Monitoring of Post Restoration Habitat Conditions in Shorey's Brook

Jacob Aman

Wells National Estuarine Research Reserve

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This report is dedicated to the memory of Dr. Michele Dionne.

Acknowledgements

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Cover photo: Shorey's Brook dam removal site, March 2012.

Dedication page photo: Shorey’s Brook dam, prior to removal, April 2011.

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Introduction

In January 2012, the Great Works Regional Land Trust contracted the Wells National Estuarine Research Reserve to conduct habitat monitoring of post dam removal conditions in Shorey's Brook in Eliot and South Berwick, ME. The Wells NERR conducted monitoring of habitat conditions in the Shorey's Brook watershed prior to the dam removal in 2011, which included limited monitoring of diadromous and resident fish use of the estuary portion of the brook, as well as habitat and barrier surveys throughout the watershed upstream of the dam, and water quality monitoring just below the dam (Aman, Thornton, Van Boer, & Dionne, 2012). The 2011 habitat surveys demonstrated that the Shorey's Brook watershed was not suitable for coldwater fish species, and due to its small size, and presence of upstream barriers, the system did not offer significant habitat for diadromous species such as blueback herring, or American shad. The dam removal site and immediate downstream reach did however promise to provide potential spawning habitat for rainbow smelt, and this species was the target of post dam removal monitoring.

Geography

Shorey's Brook is a tributary of the Salmon Falls and Piscataqua Rivers located in Eliot and South Berwick, Maine. The brook is approximately 2.3 miles in length, with one tributary, Lord Brook, which runs for an additional 1.7 miles through South Berwick, for a total of 4 stream miles. Shorey's Brook joins the Salmon Falls River very near to its confluence with the Cocheco River and the Piscataqua River, approximately 12 miles upstream of the Gulf of Maine.

History

The first water powered sawmill and gristmill in the new world was built in 1634 on the nearby Great Works River, a tributary to the Salmon Falls. It is likely that the Shorey's Brook dam at the head of tide was the also the site of early grist and lumber mills. Shorey's Brook was part of a resort destination site for about 60 years starting in the late 1800s. First as a resort known as "Porter Pines" and later as an entertainment venue called "Radio Ranch", which closed in 1945. The dam on the brook created a pond for swimming and fishing.

In 1996 the dam at the head of tide on Shorey's Brook was partially breached. In 2008 the dam and 27 acres of adjacent property were acquired by the Great Works Regional Land Trust.

In the fall of 2010 GWRLT received funding for an anadromous fish restoration feasibility study and implementation plan. This study developed a design for fish passage at the current dam site, and through the culvert where Shorey's Brook passes under Route 101 (in coordination with a planned culvert replacement by the Maine Department of Transportation). The potential for fish

passage under the bridge at the Old Fields Road and through the culvert at Rt. 236 was also assessed.

In 2011 the Wells NERR conducted pre-dam removal monitoring of fish populations and habitat in Shorey's Brook and documented habitat suitable for rainbow smelt, blueback herring, American eel, and sea lamprey.

In November 2011, the head of tide dam was removed, and the stream channel has been allowed to emerge naturally, without manipulation.

Target Species

Rainbow smelt occur from New Jersey to Labrador and the St. Lawrence River. Smelt are anadromous and migrate each winter and spring to spawn in gravel and cobble beds of coastal rivers. Adult smelt typically range in size from 17 cm to 22 cm. Smelt are an important forage fish for larger species such as striped bass, and are sought after by anglers who fish for them through the ice on frozen rivers. Rainbow smelt populations have gone into decline across their historical range due to habitat degradation from stream barriers and pollution (Chase, 2006), and are listed as a species of concern by the National Marine Fisheries Service (NMFS, 2007).

Adult rainbow smelt captured in Shorey's Brook 4/5/12.

Project Description

Post-dam removal monitoring was designed to assess potential spawning habitat for rainbow smelt in the restored reach of Shorey's Brook, from the Route 101 crossing to the estuary. A monitoring plan was developed in collaboration with GWRLT to meet their project needs, and with guidance from the NOAA Restoration Center and the Maine Coastal Program.

