic River flow will be flowing through the two culverts that outlet close to each other in a deep pool artificially elevated by the USGS weir downstream. Because of the force of water coming through the culvert, re-circulating eddies form adjacent to the culverts. These eddies and other underwater currents caused by the culvert outlets may be challenging for fish to navigate. Many fish ladders are ineffective because the flows coming through the fish ladder are not attractive enough compared to swifter flows coming over a dam or nearby outlet. The two culverts at Upper Mills Dam present a classic example of two attractive flows for fish. Migrating fish will be drawn to the swift water and may not find the entrance to the fish ladder with the south culvert outlet nearby.

Alaskan steep pass ladders do not provide natural channel conditions and do not provide any type of habitat. However, they have been effective at passing alewives and herring in the northeast. The relatively low slope of the culvert at this location and the resting areas provided by the ladder should also allow American eels to pass. Some fish may have difficulty navigating the turbulent flows and finding refugia, but passage is likely to improve upon current conditions. However, Alaskan steep pass ladders present a velocity barrier for resident fishes such as largemouth bass, chain pickerel, bluegill, brown bullhead and others in the Peconic River (Coastal Fish & Wildlife Habitat Assessment Form, 2002) that live in slower moving waters (Scott and Crossman, 1973).

Another challenge with this option is that the fish ladder will trap debris entering the culvert. All fish ladders require some maintenance to keep them clear of debris and functioning properly. This alternative presents the added challenge of cleaning a ladder within a small-diameter culvert. It will be difficult to enter the culvert to clear out any blockages that may develop beyond easy reach of the culvert openings.

Constructing an Alaskan steep pass fish ladder in the north culvert at Upper Mills Dam will likely improve fish passage without increasing flood elevations in the pond upstream. However, besides the challenge of maintaining and cleaning a fish ladder inside a small culvert, the location of this culvert and the fish ladder within are not ideal for attracting migratory fish (Table 7).

Table 6. Comparison of water surface elevations 26 ft upstream from the south culvert.

Spillway option	*Stop logs present in south culvert*	*Upstream water surface elevation (ft)*		
		2-yr	10-yr	100-yr
Existing geometry	Yes	12.26	13.19	13.78
Existing geometry	No	11.74	13.02	13.79
Alaskan steep pass	No	11.96	13.23	13.81
Baffle retrofit	No	11.94	13.22	13.80
New 200-ft fishway	No	11.29	12.19	13.23

Table 7. Alternative 1 – Alaskan Steep Pass Fish Ladder

Estimated cost	Advantages	Disadvantages
$138,000	Somewhat improved fish passage for alewives Maintains current low flow pool elevations Does not substantially increase flood flow pool elevations (assuming stop logs are removed) Lower cost option	Flows from south culvert may confuse fish attempting to find the fish ladder Re-circulating eddies and currents at the outlet of the culverts make it difficult for fish to find the fish ladder Maintenance is difficult and costly Fish passage for resident species is likely not improved Requires active management of stop logs during flood events to prevent rising of the upstream water surface

2. *Baffles in the Existing North Culvert*

Installing baffles in the existing north culvert may provide slightly different conditions than the Alaskan steep pass fish ladder and was not originally proposed by American Rivers in their concepts. This option was devised after completing the existing fish passage analysis of the north culvert and is specific to this site where providing passage through an existing culvert needed to be assessed. The Haro model indicated that a large portion of alewives are capable of sprinting through the velocities that exist in the culvert, but that the distance that they could sprint was much smaller than the overall culvert length. Similar to the Alaskan steep pass ladder, if the overall culvert length could be reduced into smaller segments with the use of baffling, backwater areas for resting will be introduced, and depths will increase.

