Biological Survey of the Cupsuptic River

By Forrest R. Bonney

Caring for Maine's Outdoor Future

February, 2006
Maine Department of Inland Fisheries and Wildlife
Division of Fisheries & Wildlife
INTERIM SUMMARY REPORT NO. 06-02
BIOLOGICAL SURVEY OF THE CUPSUPTIC RIVER

By
Forrest R. Bonney

Maine Department of Inland Fisheries and Wildlife
Fisheries and Hatcheries Division
Augusta, Maine

February, 2006
SUMMARY

The Cupsuptic River, a tributary to Mooselookmeguntic Lake in the Rangeley chain of lakes in Western Maine, provides habitat for wild brook trout (*Salvelinus fontinalis*) and, to a lesser extent, landlocked salmon (*Salmo salar*). The lower portion of the river serves as spawning and nursery habitat for Mooselookmeguntic Lake’s salmonid population.

Degradation of the river resulting from timber harvesting and log driving operations over a period of many decades prompted the Department of Inland Fisheries and Wildlife (DIFW) to assess the feasibility of brook trout habitat restoration. In a collaborative project, DIFW and the Rangeley Region Guides and Sportsmen’s Association surveyed the river in 1997. In addition to documenting degraded areas, we conducted a complete biological survey of fisheries habitat, which allowed quantification of the river’s value as fishery habitat. We concluded that sediment transport was filling in pools that provided important adult brook trout habitat. As a result, we constructed grade control structures in 2002 in an effort to arrest the downstream migration of sand and gravel. This report describes construction of the grade control structures and monitoring efforts through 2005.

INTRODUCTION

Over a period of many decades, the Cupsuptic River has been degraded by extensive timber harvest and log driving operations that resulted in destabilization, erosion and siltation within the drainage. As a result, excessive sediment transport has reduced pool volume. Because pools serve as the primary holding habitat for adult salmonids, pool degradation is presumed to have resulted in a reduction in the carrying capacity of the river. It was for this reason that the Rangeley Guide’s and Sportsmen’s Association requested that DIFW survey the Cupsuptic River and make recommendations for habitat restoration, a process that led to the
construction and evaluation of grade control structures to reduce sediment transport and restore pool depth.

DESCRIPTION OF THE DRAINAGE

General

The Cupsuptic River, located in northern Oxford County, originates near the Quebec border and flows southward to Mooselookmeguntic Lake. The river is 19.3 miles long and has a drainage area of 62.5 square miles. River sinuosity (the ratio of the channel length to the valley length) is 1.5. The river drops from an elevation of 2,468 feet at Cupsuptic Pond, its origin, to 1,467 at Mooselookmeguntic and Cupsuptic Lakes, for a total of 1,001 feet or 50.8 feet per mile and an average slope of 0.96%. The drainage lies primarily within the townships of Oxbow (T4 R5 WBKP), Upper Cupsuptic (T4 R4 WBKP), and Lower Cupsuptic (T4 R3 WBKP).

The watershed is steep, hilly, and forested primarily with spruce-fir and areas of mixed hardwoods. Unlike its neighboring drainages, the Cupsuptic drainage has few lakes. The only lakes greater than 10 acres in size are Cupsuptic Pond and Fox Pond, each of which is 20 acres in size. The river’s unusually cold and abundant discharge is provided by groundwater. Eight named tributary streams total 25.7 miles in length; none has been extensively surveyed.

Significant physical features of the Cupsuptic River include (from the bottom of the drainage) Little Falls, near the river’s mouth; Big Falls, which provides the first barrier to upstream fish migration seven miles from the river’s mouth; and Big Canyon, a mile-long gorge which contains several falls that are impassable to upstream fish migration. The entire river supports a wild brook trout population, and landlocked salmon occur below Big Falls.

The primary land use within the drainage is forestry, and there is little cultural development within the watershed. A network of gravel logging roads provides access to much of the river. Several wooden log-driving dams once limited fish movement, but have deteriorated to the point that they no longer hold water or obstruct fish migration. In the 1960’s, the drainage was heavily cut, resulting in severe erosion and siltation of the river as well as degradation of fisheries habitat.
HISTORY OF USE

Fisheries

Early biological surveys of the Rangeley lakes make passing reference to the Cupsuptic River. Kendall (1918) noted that “In the early [18]70’s trout from three-fourths to 1 ½ pounds were plentiful in this river, but in late years they appear to have diminished in number”. Cooper (1940) sampled brook trout and blacknose dace from an unidentified reach of the Cupsuptic River, and noted that trout were abundant. He stated that the Cupsuptic is “The most important breeding stream of the trout in Mooselookmeguntic”. Cooper estimated a mid-September flow of 70 to 90 cfs, which lies within the estimated September range of 7-344 (mean = 61) cfs estimated from the Diamond River data.