Monitoring activities were comprised of three primary data collection efforts:

- continued deployment of a long term water quality monitoring station upstream and downstream of the former dam site (water temperature, depth, salinity),

- fyke net sampling for rainbow smelt in the estuary, surveys for rainbow smelt eggs in potential spawning areas,

- and assessment of potential spawning areas for rainbow smelt, including:
    - mean water velocity;
    - dominant and sub-dominant substrate types;
    - mean channel width;
    - mean water depth;

- instantaneous dissolved oxygen percentage and concentration, water temperature, and specific conductance;
- length of potential spawning substrate;
- observations of erosion.

All monitoring activities were carried out by Wells NERR staff, interns, and volunteers, with assistance from GRWLT staff and volunteers, and in coordination with other monitoring efforts conducted by project consultants.

Methods

Water Quality

Water quality monitoring stations were deployed upstream and downstream of the site of the former dam to record fluctuations in depth, water temperature, and salinity. The long term water quality monitoring stations were deployed continuously from March 7th to October 17th at the downstream site, and March 7th to April 5th at the upstream site. The downstream station was deployed at the same location as the pre-dam removal monitoring station. This area was known to be tidally influenced and located in a potential spawning area for rainbow smelt, which allowed the data to be used to assess spawning conditions as well as tidal incursion. The downstream station was deployed continuously during spring habitat and fisheries assessments, and the deployment was extended until October to collect capture changing conditions as the system transitioned from an impoundment to a free flowing stream. The upstream station was deployed at the likely extent of tidal incursion delineated by the first visually significant elevation change in the brook upstream of the removed dam site. In-situ Aqua TROLL Level-Temperature-Conductivity data loggers were placed in perforated PVC tubes positioned vertically and supported by metal stakes driven into the stream bottom. The PVC tubes had end caps attached at the bottom to position the data loggers above stream sediment. Data loggers were periodically replaced to ensure continued operation and to retrieve data.

Upstream water quality monitoring station.

Fisheries Assessment

Fyke net sampling was conducted at a location downstream of the first potential spawning area and at or upstream of the tidal salt wedge, based on recommendations from the Maine Department of Marine Resources rainbow smelt biologist Claire Enterline. Fyke net sampling occurred twice weekly during consecutive nighttime incoming tides from March 7th to April 4th.The net was positioned in the deepest part of the channel so that captured fish would remain in the water column even at low water to avoid fish mortality.

The fyke net included a 48” square main fyke frame with ¼” nylon mesh, leading to three 1/8” net chambers supported by 24” frames and connected with 1/8” mesh funnels. Soft wings measuring 50’ x 4’ were extend at a 45° angle from the main frame to the adjacent marsh surface. The bottom edges of the wings were secured to the stream bottom with stakes, and the top edges were fitted with floats so that the wings would rise with the incoming tide. The opening of the fyke net was oriented facing downstream to enable capture of in-migrating rainbow smelt. The fyke net was also secured with anchors at the upstream and downstream ends. The catch was retrieved through a drawstring cod end and the rear of the fyke net, and fish were also removed from any other net chamber.

The fyke net was collapsed and secured to the stream bottom during daytime tides between nighttime sampling, and reset each day before the nighttime incoming tide. Captured fish were placed in 5-gallon buckets with battery powered aerators. Species, weight, and length was recorded for each individual up to the first 20 individuals of each species. Weight, length, and sex were recorded for each rainbow smelt, and scale samples were collected from some individuals. Fish were then returned alive to the stream. Weather observations and water temperature were recorded.

Egg Surveys

Visual egg surveys were conducted at potential spawning areas once per week from March 7th to April 16th.Gravel and cobble substrates were removed from the streambed by hand and inspected for presence of smelt eggs. Particular attention was given to locations with riffles and higher velocity, or noticeable lack of algal growth. Surveys were conducted starting at the most downstream end and moving upstream to avoid reducing visibility by disturbing sediment.

Examining substrate for presence of smelt eggs.

Habitat Assessment

Assessment of potential spawning areas was conducted once per week from March 7th to April 4th. Potential spawning areas were identified by visually inspecting the stream bottom for the presence of appropriate spawning substrate types. These areas were delineated by placing wooden stakes in the stream bank at the upstream and downstream extents of spawning substrate. This enabled easy location of study reaches. Potential spawning areas were assessed after egg surveys were completed to avoid disturbing sediment. Each study area was assigned a unique site ID (PAS01, PSA02, etc…) Initial lengths were recorded and used to delineate each reach. Subsequent length measurements were taken if it was apparent that potential spawning areas had changed erosion, movement, or deposition. Dominant and sub-dominant substrate types were identified according to size, and observations were made as to the degree of erosion or accretion of sediment. Water velocity, water depth, water temperature, dissolved oxygen, and specific conductance were measured at the downstream, middle, and upstream end of each study reach.

