FISH PASSAGE EFFECTIVENESS STUDY FOR THE GARDNERS FALLS HYDROELECTRIC PROJECT (FERC NO. 2334) SPRING, 2000

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1.0 INTRODUCTION

Consolidated Edison Energy Massachusetts Inc. (CEEMI), a subsidiary of Consolidated Edison Development, owns and operates the Gardners Falls Hydroelectric Project, FERC license No. 2334, located on the Deerfield River in Buckland, Massachusetts. CEEMI purchased the Project in 1999 from the Western Massachusetts Electric Company (WMECO). In accordance with article 403 of the Project's FERC license, a downstream fish passage facility was installed in 1999. Article 404 of the license requires the Licensee to monitor the effectiveness of the installed downstream passage facilities. WMECO tested the effectiveness of the passage facilities in the spring of 1999 using radio telemetry techniques and results of that evaluation documented that 72% of the radio- tagged smolts used the bypass at generation flows less than 600 cfs. There were no smolt releases at high generation flows (>800 cfs) in 1999 because of drought conditions.

In order to document downstream passage effectiveness under generation flows greater than 800 cfs, CEEMI contracted Normandeau Associates Inc. (Normandeau) to conduct a second radio telemetry study in the spring of 2000 to determine the efficiency of the louver array/ bypass system at passing salmon smolts at higher generation flows.

The 66 ft long floating louver array tested in 1999 consisted of ten sections approximately 6.0 ft in length by 8 ft deep, with each section made up of polypropylene louver slats spaced 3 inches apart. The last louver section (adjacent to the bypass) was replaced in the spring of 2000 with a hinged perforated steel plate-and-frame. This modification was made by CEEMI to close the one-foot gap that existed at the end of the louver array during the 1999 evaluation.

Additional modifications were made to the project's downstream bypass system and plunge pool prior to the spring 2000 test, based on Agency comments on the 1999 report. These additional modifications included installation of a steel ramp below the bypass gate to divert bypass flow away from the toe of the dam, increased plunge pool depth, removal of rock outcrops and the configuration of the pool exit notch.

Normandeau also conducted downstream passage studies for PG&E Generating (PG&E) on the Deerfield River during the spring of 2000, with telemetry monitors installed on Deerfield Projects No. 4, No. 3 (above Gardners Falls) and No. 2 (below Gardners Falls). There were three other monitoring stations set-up downstream of Deerfield No. 2 (and Gardners Falls) during the spring 2000 study including one at Bardwell Ferry Bridge (Deerfield River), another at Cabot Station and the third was located 0.25 miles below the confluence of the Deerfield and Connecticut Rivers. Data generated by Gardners Falls smolts moving past these downstream monitors was made available for this study. Also, data from PG&E fish released upstream of the Deerfield No. 4 Project that moved through Gardners Falls was included in this report.

Normandeau conducted a bypass survival test at the Gardners Falls Project in 2000 using marked Atlantic salmon smolts. For this test, smolts were tagged, held for at least 24 hours, released into the bypass flow and recovered via a bypass net, or seined out of the plunge pool after the bypass flow was temporarily discontinued. Recovered fish were held for 72 hours to determine bypass survival.

2.0 METHODS AND PROCEDURES

2.1 STUDY SITE

The Gardners Falls Hydroelectric Project is located at river mile 15.7 on the Deerfield River in Buckland, MA. The project's powerhouse contains three vertical shaft Francis type turbines (No.'s 3, 4 and 5) currently in operation, plus two horizontal shaft turbines (No.'s 1 and 2) not in use during the study period. Maximum rated generation for the operational units is 3.2 megawatts at 1190 cfs. Water is supplied to the powerhouse through a 0.25 mile long canal, which runs adjacent and parallel to the west bank of the Deerfield River. The project has been in operation since 1904.

The study area comprised 2.1 miles of the Deerfield River, beginning 0.25 miles upstream of the Gardners Falls dam, continuing downstream beyond the Project's powerhouse to the PG&E Deerfield No. 2 station, located 1.5 miles downstream. (Figure 2-1). Radio-tagged smolts that passed the Gardners Falls Project were also monitored in a separate study at Deerfield No. 2, and at three additional monitoring stations - Bardwell Ferry Bridge, Cabot Station and 0.25 miles below the confluence of the Deerfield and Connecticut Rivers.

The Gardners Falls Project has three possible downstream passage routes, including passage over the dam during a spill event, passage through the fish bypass system, or exiting through the project turbines. The downstream fish passage facility consists of two parts: a floating louver array and a bypass minimum flow gate. The purpose of the louver array is to guide downstream migrating Atlantic salmon smolts to the bypass flow gate thereby avoiding potential entrainment. The project's downstream fish bypass entrance is located on the western end of the dam, approximately 10 ft. from the entrance to the powerhouse canal (Figure 2-2). The six ft wide bypass gate is operated by an automatic programmable-logic controller and is set to maintain an attraction flow of 150 cfs (approx. 13% of full generation flow). Downstream migrating smolts exiting through the bypass are spilled approximately 15 ft into a plunge pool in the bypass reach, where they can continue their downstream movements.

The entrance to the canal is flanked on its northern (upstream) end by an approximately 60 ft. long concrete jetty and the dam on its southern side. The 66 ft long floating louver array is anchored on its upstream end to the tip of the jetty and to the bypass gate pier on its downstream end, closing the canal entrance at an approximate 30° angle to the flow (Figure 2-2). The louver array is made up of ten removable 6.0 ft wide by 8 ft deep polypropylene louver sections. The louver section closest to the bypass gate was replaced prior to the spring 2000 evaluation with a hinged perforated-steel plate. This modification was made to close the one-foot gap on the downstream end of the louvers that was noted in the 1999 report.

2.2 MONITORING STATIONS

A total of six stationary monitoring stations were installed at the Gardners Falls project in the Spring of 2000. Station 1 consisted of a Lotek Engineering SRX 400 W16 telemetry receiver/data logger (stationary receiver) connected to a 4-element directional Yagi antenna (Figure 2-2). Station 1 antenna was mounted on the jetty end of the project's louver array, looking straight across the impoundment to monitor arrival and departure of radio-tagged smolts into the study area. Station 2

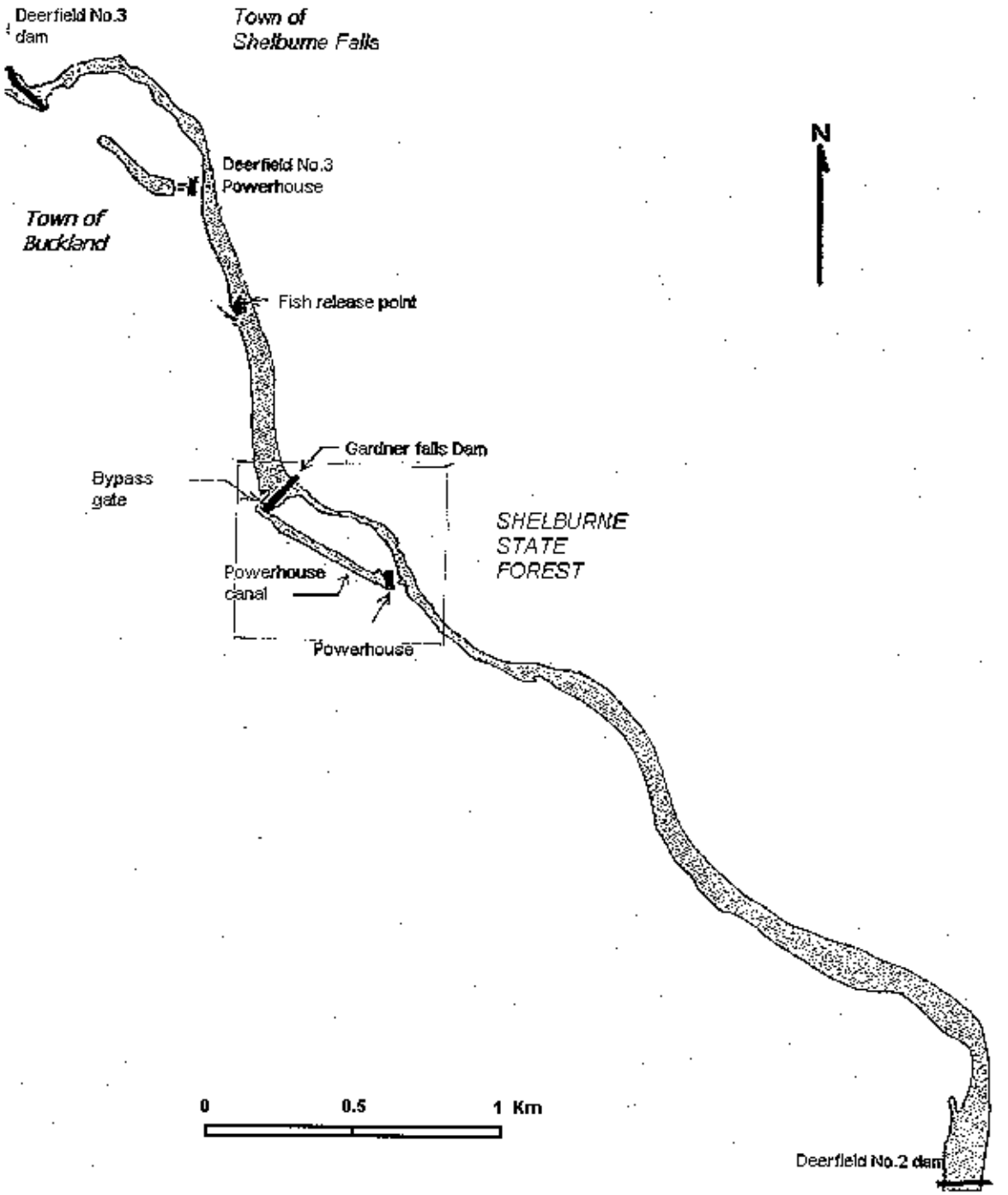


Figure 2-1. Diagram of the Gardners Falls Project located on the Deerfield River near Buckland, MA.