Many of the same challenges identified for the fish ladder in the above section will remain challenges for this alternative: re-circulating eddies and currents making it difficult for fish to find the north culvert, the proximity of flows emanating from both culverts confusing migrating fish, lack of passage for resident species, maintenance challenges, and required management of the south culvert stop logs. However, installing baffles custom made for this culvert does solve one of the problems associated with the Alaskan steep pass ladder. The baffles in this alternative will be designed and cut to fit within a round culvert, thereby concentrating all flows into the middle of the culvert and preventing substantial amounts of water from flowing between the baffles and the culvert walls. If the stop logs in the south culvert are currently not used to manage flows and impoundment elevations, they could be removed during flood flows to provide the necessary hydraulic capacity lost with the installation of the baffles in the north culvert (Table 6).

Installation of these baffles adds a significant challenge over Alternative 1: each baffle will need to be welded or bolted into place inside the culvert. The small size of the culvert makes this difficult and time consuming.

Table 8. Alternative 2 – Baffles in the Existing North Culvert

Estimated cost	Advantages	Disadvantages
$120,000	Somewhat improved fish passage for alewives Maintains current low flow pool elevations Does not substantially increase flood flow pool elevations (assuming stop logs are removed) Lower cost option Customized for round culverts	Flows from south culvert may confuse fish attempting to find the fish ladder Re-circulating eddies and currents at the outlet of the culverts make it difficult for fish to find the fish ladder Installation and maintenance is difficult and costly Fish passage for resident species is likely not improved Requires active management of stop logs during flood events to prevent rising of the upstream water surface

3. *100 ft long Natural Fishway*

This alternative utilizes a relic channel to the south of the two existing culverts. The new channel would be configured to maintain adequate depth and velocity for the majority of alewives migrating upstream. Boulders would be placed throughout this channel to provide resting areas and increase the depth of the channel. Assuming a channel with a top width of 12 ft and 2-ft banks at 2:1 (horizontal:vertical) side slopes, preliminary calculations result in water velocities between 3 ft/s and 5 ft/s. Combining a 4.5 ft/s velocity with resting spaces behind large rocks approximately 5 ft apart, the Haro model predicts a passage rate of 92%. Despite this large improvement, depths remain between 0.4 ft and 0.8 ft in many locations. Although these depths are sufficient for many fish, a water depth of at least one foot would be preferable to pass larger fish during all flows. This alternative also provides passage to a greater array of life stages for resident species, though it is difficult to quantify the use of this fishway by species not required to migrate to successfully complete their life cycle.

This alternative provides many benefits over the first two alternatives including natural substrate and in-stream habitat, lower channel gradient, decreased maintenance challenges, and no impacts from the outlets of the two culverts because the channel outlet will be downstream of the eddies and scour pool (Table 9). Access is also easy at this location: a gate maintained by LIPA provides access along a dirt road to an open field adjacent to the relic channel (Figure 11). The road can be used for access and the field can be used for staging. Although some vegetation will need to be removed to complete construction, much of the existing vegetation and canopy will remain to provide cover and shade.

Figure 11. (Top) Dirt access road looking towards dam; (bottom) open field looking towards proposed fishway.

The primary challenge with this alternative is the installation of a new culvert through the dam. As described in the 'Existing Conditions' section, utility lines lie beneath the road. A culvert can be installed without stopping flow of electricity and without impacting the utilities as was demonstrated during the emergency culvert replacement in 2005. However, removing the pavement, installing the culvert, and repaving the road adds considerable cost to this alternative. A box culvert set below grade or a bottomless arch culvert would allow natural channel substrate to be installed in the culvert without affecting the hydraulic capacity. To accommodate the new culvert, the natural substrate at the necessary elevation, an appropriate depth of water, and the utility lines, the road elevation may need to be increased slightly. Final design would dictate the specifications needed to ensure the integrity of the culvert, utilities, and road.