Results

Water Quality

Monitoring with the Aqua TROLL data loggers identified tidal fluctuations at both the downstream and upstream stations. The upstream station experienced an average depth (in meters) of 0.20m, with a range of depth from .17m to .38m, the greatest depth occurring during an astronomical tide on March 14th. Depth at the downstream station averaged .26m and ranged from .021m to 1.39m, with the greatest depth occurring during an astronomical tide on June 4th. Salinity (measured in practical salinity units, roughly equivalent to parts per thousand) at the upstream site averaged 0.12, ranging from 0.06 to 0.94. Salinity at the downstream station averaged 1.03, ranging from 0.01 to 22.47. Further results are included in Table 1.

Table 1. In-Situ Aqua TROLL data logger stations.

	Upstream (3/31-5/19)	Downstream (3/7-10/17)
Avg. Depth (m)	0.20	0.26
Max Depth (m)	0.38	1.39
Min Depth (m)	0.17	0.02
Avg. Salinity (PSU)	0.12	1.03
Max Salinity (PSU)	0.94	22.47
Min Salinity (PSU)	0.06	0.01
Avg. Temp. (°C)	8.11	13.72
Max Temp. (°C)	19.88	32.22
Min Temp. (°C)	1.70	0.51
Avg. Spec. Cond. (µS)	242.62	1821.61
Max Spec. Cond. (µS)	1849.51	35724.21
Min Spec. Cond. (µS)	129.80	14.17

Fisheries Assessment

Rainbow smelt were captured on April 3rd and April 4th. A total of 22 individuals were captured, including 5 females and 17 males (Table 2). Male smelt total lengths (in millimeters) ranged from 135mm to 216mm, and weights ranged (in grams) from 13.2g to 44.3g. Female smelt total lengths ranged from 173mm to 207mm, and weights ranged from 21.5g to 65.3g.

Table 2. Rainbow Smelt Data

Fished Date/Time	Length (mm)	Weight (g)	Sex
4/4/12 6:30	182	21.5	F
4/4/12 6:30	180	29.1	F
4/4/12 6:30	154	17.7	M
4/4/12 6:30	160	18.8	M
4/4/12 6:30	164	20.2	M
4/4/12 6:30	160	20.3	M
4/4/12 6:30	171	22.5	M
4/4/12 6:30	179	26.7	M

4/4/12 6:30	179	26.8	M
4/4/12 6:30	178	28.5	M
4/4/12 6:30	182	32.7	M
4/4/12 6:30	216	44.3	M
4/5/12 7:40	173	24.8	F
4/5/12 7:40	204	57.4	F
4/5/12 7:40	207	65.3	F
4/5/12 7:40	135	13.2	M
4/5/12 7:40	159	18.3	M
4/5/12 7:40	176	24.5	M
4/5/12 7:40	173	29.2	M
4/5/12 7:40	179	30.1	M
4/5/12 7:40	179	31.4	M
4/5/12 7:40	205	40.3	M

Fyke net bycatch included 14 additional species of fish, and 2 species of decapods (Table 3). Other diadromous species captured include Atlantic tomcod and American eel.

Table 3. Shorey's Brook Fyke Net Fish Species List

Scientific Name	Common Name
Anguilla rostrata	American eel
Apeltes quadracus	fourspine stickleback
Clupea harengus	Atlantic herring
Crangon septemspinosa	sand shrimp
Fundulus heteroclitus	mummichog
Fundulus majalis	striped killifish
Gasterosteus aculeatus	threespine stickleback
Lepomis gibbosus	pumpkinseed
Liopsetta putnami	smooth flounder
Menidia menidia	Atlantic silverside
Microgadus tomcod	Atlantic tomcod
Morone americana	white perch
Myoxocephalus aeneus	grubby sculpin
Osmerus mordax	rainbow smelt
Palaemonetes pugio	grass shrimp
Pungitius pungitius	ninespine stickleback
Semotilus atromaculatus	creek chub

Egg Surveys

Smelt eggs were observed below the former dam site within an 8 meter riffle at the location of the downstream data logger. Smelt eggs were only observed on April 2nd. After discovery of eggs, two additional egg surveys were conducted over the following two weeks, but no further eggs were observed.