A 500-foot section of the Cupsuptic River ¼ of a mile above Big Falls was electrofished by the Fishery Division in August 1976. Forty-four brook trout, ranging from 3.1 to 7.8 inches, and aged 0+ to III+. Population estimates made in the upper river in the 1990’s indicated a population of 104 legal-size (6-inch or longer) brook trout per mile, compared to a statewide average of 102.

Water Quality

The Cupsuptic River’s water quality has been designated Class A by the Maine Department of Environmental Protection (MDEP), indicating the second highest rating given for fresh surface waters. Waters of this class are suitable for recreational purposes and for public water supplies after disinfection. In response to habitat degradation resulting from clear cutting within the drainage in the 1960’s, MDEP conducted macroinvertebrate monitoring in 1976. Sampling was conducted ½ mile above Cupsuptic (Big) Falls, at river mile 8.7. Results indicated that productivity was “low by comparison with other Maine rivers”. The report concluded “There appears to be no impact on the Cupsuptic River (from siltation resulting from extensive logging within the watershed) at this time. The habitat ...is naturally low in productivity. Effects of siltation such as increased turbidity, covering or clogging of the substrate were not observed. The community is made up of a number of types of filter feeders and gill breathing types which might be eliminated by abnormal siltation.”
MDEP repeated Benthic macroinvertebrate sampling as part of their River and Stream Biological Monitoring program at the same location in 1999. Rock filled mesh bags were placed in the river from August 4 to September 2. The reach sampled – immediately downstream of the old dam site - was steep with boulder/cobble substrate. Pollution-sensitive insects made up the majority of the sample, confirming that the Cupsuptic meets Class A standards, defined as "natural habitat for aquatic life; aquatic life shall be as naturally occurs" (Davies and Tsomides 1997).

Additional samples have since been collected by DIFW (Table 1). Sampling sites vary from that of MDEP in that these samples were taken from the deeper run/glide reaches with predominately gravel/sand substrate. In 2003, five orders (Diptera-flies, Ephemeroptera-Mayflies, Odonata-Dragonflies, Plecoptera-Stoneflies, Trichoptera-Caddisflies) of insects were collected, representing 16 families, for a total of 85 insects. In 2004, 6 orders of insects (those above, plus Coleoptera-beetles) representing 20 families were collected, for a total of 129 insects collected.

Season-long water temperatures were continuously recorded at miles 7.4 (1/3 mile above Big Falls) and 18.8 (the 'Bowmantown Express' site) from May 30 to Sept. 9, 1997. Water temperatures, which were recorded hourly, never exceeded 68°F and are considered to be ideal for brook trout. Monthly averages (Table 2) indicate the warmest temperatures, averaging 59°, occur in July and August. Temperatures at the lower site averaged 4-5 degrees warmer than those at the upper site; 13 river miles separate the two sites.

Water quality analysis was first conducted on the Cupsuptic River by MDIFW in 1996 and 1997 in conjunction with brook trout population estimates made at river mile 18.8 (Table 3). All parameters measured were suitable for the survival of brook trout and other cold-water fish species.

GEOMORPHIC ASSESSMENT

At the time of the 1997 survey, portions of the Cupsuptic watershed showed evidence of instability. In the upper watershed, debris dams and eroding stream banks indicated severe flow fluctuations. Significant areas of fines, including sand and silt, were evident in low-velocity areas the
entire length of the river. In the lower sections, characterized by ‘deadwaters’ and runs, organic fines were the predominant substrate type. Remains of four log-driving dams (at river miles 0.2, 8.7, 13.9, and 16.2) suggested that degradation resulted from log drives (including alterations made to facilitate log drives) and associated timber cutting within the drainage.

An initial effort to deepen a filled-in pool was attempted in 1998 when the Environmental Studies class at Rangeley Lakes Regional School removed sand and gravel from the first pool downstream of the Riverside Dam with a suction dredge. Their efforts were negated the spring of 1999, however, when high flows washed additional sediment into the pool. These results confirmed that downstream migration of sediments was the cause of pool filling.