Table 9. Alternative 3 – 100 ft long natural fishway

Estimated cost	Advantages	Disadvantages
$195,000	Improved fish passage for migratory and resident species Improved in-stream habitat Little maintenance Increase the current dam spillway capacity Lower upstream water surface elevations during floods Requires less earthwork than the 200 ft fishway	Increased cost relative to alternatives 1 and 2 Shallow depths and high velocities may prevent some fish passage New culvert will require care involving utilities under road

4. *200 ft long Natural Fishway*

Extending the natural fishway to a 200-ft length would include most of the advantages and disadvantages of the 100-ft fishway (Table 10). However, the longer channel length and lower gradient would further improve the passage rate for alewives and other fish species by decreasing the water velocity and increasing the water depth. Appendix A shows the location of the fishway. Preliminary calculations indicate that the fishway would maintain at least a one foot water depth during all flows at or above the 90% exceedance probability flow. Velocities also remain low with a maximum estimate of 3.25 ft/s. Modeling this velocity with a distance of 5 ft to account for the resting areas behind rock, the Haro model predicts 94% of alewives would be capable of migrating upstream. This is only slightly higher than the 100-ft fishway alternative, but there is no depth constraint. Resident species migrating upstream would have the easiest hydraulic conditions under this option.

The only disadvantage of this alternative over Alternative 3 is the slightly higher cost of construction due to increased channel excavation and rock material. Of all the alternatives, however, the 200-ft fishway channel provides the most natural in-stream conditions and habitat and the highest percentage of fish passage for migratory and resident species. There are few if any long-term maintenance challenges and the elevation of the pond upstream will be maintained during low flows and decreased during flood flows.

Table 10. Alternative 4 – 200 ft long natural fishway

Estimated cost	Advantages	Disadvantages
$210,000	Significantly improved fish passage for migratory species Create river connectivity for resident fishes Improved in-stream habitat Little maintenance Increase the current dam spillway capacity Lower upstream water surface elevations during floods	Cost Requires a larger footprint than the 100 ft fishway New culvert will require care involving utilities under road

USGS Weir

Before fish reach the Upper Mills Dam, the USGS weir presents an impediment that must first be navigated. The main portion of the weir has a 2.5-ft drop which alewives are not able to pass during lower flows. Flood flows at the 5-yr recurrence interval and higher do allow the weir to become submerged, which provides some fish passage less than 5% of the time. This presents a significant barrier to fish passage. It will be important to address this barrier at the same time as passage around Upper Mills Dam is addressed. The following discussion considers alternatives for passage.

Access to the USGS weir for all alternatives is likely easiest along the south side of the Peconic River. Using the LIPA dirt road, access could either proceed east through a wooded area past the USGS gagin station or downstream along the river. Vehicle access through the wooded area would require the removal of a few trees and shrubs, but large trees could likely remain. Access through the river may require the temporary installation of a rock ramp and road depending on the depth of the channel during construction. This would add to the project expense depending on the amount of rock that would need to be imported or the type of road that would need to be built. If water flow is diverted from above the dam to below the USGS weir, access could also be gained in the river along the north side, using the existing public parking lot and river access point.

1. *Rock Ramp*

The first option is to install a rock ramp from the crest of the weir to the river bed downstream. Larger rock would be placed to prevent the waterfall effect that currently exists. The hydraulic characteristics would be similar to the 200 ft long fishway with at least a one foot depth maintained and resting areas behind rocks. This is the most expensive alternative because of the cost of the rock. However, this option would likely result in the least amount of work for the USGS to update the stage-discharge relationship necessary.

Table 11. Alternative 1 – Rock ramp

Estimated cost	Advantages	Disadvantages
$25,000	Significantly improve fish passage for migratory fish	Fish passage not as favorable as removing the entire weir.
	Create river connectivity for resident fishes	Structure remains in channel disrupting natural fluvial functions
	Maintain upstream water surface elevations	Some re-calibration of stage-discharge relations for the USGS would be necessary (added cost)