Translucent rainbow smelt eggs adhered to cobble.

Habitat Assessment

Five potential spawning areas (PSA) were identified downstream of Route 101. Four of these were upstream of the former dam site, and one was located downstream (Figure 1). Two cascades were identified within the restored stream reach.

PSA01 was the most upstream site monitored, and was immediately downstream of the second cascade. This site was 8.59 m in length, 4.31 m wide, and had an average depth of 0.41 m. The dominant substrate type at this site was fines (clay and silt) and the sub-dominant substrate type was sand (<0.25" diameter). Light sedimentation was observed on March 13th, and erosion of the stream bank was observed on March 13th and April 3rd. The average water velocity in PSA01 was 0.27 m/s (meters per second). The average dissolved oxygen percentage and concentration, water temperature, and specific conductance were 110.34%, 12.95 mg/L (milligrams oxygen per liter of water), 8.66 °C (Celsius), and 174.42 µS (conductivity) respectively.

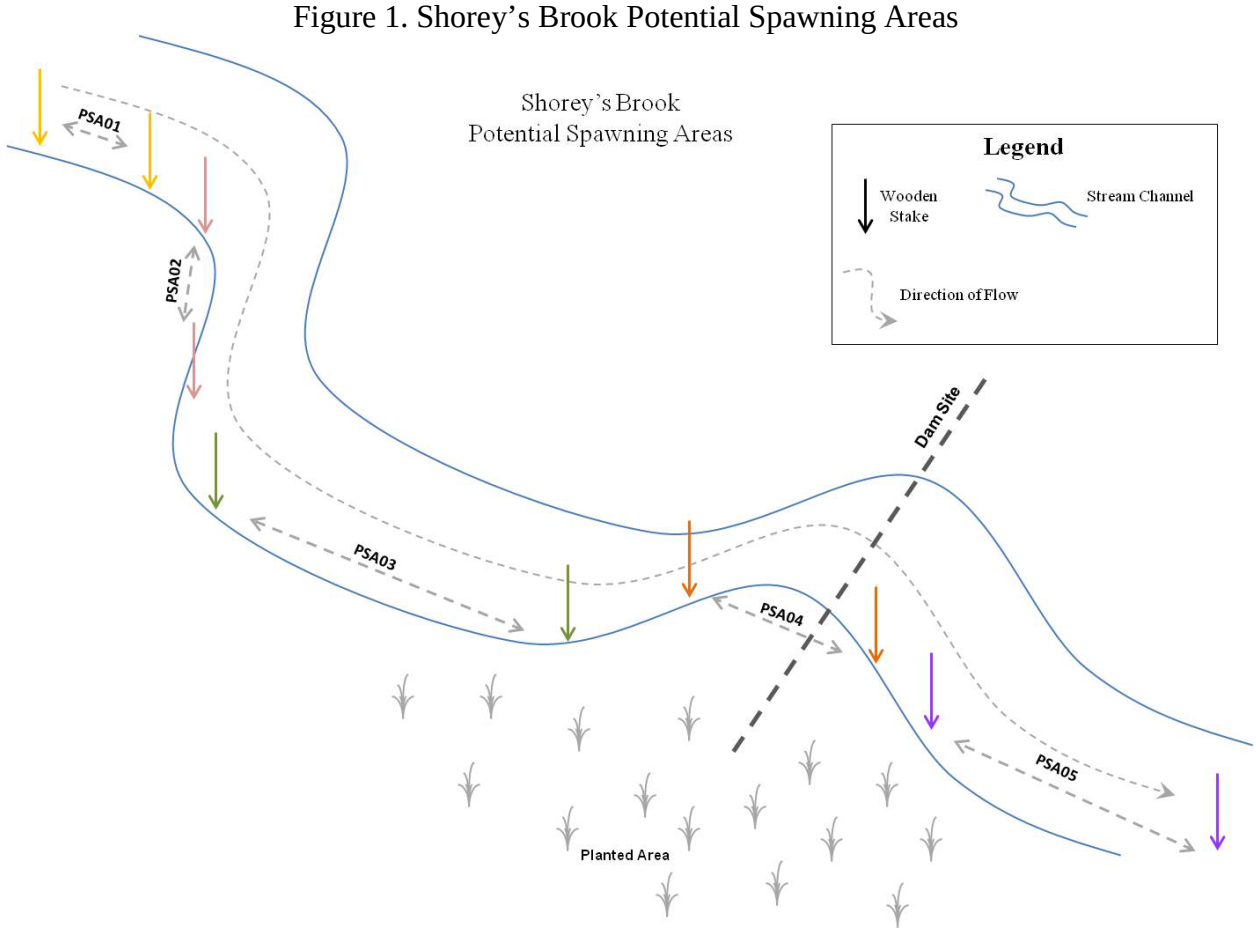
PSA02 was the second most upstream site monitored. This site was 6.40 m in length, 2.78 m wide, and had an average depth of 0.30 m. The dominant substrate type at this site was sand (<0.25" diameter) and the sub-dominant substrate type was fines (clay and silt). Light