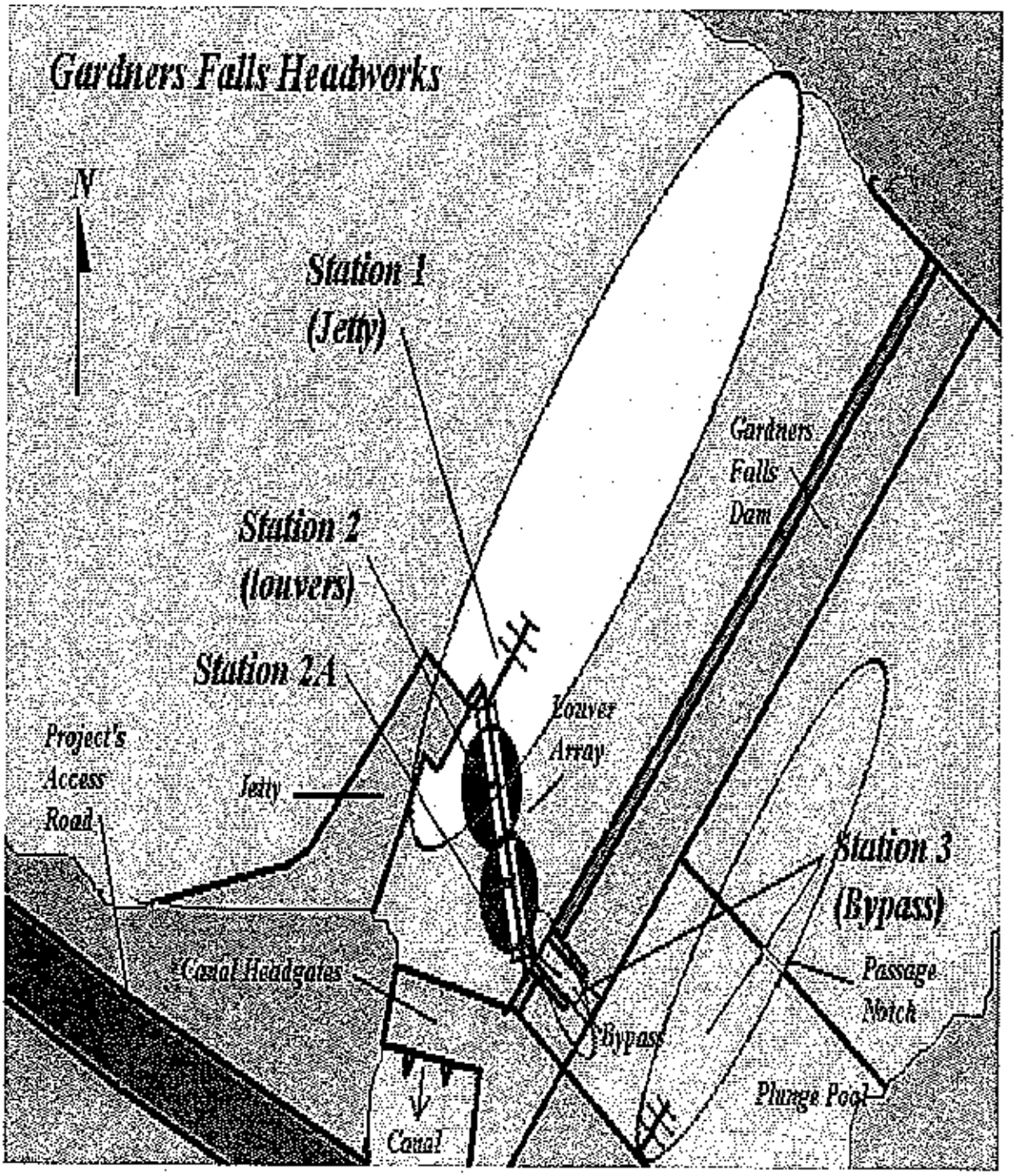


Figure 2-2. Schematic of the Gardners Falls Head Works showing telemetry stations and approximate coverage areas monitored during Spring, 2000 (not to scale).

monitored the louver array and consisted of a Lotek stationary receiver coupled to a double underwater antenna array. The two underwater antennae were mounted 1/3 and 2/3 of the distance down the length of the louvers for the first release during the 2000 test. A second Lotek stationary receiver was added after the first test, one for each of the louver array's underwater antennae to further differentiate the smolts movements along the louver array (station 2 for the upstream louver antenna, and station 2A for the downstream louver antenna). Both antennae were tuned to detect radio-tagged fish within 3 ft of the face of the louver array and to a depth of 8 ft.

Station 3 consisted of a Lotek stationary receiver connected to an underwater antenna positioned immediately in front of the bypass gate and calibrated to detect radio-tagged smolts within 3 ft of the bypass entrance. This coverage area included a portion of the last section of louver array. A de-tuned (to limit its detection range) 4-element Yagi antenna aimed at the bypass plunge pool was combined to the same bypass stationary receiver to ensure that radio-tagged salmon smolts using the bypass were detected and to estimate plunge pool residency time.

Station 4 monitored the power canal, and consisted of a 4-element Yagi antenna mounted just upstream of the powerhouse (over units 3 and 4 penstocks) coupled to a Lotek stationary receiver (Figure 2-3). This station was calibrated to detect smolts within 50 ft of unit 5 and within 200 ft of units 3 and 4. Station 5 was a 4-element directional Yagi antenna connected to a Lotek stationary receiver and tuned to detect radio-tagged fish in the bypass reach. This station detected radio-tagged smolts that spilled over the dam and also fish that exited through the bypass system. Fish detected in the bypass reach (Station 5) but not detected on the bypass receiver (Station 3) were assumed to have spilled over the dam.

Station 6 monitored the project tailrace and consisted of a Lotek stationary receiver coupled to a 4-element Yagi. This antenna was calibrated to detect radio-tagged smolts in the Project's tailrace that had passed via the turbines. It also recorded fish that had either spilled over the dam or passed via the bypass system. Fish that exited via the turbines were detected in the canal first (Station 4), then at Station 6 following turbine passage. Stations 5 and 6 were temporarily coupled to a single stationary receiver using a Lotek antenna switching peripheral (ASP-8) beginning on the second release on 5/5 until 5/7/00. However, the ASP-8 failed the evening of 5/5 and was replaced with a second ASP-8. An additional Lotek stationary receiver was obtained and installed on 5/8 to eliminate any further need for the ASP-8 and both stations were monitored separately.

2.3 PROCEDURES

The study objective was to determine the effectiveness of the bypass/louver array at passing Atlantic salmon smolts during generating flows greater than 800 cfs. To achieve the objective, radio-tagged Atlantic salmon smolts were released above the project when the flows were greater than 800 cfs and their downstream passage routes were determined. Additional radio-tagged smolts from a separate study for PG&E were also monitored during their passage through the project.

Lotek Engineering Inc. SRX 400-W16 receiver/data loggers were used for continuous monitoring at the six stations described above, as well as for manual tracking purposes. The receivers were designed to identify digitally encoded pulses from radio transmitters (tags). When a radio-tagged salmon entered the reception field of a stationary receiver, the receiver would record the time, date, signal strength, tag code and frequency (channel) of the tag. Each tag used in the study was assigned

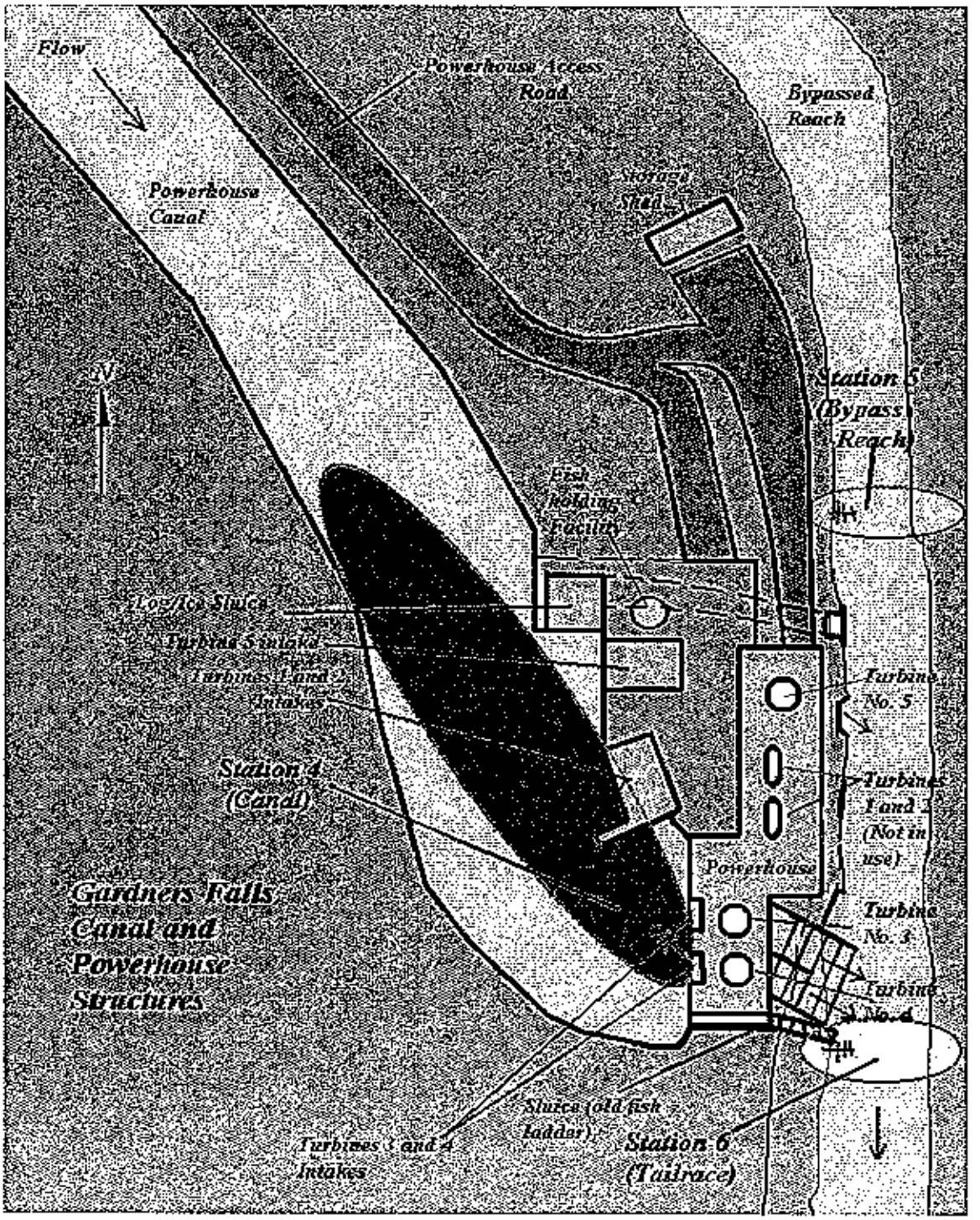


Figure 2-3. Schematic of the Gardners Falls Powerhouse showing telemetry installations and approximate coverage areas monitored during Spring, 2000 (not to scale).

its own unique code number and operated on 149.360 MHz (channel 3). Radio-tagged smolts for the PG&E study operated on 149.740 MHz (channel 22) and 149.760 MHz (channel 23). Radio tags for both studies were manufactured by Lotek Engineering, had a 2.5 second burst rate, measured 20-mm x 8-mm, weighed approximately 2 grams, and had an approximate operating life of 14 days. Atlantic salmon smolts for this study were obtained from the White River National Fish Hatchery in Bethel, VT. Fourteen days prior to the first release, the smolts were transported to the Project site in a 180-gallon oxygen aerated tank. At the Project, the fish were held in a 1000-gallon tank equipped with a flow-through river water system. The tank was set up within the fenced in area of the powerhouse near the intake for the No. 5 turbine. Smolts were fed pellet food once daily until 24 hours prior to tagging.

Atlantic salmon from the White River National Fish Hatchery (WRNFH) were tested during spring 2000 by Dr. Stephen D. McCormick at the Conte Anadromous Fish Research Center to determine if they had smoltified. Dr. McCormick deemed that the majority of WRNFH salmon tested were normally developed smolts (mean gill NA+/K+ - ATPase >4). He suspected that WRNFH salmon smaller than 180 mm were less likely to be smolts. Smolts from WRNFH used for the Gardners Falls tests had a mean length of 219 mm (range 186-249 mm).

Smolts were radio-tagged using the following procedure. At least 24 hours prior to each release, groups of 3 to 5 fish were seined from their holding tank and placed in a bath containing a buffered solution of MS 222 (tricaine methane sulfonate) at a concentration of 50 mg/l. After a fish was sufficiently anesthetized, a glycerin coated radio tag was then gently inserted in the stomach via the esophagus. The fish was then removed from the bath, quickly measured to the nearest mm and placed in a recovery tank for at least 24 hours to document any handling mortality or regurgitated tags.

Prior to each release, radio-tagged smolts were removed from the holding tank, transferred to 30-gallon coolers and then transported to the release site. Transport to the release site usually took less than 15 minutes. The release site was located on the west bank of the Deerfield River, approximately 0.25 miles upstream of the Gardners Falls dam (Figure 2-1). The radio-tagged smolts were release from the shore throughout the study.

Mean hourly flows (cfs) through the powerhouse canal and automatic bypass gate were calculated using the Project's power generation records. Instantaneous generation and bypass flows were determined using continuous time-lapse video recordings of the Project's kilowatt hour gauges and the gauge for the downstream bypass gate. Instantaneous data were used to determine canal and bypass gate flow the moment a radio-tagged smolt exited the project via a particular route (e.g. through bypass, turbines or spilled).

Ambient river water temperature was recorded daily throughout the study period and immediately after each release at the Project's jetty using a 76-mm immersion thermometer. Water velocity measurements were taken at 1/3 and 2/3 the length of the louver array at two depths (1 ft and 4 ft deep) and at the bypass entrance during each of the five fish releases using a Marsh-McBirney Model 201 water velocity meter. Additional water velocity measurements were taken at 7/8 of the louver length on two occasions to document changes in the magnitude of the flow velocity in the immediate vicinity of the bypass entrance.