On June 28, 2000, Jock Conyngham, then employed by Trout Unlimited, visited the site to evaluate degradation and recommend a restoration strategy. A summary of his report follows:

The Cupsuptic showed marked delineations between low gradient, highly sinuous reaches with fine bed and bank material and high gradient, step pool reaches with very large cobble-boulder bed and bank material. In the high gradient reaches examined, pool widths were dramatically higher than riffle widths (between two and three times as wide, e.g. 108-115' vs. 38-43' in the reach below the upper dam). Because pools are usually somewhat narrower than riffles, this condition represents a departure from the norm. Overwidened pools often indicate channel incision, though in Maine they could result from pool-based log jams causing bank erosion. It was clear that sand accumulations were a result rather than a cause of the widening.

The presence of bankfull indicators 1.7-2.3 feet below the prevailing bank height in the low-gradient, highly sinuous reach above the dam site strongly suggested that some combination of logging dam failure, blasting for the log runs, and the erosive action of the log drives themselves had led to an incising, erosive state. Due to the degree of grade control change at the dam and the degree of armorining in the high-gradient reach below, the channel has not been able to heal itself and should not be expected to in any predictable time frame. High failing banks in the low gradient reaches represent the probable source of the sand in downstream pools. IF&W surveys in a downstream low gradient reach had classified it as a Rosgen F, a high width-to-depth ratio channel resulting from incision. Point bar slopes in the lower reach showed a concave profile, also suggesting incision.

Substrates are embedded with sand throughout the surveyed reach in both low and high gradient areas. In a system such as this I would expect significant impacts on adult overwintering and redd function as well as lesser degrees of impact on thermal stability, juvenile overwintering, and macroinvertebrate habitat.

The grade controls at the lower end of the low gradient reaches can be raised with minimal placement of boulders in order to reconnect the floodplain and relieve pressure on the channel. Since sinuosity and riparian vegetation appear fine, this should be enough to stabilize these reaches and tie up the excess supply of sand. The channel downstream could then be expected to clean itself of sands over a period of three to ten years, depending on the frequency, magnitude, and duration of bankfull and overbank flows that occur. Furthermore, substantial areas of wetland will be re-invigorated, helping raise base flows and returning wetland function to a currently overdrained area. Pool restoration should focus on the importation of small boulders and large cobble to narrow the pools to bankfull widths observed in the riffles.
Despite the widespread evidence of habitat instability along much of the river, the only sites identified for restoration was the run upstream of the Riverside crib dam at river mile 8.7. The reasons for this decision are as follows:

1. The reach upstream of the Riverside dam site was unstable (as evidenced by entrenchment and unstable banks) and was contributing large amounts of sand and gravel that was migrating downstream and filling pools.

2. The Cupsuptic River survey identified ample brook trout spawning and nursery habitat; pools that serve as adult habitat, especially in the section of the river above Big Falls, were few in number, were frequently silt-laden, and would thereby benefit from reduced sediment transport.

3. At river mile 8.7, the drainage area of the Cupsuptic River is 28 mi.², approaching the upper limit for which structures may be expected to endure high flows.

4. The Riverside site was one of the few that afforded vehicular access.

**HABITAT RESTORATION**

Restoration work involved the construction of two grade control structures composed of logs and rocks, and located approximately 1,100 feet apart (Figure 1) 8.7 miles above the mouth of the Cupsuptic River. The purpose of the grade control structures is to raise the bottom of the river through aggradation of sediments behind (upstream of) the structures, thereby reconnecting the entrenched reach with the floodplain, restoring a proper width-to-depth ratio, and reducing downstream migration of sediment that is filling pools that provide critical adult brook trout habitat. The structures are located at river miles 8.7 and 8.9, approximately one mile upstream of Big Falls, which is a barrier to upstream fish migration.

The work was conducted from July 29-31, 2002 by M&H logging of Rangeley, under the direction of Parish Geomorphic. A total of about 16 tree-length logs were cut nearby, skidded to the site, placed with the excavator, and held in place with boulders and rocks. The lower grade control structure was built at the site of a log-driving dam, and rock fill from the wings were used to hold the logs in place. This structure was built in two sections, using a small island as a mid-channel support. The upper structure was sited near a number of large boulders in the stream that
were used as supports for the logs. Additional boulders and rocks were placed around the logs to hold them in place and to minimize flow through the structures.

The upper structure was built across the river and is about 40 feet long. Each of the lower structures, built in two sections, is about 20 feet long. Both structures are about 3 feet high. This height corresponds to the calculated depth of entrenchment and is intended to raise the bottom profile of the river to its original elevation. To date, the structures have remained in place for more than three years despite a number of high-flow events. Some maintenance has been required. Erosion of the right end of the upper structure was arrested by the placement of brush that reduced water velocity in the area, and rocks washed from below the lower structure have been replaced by hand.