sedimentation was observed on March 13th, and erosion of the stream bank was observed on March 13th and as well as bank slumping on April 3rd. The average water velocity in PSA02 was 0.38 m/s. The average dissolved oxygen percentage and concentration, water temperature, and specific conductance were 109.02%, 12.68 mg/L, 9.02 °C, and 168.92 µS respectively.

PSA03 had a length of 21.34 m, a width of 2.92 m, and an average depth of 0.38 m. The dominant substrate type at this site was sand (<0.25" diameter) and the sub-dominant substrate type was fines (clay and silt). Light sedimentation was observed on March 13th, and erosion of the stream bank was observed on March 13th and as well as bank slumping on April 3rd. The average water velocity in PSA03 was 0.41 m/s. The average dissolved oxygen percentage and concentration, water temperature, and specific conductance were 107.72%, 12.55 mg/L, 8.94 °C, and 175.08 µS respectively.

PSA04 had a length of 18.62 m, a width of 4.43 m, and an average depth of 0.26 m. The dominant substrate type at this site was cobble (6" – 12" diameter) and the sub-dominant substrate type was sand and gravel (<0.25" – 6" diameter). Light sedimentation was observed on March 13th, and erosion of the stream bank was observed on March 13th. The average water velocity in PSA04 was 0.42 m/s. The average dissolved oxygen percentage and concentration, water temperature, and specific conductance were 107.42%, 12.52 mg/L, 8.88 °C, and 175.24 µS respectively.

Figure 1. Shorey's Brook Potential Spawning Areas



PSA05 was located in the tidally influenced reach downstream of the former dam. This site was 31.9 m in length, 3.72 m wide, and had an average depth of 0.18 m. The dominant substrate type at this site was cobble (6" – 12" diameter) and the sub-dominant substrate type was gravel (0.25" – 6" diameter). Light sedimentation was observed on March 13th, with fines covering intertidal areas adjacent to the main channel. The average water velocity in PSA05 was 0.52 m/s. The average dissolved oxygen percentage and concentration, water temperature, and specific conductance were 110.34%, 12.95 mg/L, 8.66 °C, and 174.42 µS respectively.

Discussion

Depth data indicates that the tidal incursion now extends upstream of the removed dam. The peak depth at the upstream station was 0.18m greater than the average depth. With very little rainfall in the 48 hours prior to this measurement, it seems likely that the increased depth was due to the tidal incursion. When compared to 2011 monitoring data, depth at the downstream station was an average of 0.18m lower in 2012, possibly reflecting the dam removal. Salinity data indicates that the salt wedge can periodically extend above the downstream station. Water salinity in the Gulf of Maine typically measures 35 (GMRI, 2011). The highest salinity measurement reached 22.47. In comparison, the upstream station recorded a peak 0.94, indicating that the extent of the salt wedge lies somewhere between the upstream and downstream stations. Peak water depths at both monitoring stations corresponded to astronomical high tide predictions for the Salmon Falls River.

