Stony Brook Fishway
Conceptual Design Improvements

for Cape Cod Conservation District

and the

Town of Brewster

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Design Background

The Cape Cod Conservation District is assisting the Town of Brewster and Massachusetts State Marine Fisheries Departments in developing improvements to the existing Historic Fishway at the Stony Brook Mill. Recent upgrades in the USGS, USFWS, and NOAA Fisheries design criteria were followed in the development of the preferred conceptual design.

Population Criteria

As a first look on the projected capacity for the Stony Brook Fishway, the historic records from 1912, 225 barrels of herring were harvested and the projected harvest was for 2000 barrels. Barrels were commonly weighed to be 200 pounds and with river herring at 8 to 9 ounces, the number of fish per barrel would be 400. Thus, the harvest represents 90,000 herring and the projected capacity would be 800,000 fish.

USFWS has used a stocking rate of 6 fish per acre and a return rate of 235 fish per acre of habitat. The pond areas for Lower Mill Pond, Upper Mill Pond, and Walkers Pond are 49 acres, 260 acres, and 102 acres, respectively. The total habitat area is 411 acres. This would equate to a stocking number of about 2500 fish and the sustainable number of 96,600 river herring.

In order to check the size of pools for operating capacity the populations of 800000 and 1,000,000 river herring were used as input. To show the impact on capacity depths of 1, 2, and 3 feet were used and pool volumes, areas, and diameters for circular pools were calculated. The following tables provide the details.

Pool Capacity Calculations			For Stony Brook Pool and Weir Fishway					
Estimated population of alewife passage = 800,000								
Nt=	800000		Total number of fish to be passed in a season					
ln(Nt)	14		Population curve data		$n_D = n_T[0.4193 - 0.026 \ln n_T]$			
Nd=	52718		Peak Day Population					
Nh5	10543		Number per hour for 5 hours operation			Beta =.2		
Nh8	6589		Number per hour for 8 hours operation			More conservative		
Nh10	5271		Number per hour for 10 hours operation			Beta=.1		
Nm5	175		Number per minute for 5 hours or Beta = .2					
Nm8	109		Number per minute for 8 hours					
Nm10	87		Number per minute for 10 hours					
Volume= Nm * wf * Vc *(1+C) / r			wf= .5 lbs	Vc=.5	C=15% or .15		r=0.25 pools / min	
			alewife wt	$v_c = 0.50\ ft^3/lbf$		r= recommended passage rate		
V5	201	cubic feet						
V8	125	cubic feet						
V10	100	cubic feet						
				Diameter in feet	Depth in feet			
Area for V5 & 3’D	67	square feet		9	3			
Area for V5 & 2’D	101	square feet		11	2			
Area for V5 & 1’D	201	square feet		15	1			
Area for V8 & 3’D	42	square feet		7	3			
Area for V8 & 2’D	63	square feet		8	2			
Area for V8 & 1’D	125	square feet		12	1			
Area for V10 & 3’D	33	square feet		6	3			
Area for V10 & 2’D	50	square feet		7	2			
Area for V10 & 1’D	100	square feet		11	1			
Minimum pool depth of 4 times the differential head is recommended or 4 * 8” = 32” or 2.6 feet								

Pools that are at least 2 feet deep and 7 to 8 foot in diameter or containing a volume of 100 to 125 cubic feet are desired in order to pass the peak number of fish in 8 to 10 hours of operation. By deepening the pools to 3 feet, the representative diameter can be reduced to 6 to 7 feet or 33 to 42 square feet. Increasing the area to 38 to 48 square feet or volume up to 115 to 143 cubic feet passes the million fish as shown in the following table.