A radio-tagged salmon was considered to have exited via a particular downstream route if the fish's digital radio tag was recorded on the stationary receiver monitoring that downstream route, further

validated by data from either the bypass reach receiver (station 5) for bypassed and spilled fish, and the tailrace receiver (station 6) for turbine fish. Additionally, manual tracking results and data from PG&E's Deerfield No. 2 project located downstream of Gardners Falls were also used to verify downstream passage.

2.4 BYPASS SURVIVAL TEST

In order to determine percent survival of salmon that had passed through the Project's bypass system, marked smolts were placed directly into the 150 cfs bypass flow at a point just before it spilled into the plunge pool. Fish were recaptured with either a bypass net mounted at the exit to the plunge pool, or with a seine after the plunge pool was partially drained. After the fish were released, the bypass flow remained on for at least ten minutes. Once the flow was shut-off, any fish that had entered the bypass net were removed and transported back to the holding facility. Those fish that did not enter the net but instead remained in the plunge pool were captured with a beach seine once the plunge pool was drained. Recaptured smolts were then transported back to the holding tank and observed for 72 hours to document any delayed mortality.

The bypass collection net had an attached live car to help prevent net induced injuries. The net was mounted at the notch in the flashboards located in the lower plunge pool. This notch functioned as the exit from the plunge pool (Figure 2-2). The bypass net had an outside mesh size of 1.5 inches stretch and was lined in its entirety with 1/4 inch knotless delta weave. The live car was a baffled 6-ft by 3-ft by 3-ft aluminum frame, lined with 1/4 inch knotless delta weave.

Smolts used for this test were anesthetized with a buffered solution of water and MS-222 (50-mg/l) and marked with biologically inert streamer tags that were attached between the dorsal fin and lateral line. Tagged fish were measured to the nearest mm (total length), and placed in a holding tank for at least 24 hours prior to release to document delayed mortality due to tagging and handling stress. In addition to the test fish, thirty control fish were tagged and held for 72 hours to assess any mortality associated with tagging and handling.

3.0 RESULTS

3.1 TELEMETRY STUDIES

A total of 54 radio-tagged Atlantic salmon smolts were released in five separate groups upstream of the Gardners Falls project between 4 May and 10 May, 2000 (Table 3-1). Each group consisted of 9 to 15 radio-tagged individuals and were released in the late afternoon or early evening 0.25 miles above the Project. Fifty-one of these radio-tagged smolts were verified as passing the Project, with 13 (25%) exiting via the bypass system, 6 (12%) spilled over the dam, 31 (61%) passed through the turbines, 1 (2%) passed the project via an unknown route and three fish did not pass the Project (Table 3-1).

Of the13 radio-tagged salmon that exited via the bypass, ten (77%) did so under low flow conditions of less than 800 cfs turbine flow (Table 3-1). This occurred even though all five releases of radio-tagged salmon occurred during high flows (>800 cfs turbine flow). In most cases, these fish did not pass the project while the flow was high, but instead lingered in the project area and eventually exited via the bypass under low flow conditions. Figures 3-1 and 3-2 show turbine and bypass flow in cubic

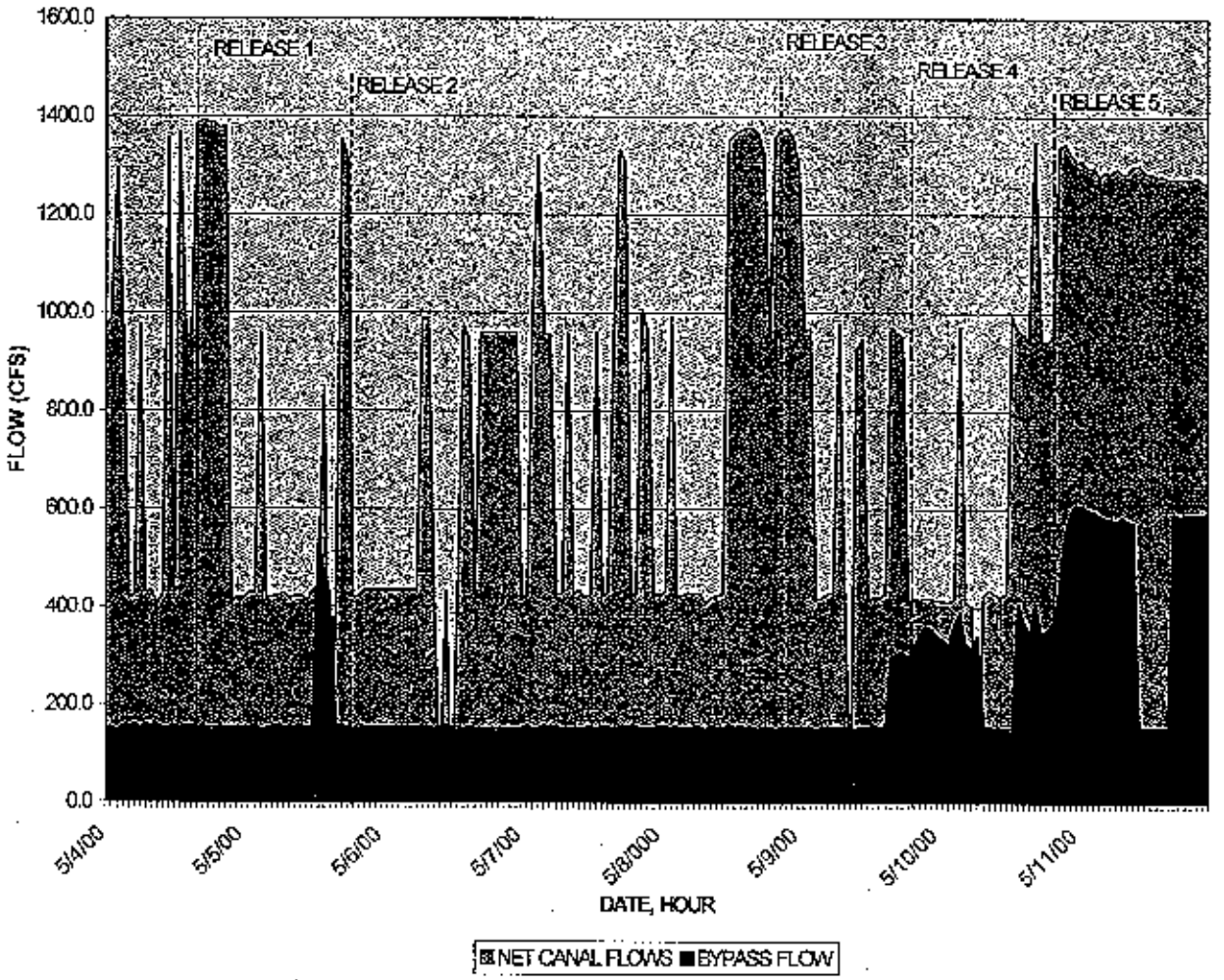


Figure 3-1. Average hourly turbine and bypass flows (cfs) at the Gardners Falls Project during releases between 4-May and 11-May, 2000.

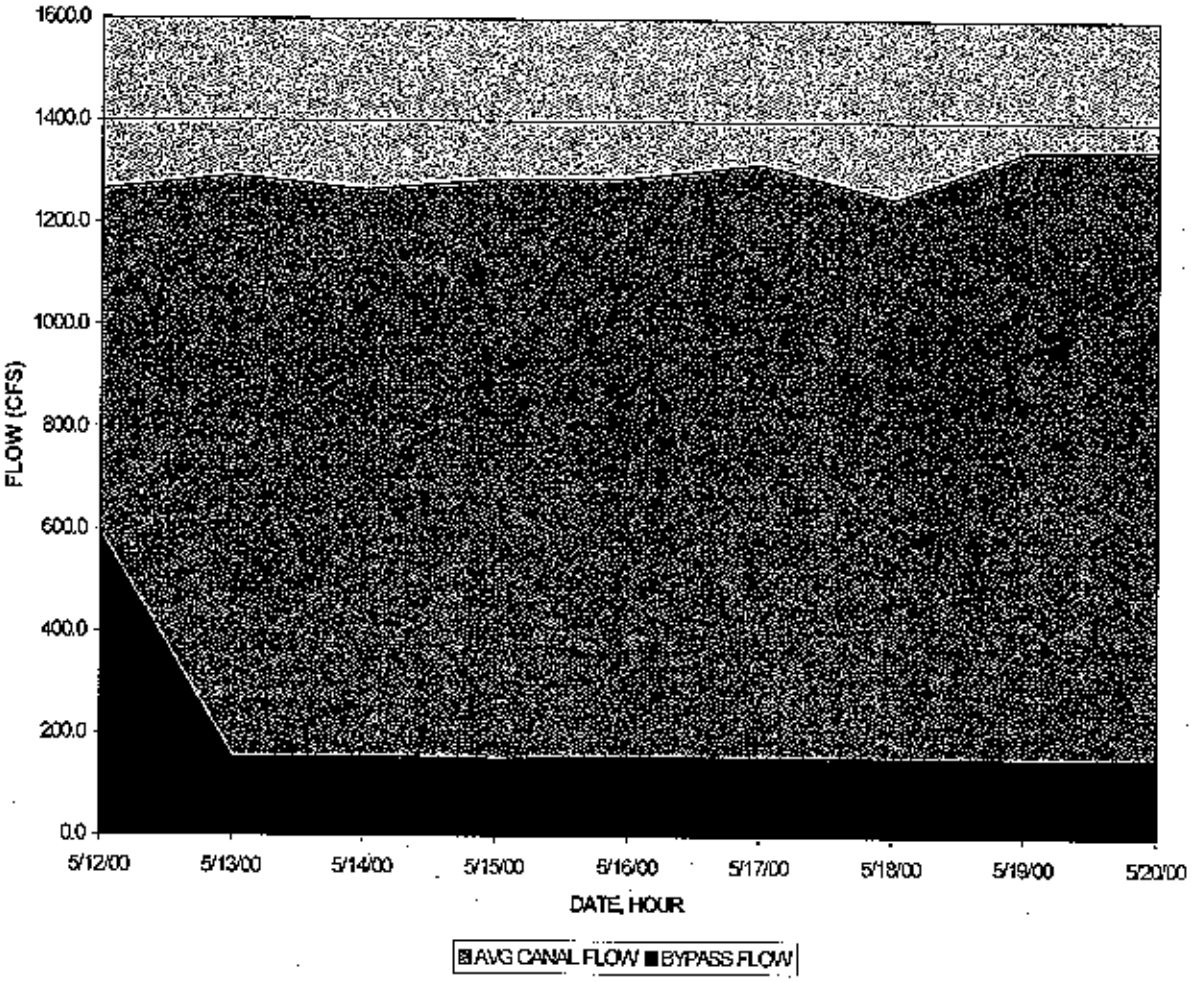


Figure 3-2. Average hourly turbine and bypass flows (cfs) at the Gardners Falls Project between 12-May and 20-May, 2000.

Table 3-1. Passage Routes Taken by Atlantic Salmon Smolts Passing The Gardners Falls Hydroelectric Project. Spring, 2000.

Date	Number Released	Through Turbines	Through Bypass Turbine Flow (cfs) >800	Through Bypass Turbine Flow (cfs) <800	Unknown	Spilled	Total Passed	Did not Pass
4 May[1]	10	10	0	0	0	0	10	0
5 May	10	3	1	5	1	0	10	0
8 May	15	12	0	1	0	0	13	2
9 May	10	3	1	4	0	2	10	0
10 May	9	3	1	0	0	4	8	1
Totals	54	31	3	10	1	6	51	3
%	100%	61%	25%		2%	12%	93%	7%
Category		Total Passed: 51				Total Released: 54		

[1] One 6 ft wide by 8 ft deep panel from array damaged.

feet per second (cfs) throughout the study period (4 May – 20 May) None of the radio-tagged smolts from the first release on 4 May exited via the bypass, but there was a problem with the louver array during this test. One of the array's panels near the middle of the array became detached and the newly installed closure plate was out of position, causing a 12-inch gap between the dam and the end of the array. It is possible that some of the smolts from this first release passed through the openings in the array and eventually through the powerhouse. The second release on 5 May happened after the array was fixed and when turbine flow was greater than 900 cfs. However, shortly after the release river flow dropped to less than 400 cfs because of operation of the upstream hydroelectric projects. Although six salmon from this release exited via the bypass, only one did so while flows were greater than 800 cfs (Table 3-1; Appendix 1). The third release on 8 May occurred when turbine flows were greater than 800 cfs, but the only smolt that exited through the bypass did so two days later (10 May) when turbine flow was less than 400 cfs (Appendix 1). Two fish from this release of 15 smolts did not pass the project and the remaining 12 passed through the turbines.