Costs of the project were as follow: project planning (Parish Geomorphic), $2,500; contractor (M&H Logging), $7,500; willows for stabilization, $800 (all funded by grants from the Trout and Salmon Foundation); and in-kind contribution of personnel and materials (including stumpage on trees and boulders, seed, and matting) by Seven Islands Land Co., $3,700. The direct cost of the project (which excludes pre- and post-construction evaluation) was $15,000.

PROJECT EVALUATION

Project evaluation is being conducted by measuring changes in longitudinal and cross sectional profiles in response to placement of the grade control structures. Eight semi-permanent transects have been located upstream, between, and downstream of the project site (Table 4). Transects 1 through 6 are in the immediate vicinity of the structures and will determine whether the river bottom is elevated over time as sediment is caught behind (upstream) of the structures. (Two of these transects were added in 2005 in areas where structure-induced aggradation had commenced after high-flow events). Transects 7 and 8 are located approximately 800 feet downstream of the project site above and in a pool and are intended to measure whether sediment is washed out of the pool over time as the supply is reduced as a direct result of the upstream structures.
Transect elevations were referenced to a benchmark designated as 100.00 feet. Measurements were made by means of a level and rod at 1 or 2 foot intervals beginning at river left and defined by a pin on each side of the river. The pins are comprised of two-foot long sections of rebar driven into the ground far enough from the bank to account for any lateral migration that may occur during the study period.

Transects 1, 2, 3, 4, and 6, as well as the Riverside Dam site (later the location of the lower grade control structure), were measured in 2000, and at least several of the transects were measured annually thereafter. Not all transects were measured all years due to high water levels and velocities, and scheduling conflicts. To date there have been no significant changes in the profile of the river bottom except at stations 257 (directly downstream of the upper structure) and 585 (the upper section of the bend downstream of the upper structure). Elevations at the lower pool have changed over time but show no trend to date. However, changes are expected to accrue over time and will be documented as they occur.

Longitudinal profiles of the reach were made in 2000, 2001, and 2002 (Table 5). This procedure establishes the elevations of the tops of the banks, the bankfull elevations, the water surface, and the maximum (thalweg) depths for the reach. It was frequently not possible to establish accurate bankfull elevations due to bank slumping throughout much of the reach.

Pebble counts have been made at several of the transects (Tables 7 and 8). Changes in the substrate size will be used to assess changes over time. Water depth (which increased by two to three feet after the construction of the grade control structures) prevented conducting pebble counts at many of the transects, but additional counts will be made whenever feasible. Three erosion pins were placed on the right bank at station 754 to monitor the rate of lateral bank erosion at that site (Table 9). To date, the bank is eroding at an average rate of 3 inches per year, with the greatest rate of erosion at the lowest elevation.

Due to the depths of the reach, it is not possible to monitor brook trout abundance by electrofishing. Further, we expect no significant changes in water quality. For these reasons, physical measurements of the restored reach and macroinvertebrate sampling (described previously) are the only methods being used to measure the results of this project.
RECOMMENDATIONS

1. Continue to remeasure the cross-sectional transects on an annual basis.
2. Conduct annual macroinvertebrate monitoring.
3. Present the results of this work, as well as additional analyses of the data presented herein, in a final report.

ACKNOWLEDGMENTS

The Cupsuptic River restoration project constructed in the summer of 2002 was funded by a generous grant from the Trout and Salmon Foundation. We also thank Seven Islands Land Company for in-kind contributions of materials. Evaluation of the project is a joint effort between the Maine Department of Inland Fisheries and Wildlife and the Rangeley Region Guides’ and Sportsmen’s Association, whose members have volunteered many hours. Members of the Guides Association who have assisted with remeasuring transects include Norm LeBlanc, Lynn Hewey, Kirby Holcombe, Rich and Diane Hubler, Mary Ellen Moroney, Shelby Rousseau, Gregg Silloway, and Patty Silvia. Biologists David Howatt and Frank Frost reviewed the manuscript and offered many helpful suggestions.

Prepared by: Forrest Bonney
February, 2006
REFERENCES

Cooper, Gerald P. 1940. A Biological Survey of the Rangeley Lakes, with Special Reference to the Trout and Salmon. Fish Survey Report No. 3. Maine Department of Inland Fisheries and Game. 182 pp.