Pool Capacity Calculations			For Stony Brook Pool and Weir Fishway					
Estimated population of alewife passage = 1,000,000								
Nt=	1000000		Total number of fish to be passed in a season					
ln(Nt)	14		Population curve data		$n_D = n_T[0.4193 - 0.026 \ln n_T]$			
Nd=	60096		Peak Day Population					
Nh5	12019		Number per hour for 5 hours operation			Beta =.2		
Nh8	7512		Number per hour for 8 hours operation			More conservative		
Nh10	6009		Number per hour for 10 hours operation			Beta=.1		
Nm5	200		Number per minute for 5 hours or Beta = .2					
Nm8	125		Number per minute for 8 hours					
Nm10	100		Number per minute for 10 hours					
Volume= Nm * wf * Vc *(1+C) / r			wf= .5 lbs	Vc=.5	C=15% or .15		r=0.25 pools / min	
			alewife wt	$v_c = 0.50\ ft^3/lbf$		r= recommended passage rate		
V5	230	cubic feet						
V8	143	cubic feet						
V10	115	cubic feet						
				Diameter in feet	Depth in feet			
Area for V5 & 3'D	77	square feet		9	3			
Area for V5 & 2'D	115	square feet		12	2			
Area for V5 & 1'D	230	square feet		17	1			
Area for V8 & 3'D	48	square feet		7	3			
Area for V8 & 2'D	72	square feet		9	2			
Area for V8 & 1'D	143	square feet		13	1			
Area for V10 & 3'D	38	square feet		6	3			
Area for V10 & 2'D	58	square feet		8	2			
Area for V10 & 1'D	115	square feet		12	1			
Minimum pool depth of 4 times the differential head is recommended or 4 * 8" = 32" or 2.6 feet								

Hydrology and Operating Flows

The streamflow in the Stony Brook which pass through the fishway in the spring are a complex mix of groundwater, surface water, evaporation, and road run-off. A separate report was developed to summarize hydrologic studies and develop operating flows. The following table give the range of flows expected to be experienced during operations.

Energy Dissipation and Velocities

The preliminary design of existing and proposed improvements used operating flows of 3, 7, and 13 cfs for the low, normal, and high water discharges. The high of 13 cfs was problematic

	Herring River gage				Stony Brook		
Exceed	DA=9.4 sm	9.4	Per 1 sm	4.7	4.21	3.6	3.07
Percent	Annual	Migration	Migration	Normal	Normal	Normal	Normal
0.05	21.0	25	2.7	12.5	11.2	9.6	8.2
0.1	18.1	22	2.3	11.0	9.9	8.4	7.2
0.2	15.3	18.9	2.0	9.5	8.5	7.2	6.2
0.3	13.0	16.9	1.8	8.4	7.6	6.5	5.5
0.4	11.0	15.4	1.6	7.7	6.9	5.9	5.0
0.5	8.9	14	1.5	7.0	6.3	5.4	4.6
0.6	7.4	13	1.4	6.5	5.8	5.0	4.2
0.7	6.2	11	1.2	5.5	4.9	4.2	3.6
0.8	4.7	9.4	1.0	4.7	4.2	3.6	3.1
0.9	2.9	7.26	0.8	3.6	3.3	2.8	2.4
0.95	1.9	6.3	0.7	3.2	2.8	2.4	2.1
	Screening Parameters						
Low (cfs)		4.0	0.4	2.0	1.8	1.5	1.3
Normal (cfs)		14.3	1.5	7.1	6.4	5.5	4.7
High (cfs)		30.4	3.2	15.2	13.6	11.6	9.9

in being able to design pools with adequate volume to dissipate energy and still stay within the existing walled areas of the fishway.

A total of 4 alternatives were evaluated varying weir locations, drop per pool from 6 to 9 inches, and pool volumes to optimize energy dissipation and minimize the number and footprint of the additional construction for historic preservation and cost limiting purposes.

The final preferred improvement scenario is represented in the following table which shows the fishway alternative meets all EDF criteria up through the discharge of 7 cfs.

Preferred Improvement Alternative

During review of the alternatives, MA Marine Fisheries recognized that 3 additional weirs had existed downstream from the Weir 1 and the footbridge. Additional detailed review in the field and from the Tighe and Bond and WSP drawings revealed possible locations in the downstream tailwater channel or where new weirs could be added at Station 80, Station 107, and Station 128. The weir sill elevations were set to meet criteria and the pool lengths are about 27