Bypass flow was increased to more than 300 cfs for the final two releases on 9 May and 10 May in an attempt to increase bypass passage efficiency. Although five out of ten smolts used the bypass from the 9 May release, only one did so under high flows (Table 3-1; Appendix 1). For the last release on 10 May, one smolt out of nine passed via the bypass when turbine flow was greater than 800 cfs; three others exited through turbines, four spilled over the dam and one did not pass (Table 3-1; Appendix 1).

Residence time in the project area for radio-tagged salmon following their release increased in 2000. In 1999, average passage time was 12 hours, however, in 2000 it was nearly 26.5 hrs. Passage times were estimated from time of release to time of passage via a particular route. In 2000, the average passage time was 26 h: 31 m, with a range of 0 h: 19 m to 218 h: 31 m. "Transit" times were estimated from time of release to the time a radio-tagged smolt was last detected at the furthest downstream receiver within the Project area (station 6). The average transit time in 2000 was 38 h: 7 m,

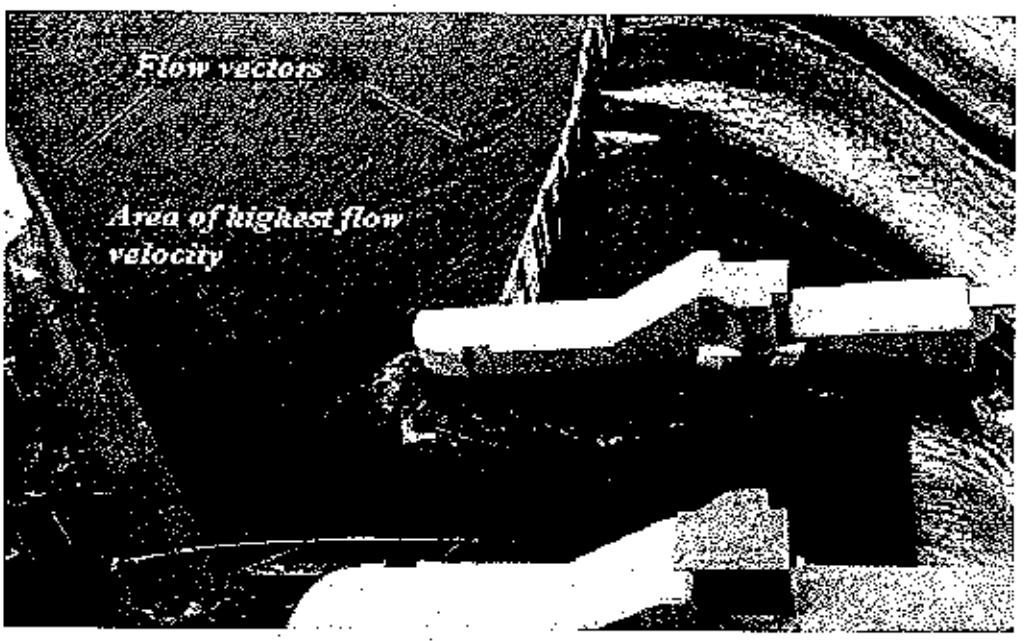


Figure 3-3. View of the louver/bypass area at the Gardners Falls Project showing flow vectors along the louver line and dam's face with a 150 cfs bypass flow, Spring 2000.

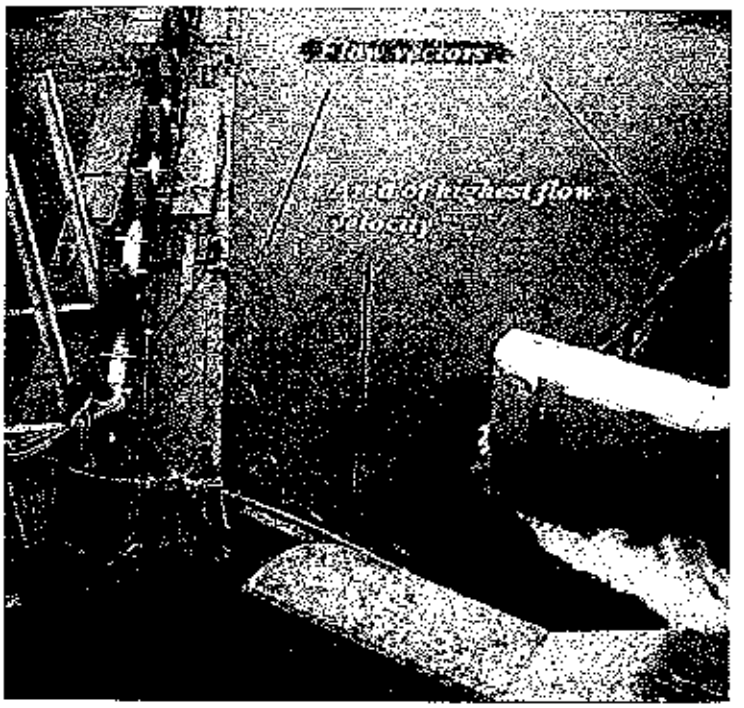


Figure 3-4. View of the louver/bypass area at the Gardners Falls Project showing flow vectors along the louver line and dam's face with a 294 cfs bypass flow, Spring 2000.

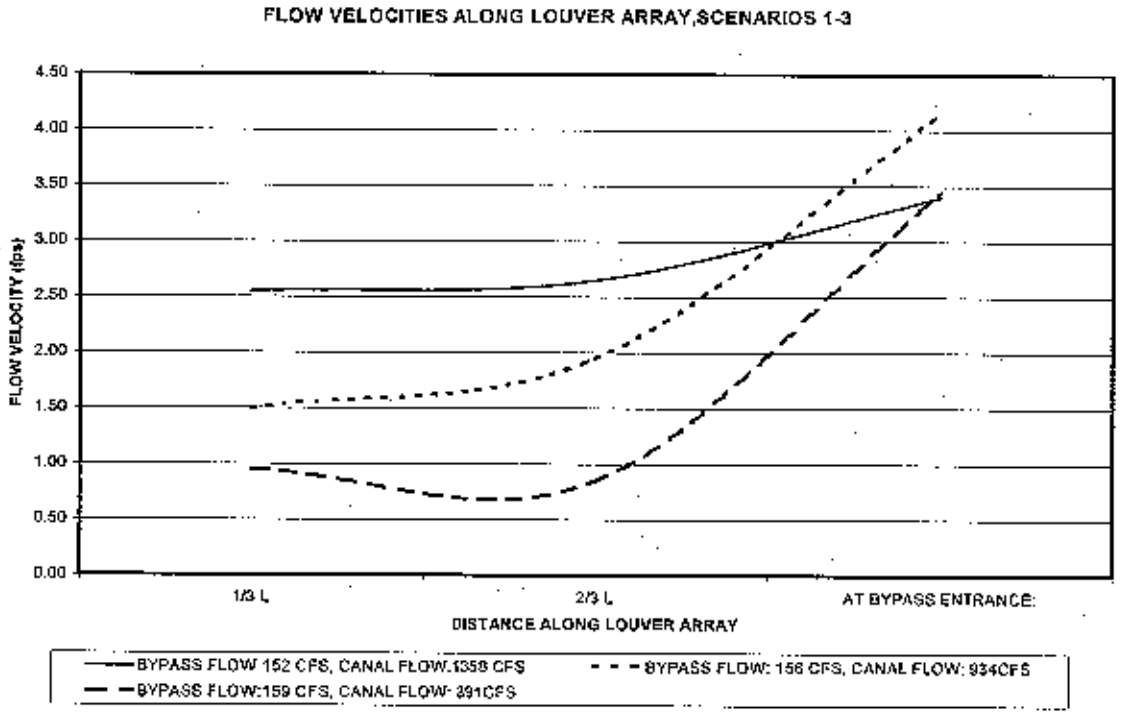
ranging from 0 h: 20 m to 218 h: 34 m. The project power canal and the area between the louvers and the canal headgates were the primary places the salmon chose to linger in.

Additionally, eighteen radio-tagged smolts that had been released above the Deerfield No. 4 project for the PG&E study were detected at the Gardners Falls Project (Table 3-2; Appendix 2). Of these, 17 were verified as passing the Project - five (29%) exited via the bypass, 6 (35%) passed through the turbines and 4 (24%) spilled over the Gardners Falls dam. One fish did not pass and 2 were detected at the arrival point but could not be located again (Table 3-2). However, of the five fish that exited via the bypass, four (80%) passed during high flow conditions. The reason this group of fish had greater passage success at the higher flows than those released into the Gardners Falls headpond may have been due to the percent of bypass flow compared to turbine flow at the time of their passage. Three of the four salmon that exited the bypass when turbine flow was higher than 800 cfs also had high bypass flows that were greater than the target bypass flow of 150 cfs. Fish 91, 96 and 105 passed when bypass attraction flows were 353 cfs, 593 cfs and 457 cfs, respectively. These bypass flows for fish 91, 96 and 105 ranged from 27 % to 46 % of turbine flow, much greater than the 150 cfs bypass flow that approximately equates to 13 % of turbine flow when the project operates at maximum generation.

Table 3-2. Passage Routes Taken by Atlantic Salmon Smolts Released Above Deerfield No. 4 Project Passing the Gardners Falls Hydroelectric Project. Spring, 2000.

Release Group	Total Arrived	Through Turbines	Through Bypass		Unknown	Spilled	Total passed	Did not Pass
			Turbine Flow (cfs)					
			>800	<800				
3 May	3 of 14	1	0	0	1	1	3	0
5 May	8 of 14	3	3	1	0	0	7	1
10 May	7 of 15	2	1	0	1	3	7	0
Totals	18 of 43	6	4	1	2	4	17	1
%	42%	35%	29%		12%	24%	94%	6%
Category		Total Passed: 17					Total Detected: 18	

Many of the radio-tagged salmon detected approaching the Gardners Falls site were not guided by the louver array, but instead, either came along the dam's face or avoided detection by swimming under the array. Of the 51 radio-tagged salmon know to have passed the project, 31 came in contact with the louver array (Table 3-3). Of these, 14 were guided to within 3 ft of the bypass entrance, but only seven opted to exit through the bypass - the remaining 17 fish either passed through or dove under the louver array or remained in the headpond. Eight radio-tagged salmon that either came along the dam face or sounded under the louver array were detected at the bypass entrance, and of these six exited through the bypass. Therefore, of the 51 fish known to have passed the project, 22 were detected within 3 ft of the bypass entrance and of these 22, only 13 exited via the bypass (Table 3-3). The remaining radio-tagged salmon that passed the project but were not detected at the louver array or within 3 ft of the bypass entrance, either passed under the louver array and exited through the turbines or spilled over the dam. Additionally, three fish did not pass the project during the study period.