2. *Weir notch*

A quick, low cost alternative for fish passage through the weir is to notch a portion of the weir so the hydraulic drop during low flows is minimized. Final design would dictate the dimensions of the notch, but this would essentially assure fish a low-flow passage option. Because of the change to the weir, the USGS would need to recalibrate at least the lower end of the stage-discharge relationship (R. Busciolano, USGS, pers. comm.). This adds cost that is not included in Table 12 below. Furthermore, this option would lower upstream water surface elevations between the weir and Upper Mills Dam during low flows. As a result, the design and costs for the passage alternatives at the dam would need to be adjusted. For the natural fishways, some added construction costs would be necessary to build a low flow channel that extends into the Peconic River. This low flow channel would not need to be as wide as the upper portions of the fishway because it would be designed for low flows, but additional channel rock would likely be necessary to provide a stable channel bed and this will increase costs somewhat. If Alternative 1 for Upper Mills Dam is chosen, the fish ladder will need to be extended to the new channel bed and this can increase costs substantially given that NOAA estimates that Alaskan steep pass ladders average about $23,000 per foot of rise for design, permitting, and construction. For Alternative 2, the culvert and the baffling within would need to be extended as well so that the culvert was not perched. Replacing the entire culvert with a longer culvert would negate the primary benefit of retro-fitting the existing culvert - not disturbing the road surface and the utilities. However, the culvert could be extended by fitting a shorter culvert of similar width inside the downstream end of the existing culvert and bolting or welding them together. This extension would add costs that may be similar, if not slightly less, than the cost of extending the fish ladder.

Table 12. Alternative 2 – Weir notch

Estimated cost	Advantages	Disadvantages
$6000 (plus costs associated with the Upper Mills Dam alternative)	Slightly improved fish passage for alewives Lowest cost option for passage at the weir Does not require completely new construction of USGS gage	Fish passage not as favorable as removing the entire weir or building a rock ramp. Passage for resident fishes is still inhibited USGS gage re-calibration is necessary (added cost)

3. *Full weir removal*

The final alternative for fish passage at the weir is full removal. This option has the obvious benefit of restoring the river to its natural state at the weir site. Fish passage conditions for migratory and resident fishes would be most favorable compared to the rock ramp or the weir. One drawback to this method, however, is the significant added expense for the USGS to build an alternative gage and stage-discharge calibration. A stage recorder would be tracking the flow in a natural channel rather than a man-made structure. The variability with the movable boundaries of a natural channel would increase costs for the USGS. Coordination with the USGS will be critical with this option. Also, as with the notching option, upstream water surface elevations would drop resulting in added costs to the selected alternative at the Upper Mills Dam.

Table 13. Alternative 3 – Full weir removal

Estimated cost	Advantages	Disadvantages
$8500 (plus costs associated with the Upper Mills Dam alternative)	Significantly improve passage for alewives Significantly improve passage for resident species Restores a riverine environment	New USGS gaging methodology and re-calibration is necessary; this would add to the overall project cost

COSTS

Channel rock for the fishway and the larger stone for the rock ramp over the USGS weir can be obtained from East Coast Mines located in East Quogue, southeast of Riverhead. The following quotes for stone were obtained:

- 12-18 inch riprap: $55/ton ($60/ton delivered on site)
- 12-18 inch rounded boulder: $100/ton (no delivery)
- 3-8 inch rock: $28.5/ton ($33.5/ton delivered on site)

The costs for replacing or installing a new culvert through the dam and under the road were estimated based on the costs from the emergency culvert replacement in 2005 and current costs of materials. In 2005, the corrugated metal culvert was replaced with a 6-ft concrete culvert with sheet pile wing walls on the upstream end. The cost for this work (construction and materials) was approximately $48,000. Concrete box culverts or bottomless arch culverts that would be of sufficient size for the natural fishway alternatives are more expensive and would cost approximately $70,000 to deliver and install.

Alaskan steep pass fish ladders have been estimated by NOAA to cost approximately $23,000 per foot of rise. This includes the design of the ladder, permitting, and construction. Placing the ladder within the north culvert would require about 5 ft of rise, resulting in a cost of approximately $115,000. Removing the USGS weir would necessitate the lengthening of the ladder to add about 2 ft of rise.