Fyke net data confirms the presence of male and female adult rainbow smelt migrating in the estuary downstream of the restored area. Smelt were only sampled on April 4th and 5th, during the final week of the assessment. It is possible that the run could have begun after March 27th and continued after April 5th. The timing of the run corresponded with anecdotal accounts of the historical Salmon Falls River smelt runs (conversation with Dave Huntress, 4/3/12). Smelt runs in the nearby Great Bay had commenced by the first week of March and lasted until the first week of May (email communication with Jessica Fischer, NHF&G, 3/28/2012), and reportedly decreased in numbers of returning fish from previous years. Volunteers with the Great Works Regional Land Trust conduct weekly nighttime visual observations at the potential spawning areas, but no smelt were identified.

The presence of spawning smelt eggs was confirmed on April 3rd. A few dozen eggs were identified at PSA05, downstream of the restored area, in an area of small riffles and pools with cobble substrate, in the vicinity of the downstream water quality monitoring station. Much of the substrate in this area was covered with periphyton (algal growth), making egg identification difficult. Eggs were only identified on one occasion, at the same time as adult smelt were sampled in the fyke net. Subsequent surveys did not locate any eggs, and it is possible that algae and sediment deposition may have covered the few eggs that were deposited previously.

The stream reach upstream of PSA01 was not monitored due to difficult access through deep mud, and significant elevation and velocity barriers deemed impassible for the target species. Cobble and gravel substrate occurs throughout the restored stream reach, with the greatest amount in PSA05, downstream of the restored area. This location had been identified as a potential spawning site in 2011, but no habitat assessment was conducted at that time. Cobble substrate also dominated PSA04, but several factors may limit smelt access to this area, including a small downstream cascade, and high water velocity. Limited amounts of suitable substrate occur at the three upstream study sites. The length extent of this substrate increased overall at PSA01 (+1.0m) and PSA02 (+0.5m), but fluctuated little at most sites. Two cascades may bar upstream migration of smelt. The first occurs at the upstream end of PS04, and the second occurs at the upstream end of PSA01. Water velocity measurements for the first cascade consistently exceeded published rainbow smelt sustained swimming capabilities of 0.39m/s – 0.59m/s (Katopodis & Gervais, 1991), however, rainbow smelt swimming capabilities are not well studied, and it is possible that larger individuals can attain sufficient burst swim speeds to pass this barrier. Velocity measurements were taken just downstream of the second cascade at the upstream end of PSA01, and are not useful for evaluating the ability of smelt to pass this barrier. Several potential elevation barriers exist in the restored area as well. Though these were not assessed, their heights were estimated at approximately 0.2m – 0.8m. A study by Canadian researchers demonstrates that adult smelt can navigate elevation drops of up to 0.26m (Clement, Torterotor, Bergeron, Plante, & Caissie, 2012), suggesting that spawning smelt could pass the smaller of the existing elevation drops in the restored reach. Water quality readings at all 5 potential spawning areas attained state of Maine standards for dissolved oxygen, and temperature. There is no standard for specific conductance, but readings were not above normal for small streams in Maine.

Upstream elevation barrier formed by underlying clay and woody debris.

Conclusions

Habitat conditions in Shorey's brook are in a state of fluctuation as the restored stream channel carves its way through the formerly impounded sediment. Future culvert replacement work at the Route 101 crossing may influence sediment regimes in the downstream restored area. It may take a period of several years before significant spawning substrates will emerge from the restored stream bottom. As the new channel forms, cascades that currently create velocity and elevation barriers for smelt, may migrate upstream or disappear entirely, enabling access to additional habitat. With smelt already utilizing downstream habitat, there is potential for these fish to utilize emerging habitat in the restored reach of the brook.

Potential sources of habitat degradation do exist in Shorey's Brook, including sedimentation, eutrophication, tidal influence, and low flows, which could contribute to increased smelt egg mortality.

Recommendations

Fish populations and habitat should be monitored again if possible within the next 3-5 years, to assess the long term status of habitat restoration. Smelt typically reach sexually maturity at age two, so it will take several years before any increases in returning fish can be expected.

Photo documentation of the restored site should continue to capture changes to the stream bed and surrounding area.

Fish passage restrictions upstream of the restored area should be removed to maximize the impact of the dam removal for migratory fish.

Degradation of spawning habitat is evident from peryphyton growth and sedimentation, and these factors should be monitored. If possible additional plantings could be made to increase shading of the riparian buffer which would decrease water temperature and inhibit algal growth. Nutrient sampling could also be conducted to detect excess inputs from the watershed.

Sedimentation of downstream potential spawning area.

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Watershed Map