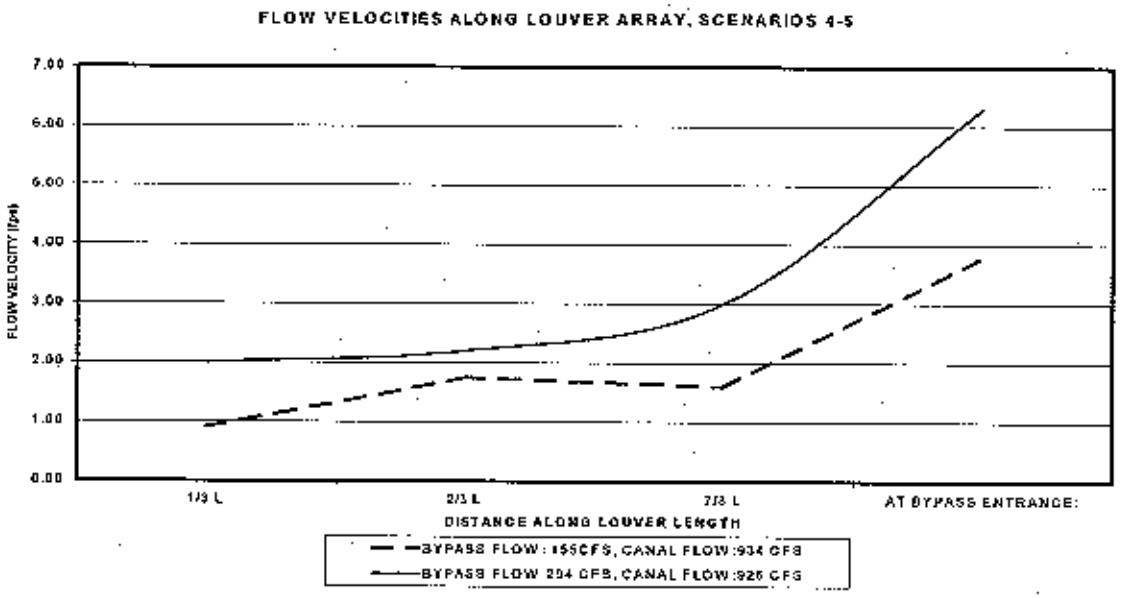


Figure 3-5. Flow velocities along the Louver array and the bypass entrance during the Gardners Falls Study. Spring, 2000.

Table 3-3. Number of smolts guided by the louver array during the Gardners Falls Study. Spring, 2000.

Guided by	Smolts Detected at Louvers	Smolts Detected within 3 ft of Bypass	Passed through By-pass	Passed through Turbines
Louvers	31	14	7	20
Other*	0	8	6	2

* Presumably guided by flow along dam's face or approached the louvers deeper than 8 ft.

Flow velocities at two locations and depths along the louver array (1/3 and 2/3 the length of the louver array) and at the bypass entrance were recorded at five different flow scenarios during the study (Figure 3-5; Appendix 4). When bypass flows were approximately 150 cfs, velocity at the bypass entrance (at 1 ft of depth) ranged from 3.5 to 4.3 ft per second. At the same time, flow velocity along the louver array ranged from 0.8 to 2.7 ft per second, generally increasing as it moved along the array toward the bypass entrance. In most cases, flow along the louver array increased as turbine flow increased. The highest velocities at the bypass entrance (6.3 ft/sec) occurred when bypass flow was 294 cfs and turbine flow was 924 cfs. Velocity along the louver array during this test scenario was also high, and ranged from 2 to 3 ft/sec.

Average daily river temperatures during the spring 2000 study period ranged between 10.9 and 17.9°C (Figure 3-6). Radio-tagged smolts used for the tests ranged in size from 186-249 mm total length, with an average of 219 mm. Twenty-four hour mortality due to tagging and handling was zero, and tag retention over the first 24 hours was 100%.

Although the louver array was not very effective at guiding smolts to the bypass gate when canal flows were greater than 800 cfs, it was effective at flows less than 600 cfs. Figure 3-7 shows the combined passage routes taken by 197 radio-tagged salmon detected at the project during the 1999 and 2000 studies. These fish include the 145 radio-tagged smolts released (and detected) at the project in 1999 and 2000 combined with the 52 radio-tagged salmon from the upstream PG&E studies (18 in 2000, 34 in 1999). Even though bypass flow varied during some of these releases, it is obvious that the bypass/louver array was successful at passing more than 70% of the salmon smolts at turbine flows below 600 cfs.

A combined total of 67 radio-tagged smolts (52 released for the Gardners Falls study and 15 for the Deerfield River No. 4 study), were verified as passing through the Gardners Falls Project's turbine during the 1999 (30 smolts) and 2000 (37 smolts) studies. Of these 67 smolts, 59 (88%) were detected at the next downstream project (Deerfield River No. 2. Only 1 (1%) smolt became stationary in the Gardners Falls tailrace area after passage through the unit in 1999. Seven (10%) of the smolts (2 in 1999 and 5 in 2000) could not be located again after passing through the Gardners Falls Project turbines. Extensive manual tracking between the Gardners Falls and the DRP No. 2 projects, particularly the 1000 ft area immediately below the Gardners Falls project's tailrace, failed to locate these fish via radio-telemetry. Loss of contact could result from 1) the radio tag malfunctioned (battery life exceeded); 2) the fish continued downstream undetected by traveling deeper than normal; 3) the fish was predated upon by another fish; or, 4) tag regurgitation after passing through the turbines.

The tracking configuration did not permit determination of passage through individual units. However, unit passage during the 1999 season occurred only during Unit No. 4 operation. Appendix 5

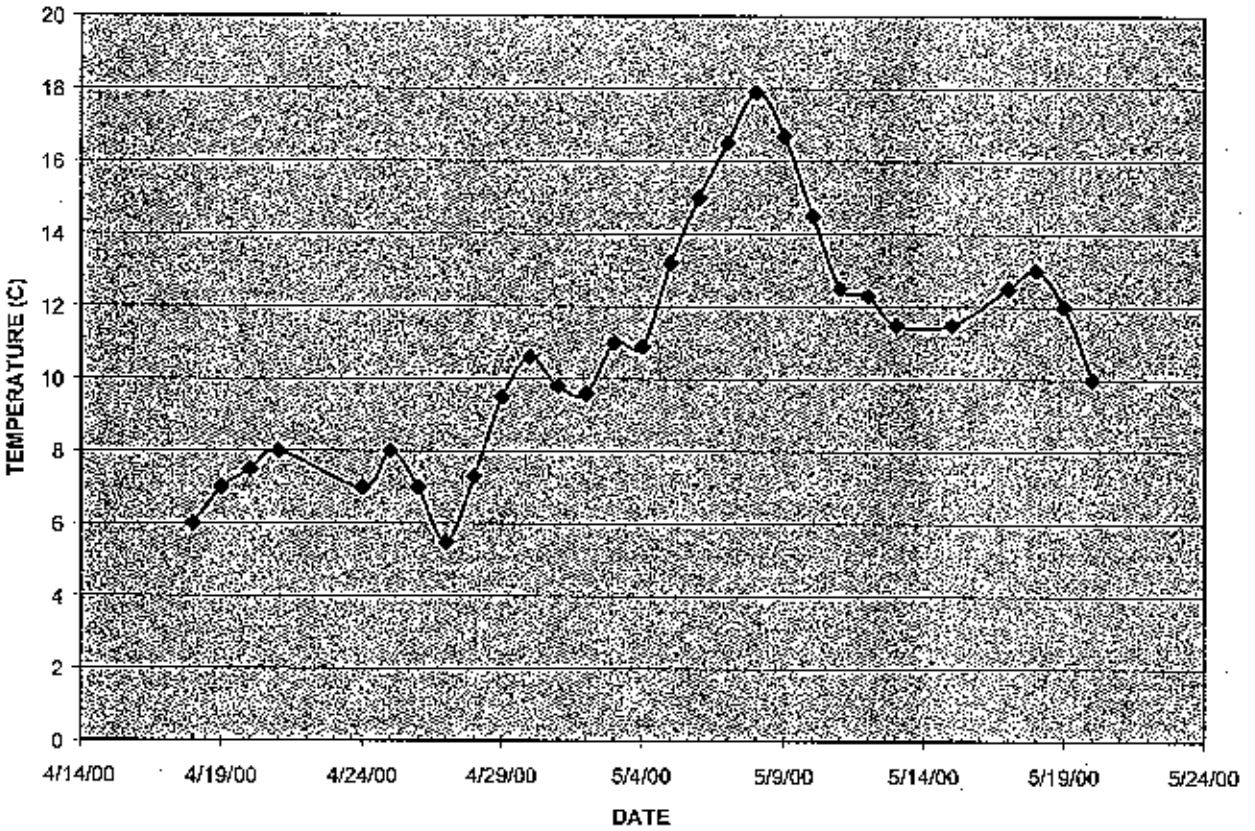


Figure 3-6. Average daily river temperatures (°C) during the Gardners Falls Study. Spring, 2000.

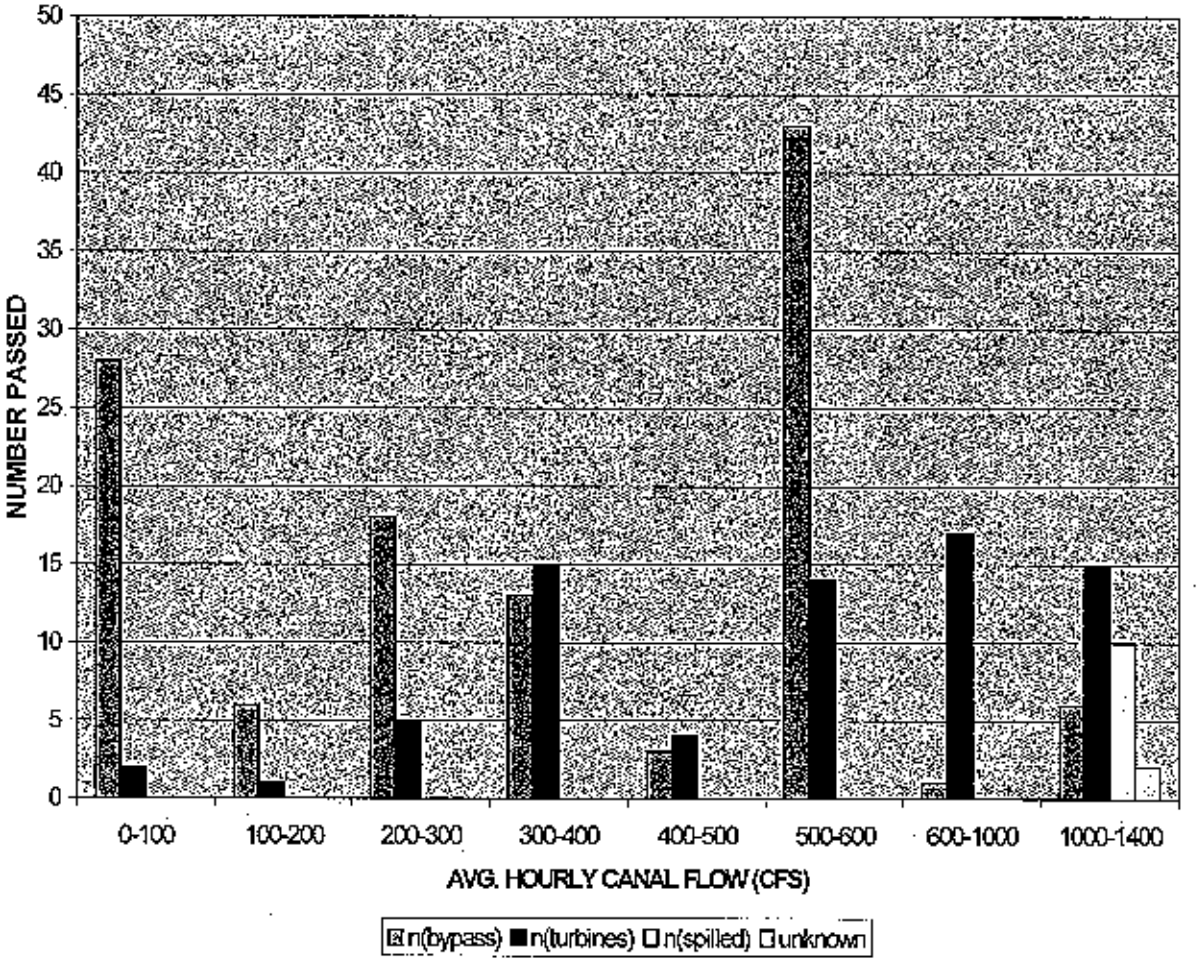


Figure 3-7. Combined Passage results from Spring 1999 and Spring 2000 for 197 radio-tagged Atlantic salmon smolts that passed the Gardners Falls Project.

contains an estimate of the individual unit flows during passage and calculated wicket gate opening. Most passage occurred at approximately 100% gate, although some passage occurred at substantially lower gate settings. Appendix 6 contains a summary of the river flows during the 1999 and 2000 studies. River flows during the 1999 study appear to be below average while river flows during the 2000 study are at or above the long term average river flow.