<table>
<thead>
<tr>
<th>Order</th>
<th>Family</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coleoptera</td>
<td>Hydrophilidae</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Diptera</td>
<td>Blephariceridae</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Diptera</td>
<td>Chironomidae</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Diptera</td>
<td>Simuliidae</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Diptera</td>
<td>Tabanidae</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Diptera</td>
<td>Tipulidae</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Ephemeroptera</td>
<td>Baetidae</td>
<td>14</td>
<td>22</td>
</tr>
<tr>
<td>Ephemeroptera</td>
<td>Baetiscidae</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ephemeroptera</td>
<td>Ephemerellidae</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Ephemeroptera</td>
<td>Ephemeridae</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>Ephemeroptera</td>
<td>Heptageniidae</td>
<td>8</td>
<td>51</td>
</tr>
<tr>
<td>Ephemeroptera</td>
<td>Leptophlebiidae</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Odonata</td>
<td>Cordulegastridae</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Odonata</td>
<td>Lestidae</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Plecoptera</td>
<td>Capniidae</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Plecoptera</td>
<td>Chloroperlidae</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Plecoptera</td>
<td>Peltoperlidae</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Plecoptera</td>
<td>Perlidae</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Plecoptera</td>
<td>Pteronarcydae</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Trichoptera</td>
<td>Brachycentridae</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Trichoptera</td>
<td>Hydropsychidae</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Trichoptera</td>
<td>Limnephilidae</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Trichoptera</td>
<td>Philopotamidae</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Trichoptera</td>
<td>Phryganoeidae</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Trichoptera</td>
<td>Polycentropodida</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2. Monthly averages of water temperatures (°F) recorded at two sites on the Cupsuptic River, 1997.

<table>
<thead>
<tr>
<th>Site</th>
<th>Statistic</th>
<th>June</th>
<th>July</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper</td>
<td>Minimum</td>
<td>38</td>
<td>47</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>50</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>61</td>
<td>64</td>
<td>65</td>
</tr>
<tr>
<td>Lower</td>
<td>Minimum</td>
<td>41</td>
<td>52</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>53</td>
<td>59</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>65</td>
<td>68</td>
<td>69</td>
</tr>
</tbody>
</table>

Table 3. Cupsuptic River water quality.

<table>
<thead>
<tr>
<th>Date</th>
<th>Location (river mile)</th>
<th>Water temperature (°F)</th>
<th>Oxygen (mg/L)</th>
<th>pH</th>
<th>Alkalinity(mg/L)</th>
<th>Conductivity(mhos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/29/1996</td>
<td>18.8</td>
<td>55</td>
<td>6</td>
<td>6.7</td>
<td>9</td>
<td>36</td>
</tr>
<tr>
<td>9/10/1997</td>
<td>18.8</td>
<td>52</td>
<td>10</td>
<td>6.4</td>
<td>7</td>
<td>36</td>
</tr>
</tbody>
</table>

1At 'Bowmantown Express' crossing.
Figure 1. Location of grade control structures and transects. Elevations are for left pins (not to scale).

Tree w/nail, 100.00

T4 Elev. 96.35
583

T5 Elev. 97.83
754

T6 Elev. 97.94
960

T7 Elev. 76.20
1,676

T8 Elev. 77.70
1,775

Transect 1 Elev. 100.43

Upper Grade Control Structure

Lower Grade Control Structure

Flow

Table 4. Location of monitoring transects.

<table>
<thead>
<tr>
<th>Transect number</th>
<th>Station(^2)</th>
<th>Left pin Elev.</th>
<th>Flow type</th>
<th>GPS coordinates, left pin</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>100.43</td>
<td>Run</td>
<td>19T0351830 4995821</td>
<td></td>
</tr>
<tr>
<td></td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>257</td>
<td>99.28</td>
<td>Run</td>
<td>19T0351757 4995784</td>
<td>Upper Structure</td>
</tr>
<tr>
<td>3</td>
<td>369</td>
<td>99.14</td>
<td>Run</td>
<td>19T0351711 4995792</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>585</td>
<td>96.35</td>
<td>Pool</td>
<td>19T0351684 4995797</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>754</td>
<td>97.63</td>
<td>Run</td>
<td>19T0351687 4995752</td>
<td>Bank pins</td>
</tr>
<tr>
<td>6</td>
<td>960</td>
<td>97.94</td>
<td>Run</td>
<td>19T0351742 4995748</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,032</td>
<td></td>
<td></td>
<td></td>
<td>Lower structure; dam site</td>
</tr>
<tr>
<td>7</td>
<td>1,676</td>
<td>76.20</td>
<td>Riffle</td>
<td>19T0351841 4995647</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1,775</td>
<td>77.70</td>
<td>Pool</td>
<td>19T0351859 4995606</td>
<td></td>
</tr>
</tbody>
</table>

\(^2\) Distance in feet from upper transect.
Table 5. Longitudinal profile, beginning 100 feet upstream of upper structure.