The least expensive alternative includes retrofitting the north culvert with baffles combined with notching the USGS weir. These alternatives would cost approximately $170,000, including the culvert extension for low flows. The fish bypass channel that is the best alternative for fish will cost approximately $225,000 with a notched weir and the necessary channel extension for low flows. Although removal of the USGS weir would be preferable for fish passage, close coordination and collaboration with the USGS will be necessary for success. Notching the weir is the least expensive option, though the cost discussed above does not take into account the recalibration of the stage-discharge relationship during low flows. A rock ramp would be more expensive because of importing rock, but re-calibration would likely require less effort.

RECOMMENDATIONS

Upper Mills Dam

Considering the performance criteria outlined at the beginning of this report, and the fish passage improvements discussed in the different alternatives, we recommend Alternative 4 – the construction of a 200-ft long natural fishway with a new culvert through the dam. Although this option is the most expensive of the four alternatives (Table 14), it will provide the most benefit for migrant and resident fishes. It will not provide a velocity, depth, length, or vertical barrier constraint on fish movement like the existing conditions and the other alternatives. Low flow pond elevations will be maintained, but flood flow elevations will be decreased because of the added hydraulic capacity. Access to the site is easy and although challenges exist with installing a culvert through the dam with surrounding utilities, it has been done recently and we can learn from that experience. Finally, the installation of a new natural 200 ft long fishway will provide the solution with the most longevity. The fish ladder and baffle options will require challenging maintenance due to debris blockages in a narrow culvert. By installing a new 200-ft long fishway, a solution is found that requires minimal maintenance and will persist longer into the future.

Table 14. Costs for fish passage around Upper Mills Dam and the USGS weir.

Alternatives	*Cost*
Alternative 1: Alaskan steep pass fish ladder - design and construction of ladder within north culvert	$138,000
Alternative 2: Culvert retrofit - design and construction of baffles within the north culvert	$120,000
Alternative 3: 100-ft long fishway - design and construction of channel; installation of culvert	$195,000
Alternative 4: 200-ft long fishway - design and construction of channel; installation of culvert	$210,000
USGS weir	
Rock ramp	$25,000
Notch	$6,000
Demolition	$8,500
Extension of fish ladder or culvert with baffles	~$46,000

USGS Gage

The USGS gage presents an additional challenge to fish passage. The period of record for the gage is extensive and should be preserved as these flow records are vitally important to the understanding of the Peconic River watershed. The concrete weir, however, is an antiquated methodology for collecting discharge data, precisely because of the impediment to fish passage and other riverine processes. Discussions with the USGS have indicated that considerable time and effort is necessary to recalibrate the gage following any changes to the configuration, particularly for the removal of the weir, but also for the notching or building a rock ramp. Given this fact, coupled with the cost of construction of either option, it may be better to apply these resources to the removal of the existing concrete weir and conversion to a modern stage recording unit. This provides a long term, sustainable solution at the site by eliminating the cost of maintenance and upkeep of the existing concrete structure as well as the obvious benefits of passing both migratory and resident fish species. This long term solution could only be feasible if significant financial contributions could be procured to offset the expense of materials and time required for both the removal of the existing structure and the installation and calibration by the USGS of a suitable replacement.

If the above long term solution is not able to be initiated in the near future, the best short term solution is to notch the USGS weir. This is a low cost option, and although it likely does not present the most effective means of fish passage when compared to a rock ramp, it should perform well for migratory species. The width and depth of the notch should be considered with the USGS in final design.