In 1999 the transit time between the Gardners Falls and DRP No. 2 projects after passage through the units averaged 15 h:25 m, median was 6 h:53 m, and ranged from 1 h:48 m to 5 d:6 h:50 m. Transit times during the 2000 study between projects were comparable to 1999 (average was 7 h:23 m, median was 4 h:53 m, and ranged between 1 h:31 m to 5 d:18 h:9 m). Appendix tables 5-1 and 5-2 list the turbine-entrained smolts, their time of passage, estimate flow at the time of passage through the Gardners Falls units and arrival time to DRP No. 2.

3.2 BYPASS SURVIVAL TEST

Normandeau biologists released marked salmon smolts into the Gardners Falls bypass flow on two separate dates. The first occurred on 13 May, when 50 streamer-tagged smolts were released directly into the bypass flow. However, shortly after the fish were released an unscheduled flow release at the upstream dam caused a spill condition at the project. When the bypass gate was closed approximately 10 minutes after the fish were released water continued to spill over the dam's flash boards, preventing full draining of the plunge pool and hampering our attempts to operate the bypass net. We reopened the bypass gate for 2 hours in an attempt to flush the marked fish out of the plunge pool and into the bypass net, however, only 14 tagged fish entered the net. During this 2-hour period, water spilled over and through cracks in the plunge pool's flash boards and some tagged fish were observed escaping over and under the flash boards. Numerous streamer tagged smolts were observed swimming in the plunge pool even after the bypass net was removed. Two of the 14 recaptured salmon were severely descaled and perished after 24 hours (Table 3-4). These 2 fish were impinged for approximately two hours against a very large log stuck in the net, which caused their descaling and death. Because the spill persisted and we could not drain the plunge pool to recover the remaining fish, the test had to be aborted A second bypass survival test was made on 17 May. Normandeau personnel used different color tags (orange) to be able to distinguish these fish from those released previously. A total of 58 streamer tagged smolts were released directly into the bypass flow. The bypass gate remained open for 10 minutes following the release, then it was closed to drain the plunge pool. Ten marked smolts were recovered in the net and 41 were seined from the plunge pool after it had been drained. Seven of these smolts were from the first release (i.e., white tags) and had remained in the plunge pool unharmed for 4 days. All fish from both releases were alert and none showed any major scale loss. All smolts were quickly transported back to the holding tank and monitored for 72 hours. Survival results from the second test showed 100% survival on the fish that were recaptured (Table 3-4). As in the first test, a number of marked smolts were observed spilling over the plunge pool impounding wall during the 150 cfs bypass spill and some others were observed escaping recapture through some large cracks that existed between the bedrock and the flashboards. Fourteen smolts from this release were not recovered for this reason. Additionally, no dead or injured/disoriented fish were observed during the test. The bypass plunge pool was fully drained following the second test and no fish were left in the plunge pool. Bypass flows for both tests were set at 150 cfs using the automated settings. River temperature was 11.5°C for the first test and 12.0°C for the second test. Survival for 30 control fish after 72 hrs was 100% (Table 3-4).

Telemetry data provided from the PG&E study indicated that of the 51 radio-tagged smolts that passed the Gardners falls project, 47 (92 %) arrived at D.R.P. No. 2 Project, 39 (76 %) passed D.R.P. No. 2, and 21 (41 %) were detected 0.25 miles below the confluence of the Connecticut and Deerfield rivers (Appendix 5). It is possible that more fish may have eventually arrived and passed DRP No. 2 and reached the Connecticut River since no allowance for tag regurgitation/expiration was made (average radio tag life expectancy is 12-18 days). No Gardners Falls smolts were detected at Cabot station.

Table 3-4. Bypass Survival Test Results for the Gardners Falls Study. Spring, 2000.

Event	Released (tagged)	Recovered	2 Hr	24 Hrs	48 Hrs	72 Hrs	Total alive	Tag retention
Control	(30)	30	0	0	0	0	30	100%
Test 1	50	14[1]	0	2	0	0	12	100%
Test 2	58	51[2]	0	0	0	0	51	100%

[1]. Test was cancelled due to spill over dam after fish were released, unable to recapture the 36 remaining fish.
[2]. Seven fish recovered were from the Test 1 release 4 days earlier. A total of 14 salmon escaped over the plunge pool wall and through cracks in the flash boards.

4.0 DISCUSSION

The Gardners Falls bypass/louver array (bypass) was not very effective at guiding and passing salmon smolts at flows higher than 800 cfs. However, the bypass was effective (greater than 70% passage) at passing salmon at flows less than 600 cfs during both the 1999 and 2000 evaluations (Figure 3-7). It is not clear why the bypass is more effective at the lower flows.

One problem noted during the test was that 43% of the radio-tagged salmon released in 2000 were not guided by the louver array, but instead either approached the bypass entrance along the dam face or sounded under the louver array and were not detected (Table 3-3; Appendix 3).

Of the 31 radio-tagged salmon that were guided by louver array during the 2000 test, 14 came within 3 ft of the bypass entrance. However, only 7 of these 14 salmon exited through the bypass. Apparently, many salmon chose to sound under the array and pass through the turbines. Indeed, of the 22 radio-tagged salmon released in 2000 that were detected within 3 ft of the bypass entrance (8 of these were not detected at louvers), only 13 eventually exited through the bypass (Table 3-3).

Increasing the bypass flow from 150 to over 300 cfs for the last two releases did not improve passage through the bypass (only 2 of 29 used the bypass during high flows). As with the other releases, four of the six fish that used the bypass during these releases did so when turbine flow was less than 800 cfs.

Improvements made to the bypass plunge pool at Garners Falls have made it a safe passage route for downstream migrating salmon. Not all of the test fish were recaptured because the large, deep plunge pool made it impossible to block all escape routes. The 150 cfs bypass flow was constantly spilling over the plunge pool flashboards at several locations during the tests. Tagged salmon were observed escaping the plunge pool by going over, under and through some of the gaps in the flash boards in-

stalled to increase the depth of the pool. However, all fish recaptured from the second test survived for at least 72 hours, including seven tagged individuals that safely remained in the plunge pool for four days before their recapture. The two salmon that died after the first aborted test were impinged for hours against a log that spilled over the dam and became lodged in our net.

The bypass system obtained the best effectiveness results during the low flow periods of the 1999 study season. By comparison with average river flows during the passage season for the Deerfield River (Appendix 6), the 1999 study season occurred during periods of river flow approximately 40% below the long term average river flows. The 2000 study began during river flows more typical of the long term average with higher than normal flows during the latter part of the study period.

Between 1999 and 2000, a total of 199 radio-tagged smolts were verified as passing the project by either the bypass, spillage or unit passage. Of the 199 fish 109 (55%) used the bypass gate, 19 (9%) passed via the spillway, and 67 (34%) passed through the turbines and contact was lost with 4 (2%) of the fish. 59 out of the 67 fish (88%) that passed through the Gardners Falls turbines were detected at the next downstream project. By combining survivals through the various passage routes (bypass, spillage and turbines), the estimated project passage survival is approximately 94%.

5.0 LITERATURE CITED

Federal Energy Regulatory Commission (FERC). 1996. Final Environmental Impact Statement, Deerfield River Projects in the Deerfield river basin (FERC Projects No. 2323, 2669, and 2334).

Normandeau Associates Inc. (Normandeau). 1999. Evaluation of Downstream Passage Facilities for Atlantic salmon (*Salmo salar*) smolts at the Gardners Falls hydroelectric Project, Deerfield River, Buckland, Massachusetts.

APPENDIX

TABLES AND FIGURES

Appendix 1. Disposition of Radio-Tagged Atlantic Salmon Smolts Released Upstream of the Gardners Falls Project During Spring, 2000.

Fish # (Digital code)	Frequency(MHz)	Passage Date/Time	Exit Route	Bypass Flow(cfs)	Canal Flow(cfs)	Last Location/Date Detected
Released 5/4/00, 1501						
1	149.360	15:20, 5/5	Turbines	422	761	Conn. River, 5/13
2	149.360	16:12, 5/4	Turbines	154	905	Conn. River, 5/7
3	149.360	22:44, 5/4	Turbines	151	1296	#2 Forebay, 5/14
4	149.360	18:04, 5/7	Turbines	156	905	#2 Tailrace, 5/22
5	149.360	18:08, 5/4	Turbines	152	905	#2 Tailrace, 5/5
6	149.360	16:10, 5/4	Turbines	154	905	Conn. River, 5/9
7	149.360	16:19, 5/4	Turbines	154	905	Conn. River, 5/7
8	149.360	20:34, 5/4	Turbines	155	905	#2 Forebay, 5/22
9	149.360	20:08, 5/4	Turbines	155	905	#2 Tailrace, 5/5
10	149.360	20:34, 5/4	Turbines	155	1337	#2 Forebay, 5/5
Released 5/5/00, 1859-1916						
11	149.360	05:13, 5/6	Bypass	153	379	Bard. Ferry, 5/7
12	149.360	20:31, 5/5	Bypass	159	370	Conn. River, 5/8
13	149.360	21:40, 5/5	Bypass	159	946	#2 Tailrace, 5/22
14	149.360	03:58, 5/6	Bypass	153	379	#2 Tailrace, 5/8
15	149.360	20:39, 5/5	Bypass	159	370	Conn. River, 5/18
16	149.360	12:24, 5/8	Turbines	159	379	Conn. River, 5/12
17	149.360	23:12, 5/5	Turbines	153	370	Conn. River, 5/14
51	149.360	07:48, 5/6	Turbines	157	1284	Conn. River, 5/11
19	149.360	20:48, 5/5	Bypass	159	370	#2 Tailrace, 5/13
20	149.360	ND	Unknown	ND	946	#2 Tailrace, 5/21
Released 5/8/00, 1858-1915						
21	149.360	21:56, 5/8	Turbines	154	1337	#2 Tailrace, 5/12
22	149.360	21:42, 5/13	Turbines	155	905	Conn. River, 5/19
23	149.360	NA	DNP	152	379	G.F. Canal, 5/20
24	149.360	21:45, 5/8	Turbines	154	905	#2 Tailrace, 5/9
25	149.360	22:51, 5/10	Turbines	554	379	Bard. Ferry, 5/13
26	149.360	00:46, 5/9	Turbines	152	905	G.F. Tailrace, 5/9
27	149.360	21:48, 5/10	Bypass	438	397	Bard. Ferry, 5/11
28	149.360	19:41, 5/8	Turbines	155	905	Conn. River, 5/11
29	149.360	21:11, 5/8	Turbines	154	905	#2 Forebay, 5/8
30	149.360	20:54, 5/8	Turbines	151	905	Conn. River, 5/12
31	149.360	20:11, 5/8	Turbines	151	905	Conn. River, 5/12
32	149.360	NA	DNP	153	379	G.F. Canal, 5/20
33	149.360	21:33, 5/8	Turbines	154	1337	#2 Forebay, 5/8

Fish # (Digital code)	Frequency(MHz)	Passage Date/Time	Exit Route	Bypass Flow(cfs)	Canal Flow(cfs)	Last Location/Date Detected
34	149.360	20:14, 5/8	Turbines	151	905	Conn. River, 5/11
35	149.360	21:21, 5/8	Turbines	154	1337	#2 Tailrace, 5/9
Released 5/9/00, 1855-1910						
36	149.360	06:06, 5/10	Bypass	316	379	Conn. River, 5/13
37	149.360	NA	Spilled	NA	1255	Conn. River, 5/20
38	149.360	07:46, 5/12	Turbines	545	379	G.F. Tailrace, 5/12
39	149.360	19:57, 5/13	Turbines	150	905	#2 Forebay, 5/22
40	149.360	20:02, 5/10	Turbines	366	379	Conn. River, 5/18
41	149.360	20:32, 5/9	Bypass	324	379	Bard. Ferry, 5/12
42	149.360	20:33, 5/9	Bypass	324	379	Conn. River, 5/16
43	149.360	17:16, 5/11	Bypass	593	1235	#2 Tailrace, 5/22
44	149.360	20:33, 5/9	Bypass	324	379	G.F. B. reach, 5/20
45	149.360	NA	Spilled	NA	1296	#2 Tailrace, 5/22
Released 5/10/00, 1855-1905						
46	149.360	21:31, 5/19	Turbines	156	1255	G.F. Tailrace, 5/19
47	149.360	NA	DNP	NA	NA	G.F. H. pond, 5/20
48	149.360	07:32, 5/14	Turbines	156	1255	Bard. Ferry, 5/14
49	149.360	NA	Spilled	NA	1296	Conn. River, 5/14
50	149.360	22:15, 5/10	Turbines	554	1296	Conn. River, 5/13
52	149.360	NA	Spilled	NA	1255	#2 Tailrace, 5/14
53	149.360	NA	Spilled	NA	1255	Conn. River, 5/13
54	149.360	NA	Spilled	NA	1255	G.F. Tailrace, 5/11
55	149.360	20:44, 5/16	Bypass	150	1312	Bard. Ferry, 5/22

Abbreviations:

G.F.= Gardners Falls Project
#2 = Deerfield Project No. 2 (USGen)
Bard. Ferry = Bardwell Ferry Bridge (Deerfield River)
Conn. River = 0.25 miles below confluence of Deerfield and Connecticut Rivers
DNP = Fish did not pass project
NA = Not available

Appendix 2. Disposition of Radio-tagged Atlantic Salmon Smolts Released Upstream of Deerfield Project No. 4 for the USGen Downstream Passage Studies Detected at the Gardners Falls Project During Spring, 2000.