<table>
<thead>
<tr>
<th>Year</th>
<th>Station</th>
<th>Left top of bank</th>
<th>Water surface</th>
<th>Thalweg</th>
<th>Right top of bank</th>
<th>Bankfull elevation</th>
<th>Physical feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>0</td>
<td>93.2</td>
<td>91.0</td>
<td>100.3</td>
<td></td>
<td></td>
<td>Transect 1</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>93.4</td>
<td>90.7</td>
<td>97.8</td>
<td>97.3</td>
<td>95.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>93.4</td>
<td>91.1</td>
<td>97.3</td>
<td>97.9</td>
<td>95.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>93.5</td>
<td>91.4</td>
<td>97.9</td>
<td>94.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>450</td>
<td>97.8</td>
<td>89.9</td>
<td>95.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>97.7</td>
<td>89.3</td>
<td>95.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>550</td>
<td>96.6</td>
<td>88.4</td>
<td>95.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>96.1</td>
<td>88.5</td>
<td>94.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>650</td>
<td>97.9</td>
<td>89.9</td>
<td>95.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>700</td>
<td>96.4</td>
<td>90.2</td>
<td>93.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>750</td>
<td>97.3</td>
<td>89.6</td>
<td>95.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>97.2</td>
<td>89.2</td>
<td>95.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>850</td>
<td>97.7</td>
<td>90.0</td>
<td>96.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>950</td>
<td>98.6</td>
<td>91.5</td>
<td>94.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1250</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1291</td>
<td>94.3</td>
<td>89.7</td>
<td>93.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>0</td>
<td>93.3</td>
<td>91.0</td>
<td></td>
<td></td>
<td>Transect 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td>Site of proposed structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>93.4</td>
<td>90.7</td>
<td>95.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>93.4</td>
<td>91.1</td>
<td>95.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>93.5</td>
<td>91.4</td>
<td>94.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>450</td>
<td>97.8</td>
<td>89.9</td>
<td>95.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>97.7</td>
<td>89.3</td>
<td>95.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>550</td>
<td>96.6</td>
<td>88.4</td>
<td>94.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>96.1</td>
<td>88.9</td>
<td>94.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>650</td>
<td>97.9</td>
<td>89.9</td>
<td>95.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>700</td>
<td>97.3</td>
<td>91.1</td>
<td>94.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>750</td>
<td>97.3</td>
<td>89.6</td>
<td>95.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>97.2</td>
<td>89.2</td>
<td>95.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>850</td>
<td>97.7</td>
<td>90.0</td>
<td>96.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>950</td>
<td>98.6</td>
<td>91.5</td>
<td>94.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1132</td>
<td></td>
<td>95.0</td>
<td></td>
<td>Dam site</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1250</td>
<td>94.3</td>
<td>89.7</td>
<td>93.0</td>
<td>Bridge site</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1291</td>
<td>90.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>0</td>
<td>101.1</td>
<td>92.6</td>
<td>100.4</td>
<td>96.8</td>
<td>Transect 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>67</td>
<td></td>
<td>90.7</td>
<td></td>
<td></td>
<td>run</td>
<td></td>
</tr>
<tr>
<td></td>
<td>92</td>
<td></td>
<td>90.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>114</td>
<td></td>
<td>89.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>129</td>
<td>101.9</td>
<td>92.3</td>
<td>100.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>157</td>
<td></td>
<td>92.4</td>
<td>97.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>179</td>
<td></td>
<td>91.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td>Upper Structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>207</td>
<td></td>
<td>90.2</td>
<td></td>
<td>Transect 2</td>
<td></td>
<td>run</td>
</tr>
<tr>
<td></td>
<td>240</td>
<td></td>
<td>92.4</td>
<td>100.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>257</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>304</td>
<td></td>
<td>92.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>333</td>
<td></td>
<td>91.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5. Longitudinal profile, beginning 100 feet upstream of upper structure (con’t).