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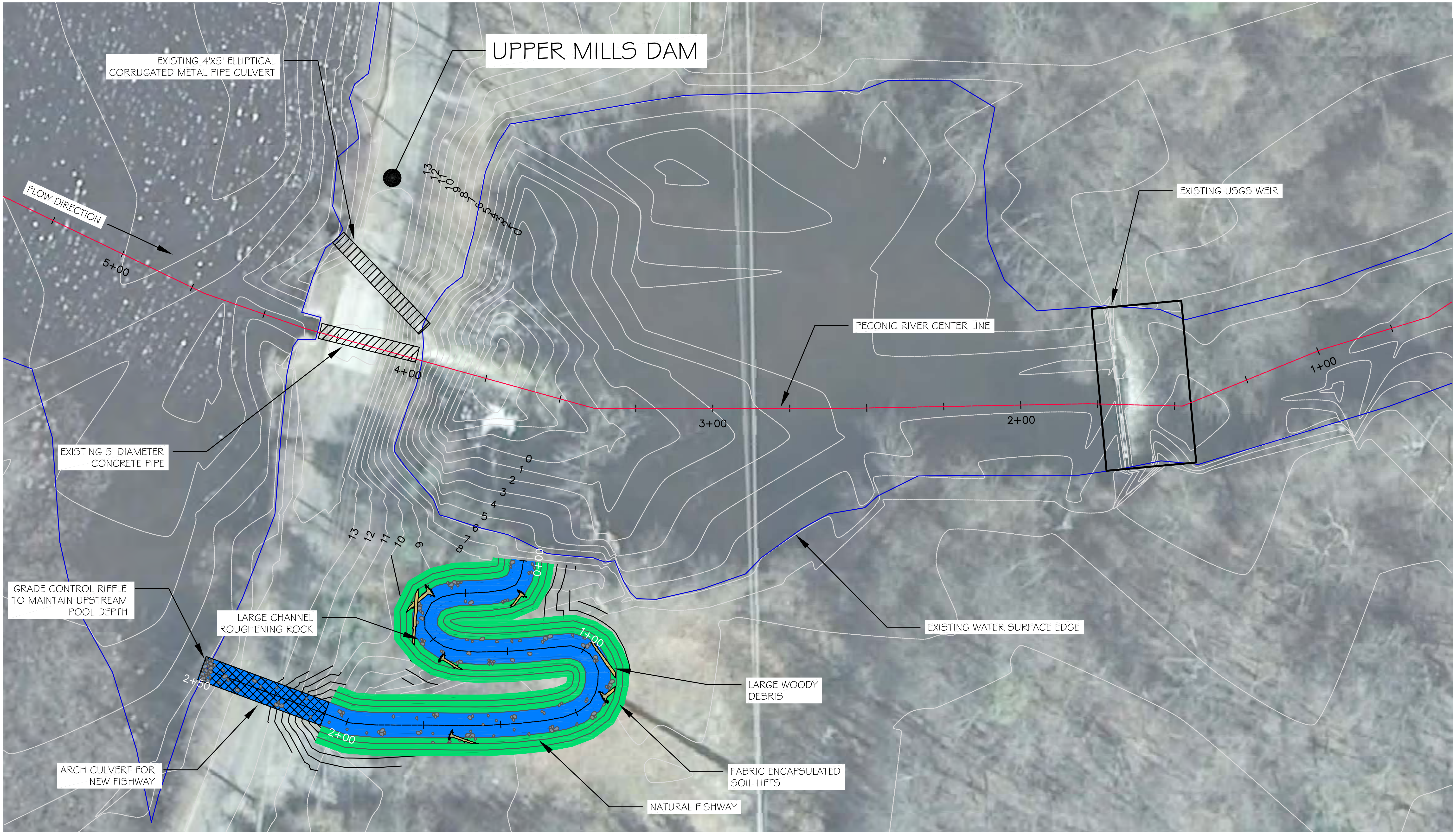

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Madison, WI 53714
608.441.0342
www.interfluve.com

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GRAPHIC SCALE
0 15 30 60
(in feet)
1"=30'

Alternative 4: 200 FT Natural Fishway
Upper Mills Dam
Riverhead, New York