Preferred Improvement Alternative

			Energy Dissipation Factors					
	Depth	Weir ID No.	Preferred Alternative Bottom El	Drop per Pool	Preferred Alternative Pool Area	EDF 3 cfs	EDF 5 cfs	EDF 7 cfs
	2	1	6.12	0.6	217.0	0.3	0.4	0.6
	2	2	6.73	0.6	189.0	0.3	0.5	0.7
	2	3	7.34	0.6	207.0	0.3	0.5	0.6
	2	4	7.95	0.7	89.0	0.6	1.1	1.5
	2	4A	8.66	0.7	112.0	0.6	1.0	1.4
	3	5	9.37	0.7	54.0	0.8	1.4	1.9
	3	5A	10.08	0.7	71.0	0.6	1.0	1.5
	3	5B	10.79	0.7	93.0	0.5	0.8	1.1
	3	6	11.50	0.7	73.0	0.6	1.0	1.4
	3	7	12.21	0.7	51.0	0.9	1.4	2.0
	3	8/9	12.92	0.7	58.0	0.8	1.3	1.8
	2	10	13.63	0.5	350.0	0.2	0.4	0.5
		11	14.13					

feet, 21 feet, and 37 feet, respectively in the upstream direction. The model was updated and calculations completed to confirm volumes and design criteria are met.

Preferred Improvement Alternative

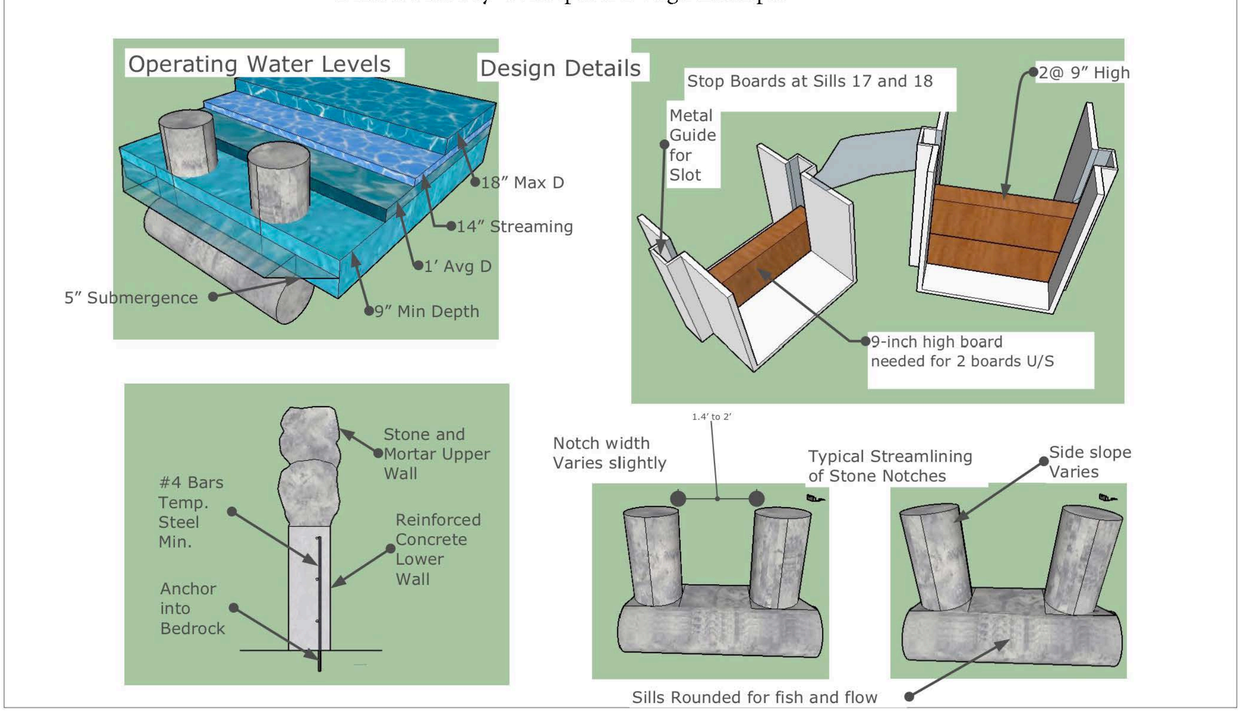
The updated model and layout depictions are under separate cover.

Weir Submergence and Overflow Characteristics

The additional comments to be considered in final design were submergence of flow over the weirs, rounding the side walls to address a smooth vena-contract over the weirs, adding

Preferred Improvement Alternative with Downstream Tailwater Weirs

Bristol Fishway Conceptual Design Example



		11	14.13						

rounded facia rocks inside the pools at selected coarse or abrupt stone intrusions to the flow, adding slots for water control at the weirs.