<table>
<thead>
<tr>
<th>Year (con’t.)</th>
<th>Station</th>
<th>Left top of bank</th>
<th>Water surface</th>
<th>Thalweg</th>
<th>Right top of bank</th>
<th>Bankfull elevation</th>
<th>Physical feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>369</td>
<td></td>
<td>92.2</td>
<td></td>
<td></td>
<td></td>
<td>Transect 3; run</td>
</tr>
<tr>
<td></td>
<td>401</td>
<td></td>
<td>91.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>464</td>
<td></td>
<td>91.0</td>
<td></td>
<td>100.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>485</td>
<td></td>
<td>91.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>565</td>
<td></td>
<td>96.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>585</td>
<td></td>
<td>95.4</td>
<td></td>
<td></td>
<td></td>
<td>Transect 4; pool</td>
</tr>
<tr>
<td></td>
<td>595</td>
<td></td>
<td>96.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>649</td>
<td></td>
<td>103.8</td>
<td></td>
<td>97.7</td>
<td>105.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>670</td>
<td></td>
<td>98.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>688</td>
<td></td>
<td>96.5</td>
<td></td>
<td></td>
<td></td>
<td>Transect 5; pool</td>
</tr>
<tr>
<td></td>
<td>718</td>
<td></td>
<td>96.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>754</td>
<td></td>
<td>94.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>774</td>
<td></td>
<td>94.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>817</td>
<td></td>
<td>97.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>839</td>
<td></td>
<td>106.0</td>
<td></td>
<td>98.7</td>
<td></td>
<td>Transect 6; run</td>
</tr>
<tr>
<td></td>
<td>859</td>
<td></td>
<td>96.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>889</td>
<td></td>
<td>97.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>934</td>
<td></td>
<td>98.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>960</td>
<td></td>
<td>95.6</td>
<td></td>
<td></td>
<td></td>
<td>Lower structure (dam site)</td>
</tr>
</tbody>
</table>

16
<table>
<thead>
<tr>
<th>Transect</th>
<th>Station</th>
<th>Flow type</th>
<th>Year</th>
<th>Treatment</th>
<th>Bankfull width(ft.)</th>
<th>Mean depth(ft.)</th>
<th>Thalweg depth</th>
<th>Xc area (ft²)</th>
<th>Width/depth ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>Run</td>
<td>2001</td>
<td>Control</td>
<td>50</td>
<td>7.7</td>
<td>9.1</td>
<td>384</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2002</td>
<td>Control</td>
<td>50</td>
<td>8.2</td>
<td>9.3</td>
<td>410</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2003</td>
<td>Control</td>
<td>50</td>
<td>8.4</td>
<td>9.4</td>
<td>421</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2004</td>
<td>Control</td>
<td>50</td>
<td>7.5</td>
<td>9.6</td>
<td>377</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2005</td>
<td>Control</td>
<td>50</td>
<td>8.4</td>
<td>13.6</td>
<td>419</td>
</tr>
<tr>
<td>2</td>
<td>257</td>
<td>Run</td>
<td>2005</td>
<td>Post</td>
<td>38</td>
<td>9.3</td>
<td>12.5</td>
<td>353</td>
<td>4.1</td>
</tr>
<tr>
<td>3</td>
<td>369</td>
<td>Run</td>
<td>2000</td>
<td>Pre</td>
<td>40</td>
<td>7.1</td>
<td>7.9</td>
<td>286</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2002</td>
<td>Pre</td>
<td>40</td>
<td>7.3</td>
<td>8.5</td>
<td>292</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2003</td>
<td>Post</td>
<td>40</td>
<td>7.1</td>
<td>8.1</td>
<td>286</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2004</td>
<td>Post</td>
<td>40</td>
<td>7.2</td>
<td>8.1</td>
<td>289</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2005</td>
<td>Post</td>
<td>40</td>
<td>7.2</td>
<td>8.3</td>
<td>288</td>
</tr>
<tr>
<td>4</td>
<td>585</td>
<td>Pool</td>
<td>2005</td>
<td>Post</td>
<td>52</td>
<td>3.5</td>
<td>10.4</td>
<td>184</td>
<td>14.7</td>
</tr>
<tr>
<td>5</td>
<td>754</td>
<td>Pool</td>
<td>2000</td>
<td>Pre</td>
<td>48</td>
<td>5.1</td>
<td>8.8</td>
<td>243</td>
<td>9.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2003</td>
<td>Post</td>
<td>48</td>
<td>5.7</td>
<td>8.7</td>
<td>275</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2004</td>
<td>Post</td>
<td>48</td>
<td>6.0</td>
<td>8.7</td>
<td>288</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2005</td>
<td>Post</td>
<td>48</td>
<td>5.9</td>
<td>8.9</td>
<td>285</td>
</tr>
<tr>
<td>6</td>
<td>960</td>
<td>Run</td>
<td>2001</td>
<td>Pre</td>
<td>42</td>
<td>6.0</td>
<td>7.9</td>
<td>254</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2002</td>
<td>Pre</td>
<td>42</td>
<td>6.0</td>
<td>7.3</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2003</td>
<td>Post</td>
<td>42</td>
<td>6.7</td>
<td>8.1</td>
<td>282</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2004</td>
<td>Post</td>
<td>42</td>
<td>5.8</td>
<td>7.0</td>
<td>245</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2005</td>
<td>Post</td>
<td>42</td>
<td>6.2</td>
<td>7.6</td>
<td>258</td>
</tr>
<tr>
<td>7</td>
<td>1,676</td>
<td>Riffle</td>
<td>2003</td>
<td>Post</td>
<td>32</td>
<td>3.5</td>
<td>4.9</td>
<td>112</td>
<td>9.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2004</td>
<td>Post</td>
<td>32</td>
<td>3.1</td>
<td>4.6</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2005</td>
<td>Post</td>
<td>32</td>
<td>3.5</td>
<td>4.8</td>
<td>111</td>
</tr>
<tr>
<td>8</td>
<td>1,776</td>
<td>Pool</td>
<td>2001</td>
<td>Pre</td>
<td>117</td>
<td>5.3</td>
<td>8.4</td>
<td>622</td>
<td>22.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2003</td>
<td>Post</td>
<td>117</td>
<td>5.2</td>
<td>7.7</td>
<td>606</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2004</td>
<td>Post</td>
<td>117</td>
<td>5.8</td>
<td>8.7</td>
<td>675</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2005</td>
<td>Post</td>
<td>117</td>
<td>4.7</td>
<td>7.6</td>
<td>550</td>
</tr>
</tbody>
</table>
Table 7. Pebble count summary by transect and year. Samples from treatment transects are bolded.