Fish # (Digital code)	Frequency(MHz)	Passage Date/ Time	Exit Route	Bypass Flow(cfs)	Canal Flow(cfs)	Last Location/Date Detected
Released 5/3/00 (3 out of 14 detected)						
139	149.740	00:56, 5/9	Turbines	152	1337	G.F. Tailrace, 5/9
140	149.740	23:00, 5/10[1]	Spilled	593	1296	G.F. Tailrace, 5/10
146	149.740	08:19, 5/11[1]	Unknown	585	1255	G.F. headpond, 5/11
Released 5/5/00 (8 out of 14 detected)						
87	149.760	17:35, 5/7	Bypass	155	1337	G.F. Tailrace, 5/8
89	149.760	20:21, 5/16	Turbines	154	1312	G.F. Tailrace, 5/16
91	149.760	19:58, 5/10	Bypass	353	1296	G.F. tailrace, 5/10
95	149.760	15:26, 5/7[2]	Bypass	156	379	G.F. Tailrace, 5/8
96	149.760	22;15, 5/10	Turbines	593	1296	G.F. Tailrace, 5/10
98	149.760	03:40, 5/12	Bypass	572	1255	G.F. Tailrace, 5/12
99	149.760	15:31, 5/11	Turbines	153	1255	G.F. Tailrace, 5/11
100	149.760	NA	DNP	NA	NA	G.F. H. pond, 5/16
Released 5/10/00 (7 out of 15 detected)						
101	149.760	04:35, 5/19	Turbines	151	1328	G.F. Tailrace, 5/19
104	149.760	05:56,5/11	Spilled	583	1255	G.F. Tailrace, 5/11
105	149.760	11:54, 5/13	Bypass	457	1255	G.F. Tailrace, 5/13
156	149.740	06:13, 5/14	Turbines	149	1255	G.F. Tailrace, 5/14
157	149.740	08;06, 5/11	Spilled	585	1255	G.F. Tailrace, 5/11
158	149.740	02;48, 5/11	Spilled	600	1276	G.F. Tailrace, 5/11
159	149.740	06:15, 5/12	Unknown	560	1255	G.F. H. Pond, 5/12

[1] Passage estimated from last detection time, passed undetected through project.

[2] Bypass and louver receivers were set to scan only two frequencies at a time to minimize data loss from Gardners Falls Fish. Channel 22 was scanned on Bypass and louver receivers until first Channel 23 fish were detected on the Jetty receiver, then Channel 23 was scanned. All other stations (Jetty, Bypass reach, Canal, and Tailrace) scanned all three frequencies throughout the study.

Abbreviations:

G.F.= Gardners Falls Project
#2 = Deerfield Project No. 2 (USGen)
Bard. Ferry = Bardwell Ferry Bridge (Deerfield River)
Conn. River = 0.25 miles below confluence of Deerfield and Connecticut Rivers
DNP = Fish did not pass project
NA = Not available

Appendix 3. Number of radio-tagged salmon detected in the vicinity of the louver array and bypass entrance during the Spring 2000 tests at the Gardners Falls Project.

FISH ID	BYPASS FLOW	CANAL FLOW	LOUVER GUIDED	WITHIN 3 FT OF BYPASS ENTRANCE	EXITED BYPASS
1	422	761	y	n	n
2	154	905	n	n	n
3	151	1296	n	n	n
4	156	905	y	n	n
5	152	905	y	n	n
6	154	905	y	n	n
7	154	905	n	n	n
8	155	905	y	n	n
9	155	905	y	n	n
10	155	1337	y	n	n
11	153	379	y	y	y
12	159	370	n	y	y
13	159	946	n	y	y
14	153	379	n	y	y
15	159	370	n	y	y
16	159	379	y	y	n
17	153	370	y	y	n
19	159	370	n	y	y
20	NA	946	unk	unk	unk
21	154	1337	n	n	n
22	155	905	y	n	n
23	152	379	y (1)	n	n
24	154	905	n	n	n
25	554	379	n	n	n
26	152	905	y	y	n
27	438	397	y	y	y
28	155	905	n	y	n
29	154	905	y	y	n
30	151	905	y	y	n
31	151	905	y	y	n
32	153	379	y (1)	n	n
33	154	1337	n	n	n
34	151	905	n	y	n
35	154	1337	n	n	n
36	316	1255	y	y	y
37	NA	na	y	n (2)	n
38	324	379	n	n	n
39	353	905	y	n	n
40	353	379	y	n	n
41	366	379	y	y	y
42	366	379	n	y	y
43	593	1235	y	y	y
44	366	379	y	y	y

FISH ID	BYPASS FLOW	CANAL FLOW	LOUVER GUIDED	WITHIN 3 FT OF BYPASS ENTRANCE	EXITED BYPASS
45	593	1296	n (2)	n	n
46	154	1255	y	n	n
47	na	na	y (1)	na	na
48	572	1255	y	n	n
49	554	1296	n	n	n (2)
50	438	1296	y	n	n
51	157	1284	y	y	n
52	588	1255	n	n	n (2)
53	na	1255	n	n	n (2)
54	575	1255	n	n	n (2)
55	150	1312	y	y	y

(1) Fish did not pass project.
(2) Fish spilled over project's dam.

Appendix 4. **Bypass attraction and canal flow scenarios during the Gardners Falls Study. Spring, 2000.**

BYPASS ATTRACTION FLOW: 152 CFS CANAL FLOW: 1358 CFS					
FLOW VELOCITIES (ft/sec)				DATE	5/4/00
at depth:	1 ft	4 ft	AVG		
1/3 L	2.40	2.70	2.55	TIME:	1115
2/3 L	2.60	2.70	2.65	TIME:	1116
AT BYPASS ENTRANCE:	3.50	3.30	3.40	TIME:	1117
BYPASS ATTRACTION FLOW: 156 CFS CANAL FLOW: 934 CFS					
FLOW VELOCITIES (ft/sec)				DATE:	5/4/00
at depth:	1ft	4 ft	AVG		
1/3 L	1.40	1.60	1.50	TIME:	1515
2/3 L	1.90	2.00	1.95	TIME:	1516
AT BYPASS ENTRANCE:	4.30	4.00	4.15	TIME:	1517
BYPASS ATTRACTION FLOW: 159 CFS CANAL FLOW: 391 CFS					
FLOW VELOCITIES (ft/sec)				DATE:	5/5/00
at depth:	1 ft	4 ft	AVG		
1/3 L	0.90	1.00	0.95	TIME:	2030
2/3 L	0.80	0.90	0.85	TIME:	2031
AT BYPASS ENTRANCE:	3.50	3.40	3.45	TIME:	2032
BYPASS ATTRACTION FLOW: 155 CFS CANAL FLOW: 934 CFS					
FLOW VELOCITIES (ft/sec)				DATE:	5/8/00
at depth:	1 ft	4 ft	AVG		
1/3 L	0.90	0.90	0.90	TIME:	1920
2/3 L	1.60	1.90	1.75	TIME:	1921
7/8 L	1.60	1.60	1.60	TIME:	1921
AT BYPASS ENTRANCE:	3.80	3.80	3.80	TIME:	1922
BYPASS ATTRACTION FLOW: 294 CFS CANAL FLOW: 926 CFS					
FLOW VELOCITIES (ft/sec)				DATE:	5/9/00
at depth:	1 ft	4 ft	AVG		
1/3 L	2.00	2.00	2.00	TIME:	1911
2/3 L	2.20	2.20	2.20	TIME:	1912
7/8 L	3.00	3.00	3.00	TIME:	1913
AT BYPASS ENTRANCE:	6.30	N/A	6.30	TIME:	1914

APPENDIX 5. **Estimated Turbine Survival through the Gardners Falls Project in 1999 and 2000**

1999. Thirty radio-tagged smolts (21 released for the Gardners Falls study and 9 for the Deerfield River Project study) were verified as passing through the Gardners Falls Project's turbines. Of these, 27 (90%) were detected at the next downstream project (DRP No. 2) but only one became "stationary" in the Gardners Falls Project's tailrace. Transit time between the Gardners Falls and DRP No. 2 projects averaged 15 h: 25m, median was 6h: 53m, ranged from 1h: 48m to 5d: 6h: 50m. Appendix table 5-1 lists the turbine-entrained smolts, their time of passage, estimate flow at the time of passage through the Gardners Falls units and arrival time to DRP No. 2. Although the tracking configuration did not permit determination of passage through individual units, unit passage during the 1999 season occurred only during Unit No 4 operation.

2000. Thirty-seven radio-tagged smolts (31 Gardners Falls fish and 6 Deerfield project fish) passed through the Gardners Falls turbines in 2000. Of these, 32 (86%) smolts were detected at DRP No 2 and no radio-tagged smolts became stationary in the Gardners Falls tailrace. Transit times between projects were comparable to 1999 (mean=17h:23m, median=4h:53m, range=1h:31m-5d:18h:9m). Appendix table 5-2 lists passage times and flow for the turbine-entrained fish in 2000 and their arrival times to DRP No 2

Summary .

Total entrainment:		**Stationary after passage:**	**Arrived at DRP No 2**
1999=	**30 smolts,**	**1 smolt**	**27 smolts**
2000=	**37 smolts,**	**0 smolts**	**32 smolts**
Total=	**67 smolts,**	**1 smolt**	**59 smolts**
Percent=	**100%**	**1.5%**	**88%**

Seven smolts (2 in 1999 and 5 in 2000) could not be located again after passing through the Gardners Falls Project turbines. Extensive manual tracking between the Gardners Falls and DRP No 2 projects, particularly the 1000 ft area immediately below the Gardners Falls tailrace, failed to locate these fish via radio-telemetry. Loss of contact could result from 1) the radio tag malfunctioned (battery life exceeded); 2) the fish continued downstream undetected by traveling deeper than normal; or, 3) the fish was predated upon by another fish after passing through the turbines.