<table>
<thead>
<tr>
<th>Transect</th>
<th>Station</th>
<th>Flow type</th>
<th>Year</th>
<th>Diameter (mm) percentiles³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D16</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>Glide</td>
<td>2002</td>
<td>0.3</td>
</tr>
<tr>
<td>3</td>
<td>369</td>
<td>Glide</td>
<td>2000</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2002</td>
<td>0.2</td>
</tr>
<tr>
<td>5</td>
<td>754</td>
<td>Pool</td>
<td>2000</td>
<td>0.7</td>
</tr>
<tr>
<td>7</td>
<td>1,676</td>
<td>Riffle</td>
<td>2002</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Table 8. Pebble count summary. Bolded values were taken post-treatment. Dominant particle-size class underlined.

<table>
<thead>
<tr>
<th>Transect</th>
<th>Station</th>
<th>Flow type</th>
<th>Year</th>
<th>Sands</th>
<th>Gravels</th>
<th>Cobble</th>
<th>Boulder</th>
<th>Bedrock</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>Glide</td>
<td>2002</td>
<td>38</td>
<td>62</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>369</td>
<td>Glide</td>
<td>2000</td>
<td>61</td>
<td>39</td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2002</td>
<td>50</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>754</td>
<td>Pool</td>
<td>2000</td>
<td>78</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1,676</td>
<td>Riffle</td>
<td>2002</td>
<td>12</td>
<td>29</td>
<td>28</td>
<td>31</td>
<td></td>
</tr>
</tbody>
</table>

Table 9. Protrusion of erosion pins placed on outside (right) bank, Station 754 (Transect 5).

<table>
<thead>
<tr>
<th>Date</th>
<th>Upper</th>
<th>Middle</th>
<th>Lower</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/17/2000</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>Installed this date</td>
</tr>
<tr>
<td>10/30/2001</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>7/9/2002</td>
<td>6</td>
<td>14</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>9/8/04</td>
<td>9</td>
<td>16</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>7/13/2005</td>
<td>11</td>
<td>18</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Average/year</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

³ Column figures represent the percent of the pebbles samples that were equal to or smaller in size to the percentiles listed.
This report has been funded in part by the Federal Aid in Sport Fish Restoration Program. This is a cooperative effort involving federal and state government agencies. The program is designed to increase sport fishing and boating opportunities through the wise investment of anglers' and boaters' tax dollars in state sport fishery projects. This program which was funded in 1950 was named the Dingell-Johnson Act in recognition of the congressmen who spearheaded this effort. In 1984 this act was amended through the Wallop-Breaux Amendment (also named for the congressional sponsors) and provided a threefold increase in Federal monies for sportfish restoration, aquatic education and motorboat access.

The Program is an outstanding example of a "user pays-user benefits", or "user fee" program. In this case, anglers and boaters are the users. Briefly, anglers and boaters are responsible for payment of fishing tackle excise taxes, motorboat fuel taxes, and import duties on tackle and boats. These monies are collected by the sport fishing industry, deposited in the Department of Treasury, and are allocated the year following collection to state fishery agencies for sport fisheries and boating access projects. Generally, each project must be evaluated and approved by the U.S. Fish and Wildlife Service (USFWS). The benefits provided by these projects to users complete the cycle between "user pays — user benefits".