Appendix 5 Turbine Entrained Smolts and Last Detection

Table 5-A: Summary of 1999 Study

Fish	Passage	Turbine Generation (KWh)				First Detected	Transit time
Ch-code	date, time	Unit 3	Unit 4	Unit 5	Total	at DRP 2	hh:mm:ss
3-2	4/29/99 21:28	0	450	0	450	4/30/99 4:56	7:28:00
3-9	4/29/99 22:20	0	690	0	690	4/30/99 22:10	23:50:00
3-14	5/1/99 21:18	0	1225	0	1225	5/2/99 0:06	2:48:00
3-22	5/2/99 16:14	0	1226	0	1226	5/2/99 22:35	6:21:00
3-28	5/5/99 22:38	0	1229	0	1229	n/a	n/a (1)
3-33	5/4/99 4:52	0	0	1042	1042	n/a	n/a (1)
3-44	5/4/99 23:02	0	0	437	437	n/a	n/a (2)
3-49	5/5/99 22:07	0	1229	0	1229	5/6/99 13:07	15:00:00
3-50	5/6/99 5:10	0	546	0	546	5/7/99 11:14	30:04:00
3-51	5/6/99 9:19	0	649	0	649	5/7/99 9:45	24:26:00
3-52	5/6/99 15:35	0	755	0	755	5/11/99 23:25	127:50:00
3-53	5/5/99 21:47	0	1229	0	1229	5/6/99 11:04	13:17:00
3-54	5/8/99 20:03	0	1232	0	1232	5/8/99 22:41	2:38:00
3-55	5/5/99 21:10	0	1229	0	1229	5/6/99 11:40	14:30:00
3-59	5/7/99 3:08	0	1097	0	1097	5/7/99 21:21	18:13:00
3-71	5/7/99 22:22	0	591	0	591	5/8/99 22:02	23:40:00
3-76	5/9/99 8:37	0	1225	0	1225	5/10/99 2:42	18:05:00
3-84	5/9/99 10:13	0	814	0	814	5/10/99 2:05	15:52:00
3-91	5/11/99 19:25	0	1230	0	1230	5/13/99 19:59	48:34:00
3-92	5/9/99 22:46	0	1227	0	1227	5/11/99 7:03	32:17:00
3-97	5/10/99 21:07	0	917	0	917	5/11/99 0:34	3:27:00
3-119*	5/8/99 19:25	0	1229	0	1229	5/9/99 0:19	4:54:00
3-121*	5/11/99 5:14	0	1244	0	1244	5/11/99 7:33	2:19:00
3-127*	5/10/99 3:52	0	1228	0	1228	5/10/99 5:40	1:48:00
3-130*	5/12/99 17:40	n/a	n/a	n/a	n/a	5/12/99 19:59	2:19:00
3-133*	5/8/99 4:37	0	561	0	561	5/8/99 11:51	7:14:00
3-163*	5/15/99 16:05	n/a	n/a	n/a	n/a	5/15/99 18:02	1:57:00
23-76*	5/7/99 0:36	0	366	0	366	5/7/99 7:08	6:32:00
23-87*	5/7/99 6:16	0	712	0	712	5/7/99 9:52	3:36:00
23-89*	5/7/99 8:35	0	857	0	857	5/7/99 12:04	3:29:00

*. Released as part of the Deerfield River Project Downstream fishways Effectiveness evaluation during Spring 1999 and 2000.

(1) Neither tag became stationary in the Project's tailrace

(2) Tag became stationary in the area immediately below the tailrace of unit 5.

Appendix 5 Turbine Entrained Smolts and Last Detection

Table 5-B: Summary of 2000 Study

Fish	Passage	Turbine generation (KWh)				First detected	Transit time
Ch-Code	Time/Date	Unit 3	Unit 4	Unit 5	Total	at DRP 2	hh:mm:ss
3-1	5/5/00 15:20	950	900	0	1850	5/5/00 17:37	2:17:00
3-2	5/4/00 16:13	0	900	1300	2200	5/4/00 21:27	5:14:00
3-3	5/4/00 22:45	900	900	1250	3050	5/6/00 5:23	30:38:00
3-4	5/7/00 18:05	950	900	1300	3150	5/10/00 8:45	62:40:00
3-5	5/4/00 18:08	950	900	1300	3150	5/4/00 20:11	2:03:00
3-6	5/4/00 16:10	0	900	1300	2200	5/10/00 10:19	138:09:00
3-7	5/4/00 16:19	0	900	1300	2200	5/4/00 19:31	3:12:00
3-8	5/4/00 20:34	950	900	1400	3250	5/5/00 0:14	3:40:00
3-9	5/4/00 20:08	950	900	1300	3150	5/5/00 15:05	18:57:00
3-10	5/4/00 20:34	950	900	1300	3150	5/4/00 22:21	1:47:00
3-16	5/8/00 12:24	0	920	1300	2220	5/8/00 15:54	3:30:00
3-17	5/5/00 23:12	900	900	0	1800	5/6/00 1:41	2:29:00
3-51	5/6/00 7:48	0	920	1300	2220	5/10/00 11:25	99:37:00
3-21	5/8/00 21:56	950	900	1400	3250	5/10/00 22:34	48:38:00
3-22	5/13/00 21:42	850	900	1300	3050	5/13/00 23:39	1:57:00
3-24	5/8/00 21:45	950	900	1300	3150	5/9/00 22:42	24:57:00
3-25	5/10/00 22:51	950	900	1300	3150	5/11/00 3:23	4:32:00
3-26	5/9/00 0:46	900	900	1300	3100	n/a (8)	n/a (3)
3-28	5/8/00 19:41	0	900	1300	2200	5/9/00 6:58	11:17:00
3-29	5/8/00 21:11	950	900	1300	3150	5/8/00 22:42	1:31:00
3-30	5/8/00 20:54	950	900	1300	3150	5/10/00 19:04	46:10:00
3-31	5/8/00 20:11	0	920	1300	2220	5/9/00 15:37	19:26:00
3-33	5/8/00 21:33	950	900	1300	3150	5/9/00 23:10	25:37:00
3-34	5/8/00 20:14	0	920	1300	2220	5/9/00 5:02	8:48:00
3-35	5/8/00 21:21	950	900	1400	3250	5/8/00 22:53	1:32:00
3-38	5/12/00 7:46	880	900	1300	3080	n/a(8)	n/a (4)
3-39	5/13/00 19:57	900	900	1300	3100	5/13/00 22:57	3:00:00
3-40	5/10/00 20:02	0	900	1300	2200	5/10/00 23:31	3:29:00
3-46	5/19/00 21:31	950	950	1400	3300	n/a(8)	n/a (5)
3-48	5/14/00 7:32	880	850	1300	3030	5/14/00 9:35	2:03:00
3-50	5/10/00 22:15	950	900	1300	3150	5/11/00 7:43	9:28:00
23-89*	5/16/00 20:21	920	900	1300	3120	n/a(8)	n/a (6)
23-96*	5/10/00 22:15	950	900	1300	3150	5/11/00 1:35	3:20:00
23-99*	5/11/00 15:31	900	900	1300	3100	5/11/00 17:39	2:08:00
23-101*	5/19/00 4:35	950	900	1400	3250	5/19/00 16:40	12:05:00
22-139*	5/9/00 0:56	900	900	1300	3100	n/a(8)	n/a (6)
22-156*	5/14/00 6:13	880	850	1300	3030	5/15/00 21:16	39:03:00

*. Released as part of the Deerfield River Project Downstream fishways Effectiveness evaluation during Spring 1999 and 2000.

(3) last detection at Gardners Tailrace 5/10/00, 7:26
(4) Last detection at Gardners talirace 5/12/00, 7:58.
(5) Last detected at Gardners tailrace 5/19/00, 21:34
(6). Fish 23-89 and 22-139 did not become stationary in the Project's area.
(7). Fish first detected on DRP 2 tailrace monitor
(8). Fish did not arrive at DRP 2

Appendix 5

Summary of Unit Flows During Smolt Passage Through the Units

Table 5-D: Unit Flows & Gate Settings During the Year 2000 Study

Fish	Exit	Turbine generation (KWh)				Flow (cfs=(kwh*11.81)/(head*eff.)*				% Wicket Gate Open		
CODE	Time/Date	Unit 3	Unit 4	Unit 5	Total	Unit 3	Unit 4	Unit 5	Total	Unit 3	Unit 4	Unit 5
1	1520, 5/5	950	900	0	1850	368	349	0	717	99%	94%	0%
2	1613, 5/4	0	900	1300	2200	0	349	463	812	0%	94%	100%
3	2245, 5/4	900	900	1250	3050	349	349	445	1143	94%	94%	100%
4	1805, 5/7	950	900	1300	3150	368	349	463	1180	99%	94%	100%
5	1808, 5/4	950	900	1300	3150	368	349	463	1180	99%	94%	100%
6	1610, 5/4	0	900	1300	2200	0	349	463	812	0%	94%	100%
7	1619, 5/4	0	900	1300	2200	0	349	463	812	0%	94%	100%
8	2034, 5/4	950	900	1400	3250	368	349	499	1216	99%	94%	100%
9	2008, 5/4	950	900	1300	3150	368	349	463	1180	99%	94%	100%
10	2034, 5/4	950	900	1300	3150	368	349	463	1180	99%	94%	100%
16	1224, 5/8	0	920	1300	2220	0	356	463	820	0%	96%	100%
17	2312, 5/5	900	900	0	1800	349	349	0	697	94%	94%	0%
61	0748, 5/6	0	920	1300	2220	0	356	463	820	0%	96%	100%
21	2156, 5/8	950	900	1400	3250	368	349	499	1216	99%	94%	100%
22	2142, 5/13	850	900	1300	3050	329	349	463	1141	89%	94%	100%
24	2145, 5/8	950	900	1300	3150	368	349	463	1180	99%	94%	100%
25	2251, 5/10	950	900	1300	3150	368	349	463	1180	99%	94%	100%
26	0046, 5/9	900	900	1300	3100	349	349	463	1161	94%	94%	100%
28	1941, 5/8	0	900	1300	2200	0	349	463	812	0%	94%	100%
29	2111, 5/8	950	900	1300	3150	368	349	463	1180	99%	94%	100%
30	2054, 5/8	950	900	1300	3150	368	349	463	1180	99%	94%	100%
31	2011, 5/8	0	920	1300	2220	0	356	463	820	0%	96%	100%
33	2133, 5/8	950	900	1300	3150	368	349	463	1180	99%	94%	100%
34	2014, 5/8	0	920	1300	2220	0	356	463	820	0%	96%	100%
35	2121, 5/8	950	900	1400	3250	368	349	499	1216	99%	94%	100%
38	0746, 5/12	880	900	1300	3080	341	349	463	1153	92%	94%	100%
39	1957, 5/13	900	900	1300	3100	349	349	463	1161	94%	94%	100%
40	2002, 5/10	0	900	1300	2200	0	349	463	812	0%	94%	100%
46	2131, 5/19	950	950	1400	3300	368	368	499	1235	99%	99%	100%
48	0732, 5/14	880	850	1300	3030	341	329	463	1133	92%	89%	100%
50	2215, 5/10	950	900	1300	3150	368	349	463	1180	99%	94%	100%
89	2021, 5/16	920	900	1300	3120	356	349	463	1168	96%	94%	100%
96	2215, 5/10	950	900	1300	3150	368	349	463	1180	99%	94%	100%
99	1531, 5/11	900	900	1300	3100	349	349	463	1161	94%	94%	100%
101	0435, 5/19	950	900	1400	3250	368	349	499	1216	99%	94%	100%
139	0056, 5/9	900	900	1300	3100	349	349	463	1161	94%	94%	100%
156	0613, 5/14	880	850	1300	3030	341	329	463	1133	92%	89%	100%

ASSUMPTIONS:

Power Factor = 0.95
Unit Efficiency = 0.8 for Units #3 & #4
0.87 for Unit #5
Avg net head = 38.1 feet

NOTE: Powerhouse generation figures for 1999 are derived from the projects hourly averages. Generation figures for 2000 were taken from instantaneous video recording of the Projects analog gauges within the Project's powerhouse

Appendix 6: Summary of River Flows

Data from Charlemont Gage (#01168500)

Month	Long Term Average Flow (1913 - 1997)	1999 Average Monthly Flow		2000 Average Monthly Flow	
		cfs	(% of average)	cfs	(% of average)
April	1870	1121	60%	1456	78%
May	1141	628	55%	No Data	
June	636	250	39%	No Data	
July	443	361	81%	1354	306%
August	453	252	56%	1374	303%
September	482	660	137%	647	134%

Data from West Deerfield Gage (#01170000)

Month	Long Term Average Flow (1904 - 1997)	1999 Average Monthly Flow		2000 Average Monthly Flow	
		cfs	(% of average)	cfs	(% of average)
April	2956	1641	56%	2249	76%
May	1728	979	57%	1643	95%
June	926	365	39%	2045	221%
July	562	456	81%	1249	222%
August	556	299	54%	1918	345%
September	607	961	158%	877	144%

Note: Flow data for 2000 is provisional