REVIEW OF APPLICATION FOR RE-CERTIFICATION BY THE LOW IMPACT HYDROPOWER INSTITUTE OF THE DEERFIELD RIVER HYDROELECTRIC FACILITY, LIHI #90

Prepared by Patricia McIlvaine
February 26, 2021

I. INTRODUCTION

This report summarizes the review findings of the recertification application submitted by Great River Hydro LLC, (GRH) to the Low Impact Hydropower Institute (LIHI), for the Deerfield River Hydropower Project (the Project). The Project holds a Major License, P-2323, from the Federal Energy Regulatory Commission (FERC). The Deerfield River Project, LIHI #90, is located on the Deerfield River, a major tributary to the Connecticut River, in Bennington and Windham Counties in Vermont, and in Berkshire and Franklin Counties in Massachusetts. The Project consists of eight Developments: Somerset, Searsburg, Harriman, Sherman, Deerfield No. 5, Deerfield No. 4, Deerfield No. 3, and Deerfield No. 2 with a total installed capacity of 86 MW (see Figure 1). All developments operate in a peaking mode with either daily, weekly or seasonal storage. The Somerset development is a storage facility only.

The Project was first certified as low impact by LIHI on September 15, 2012, for an eight-year term, effective April 25, 2012 which expired on April 25, 2020. The Certification was extended to March 31, 2021. In 2012, the Project was owned by TransCanada Hydro Northeast Inc., which was converted to a limited liability company on April 7, 2017, becoming TransCanada Hydro Northeast LLC. On April 19, 2017, the Project was sold to Great River Hydro, LLC.

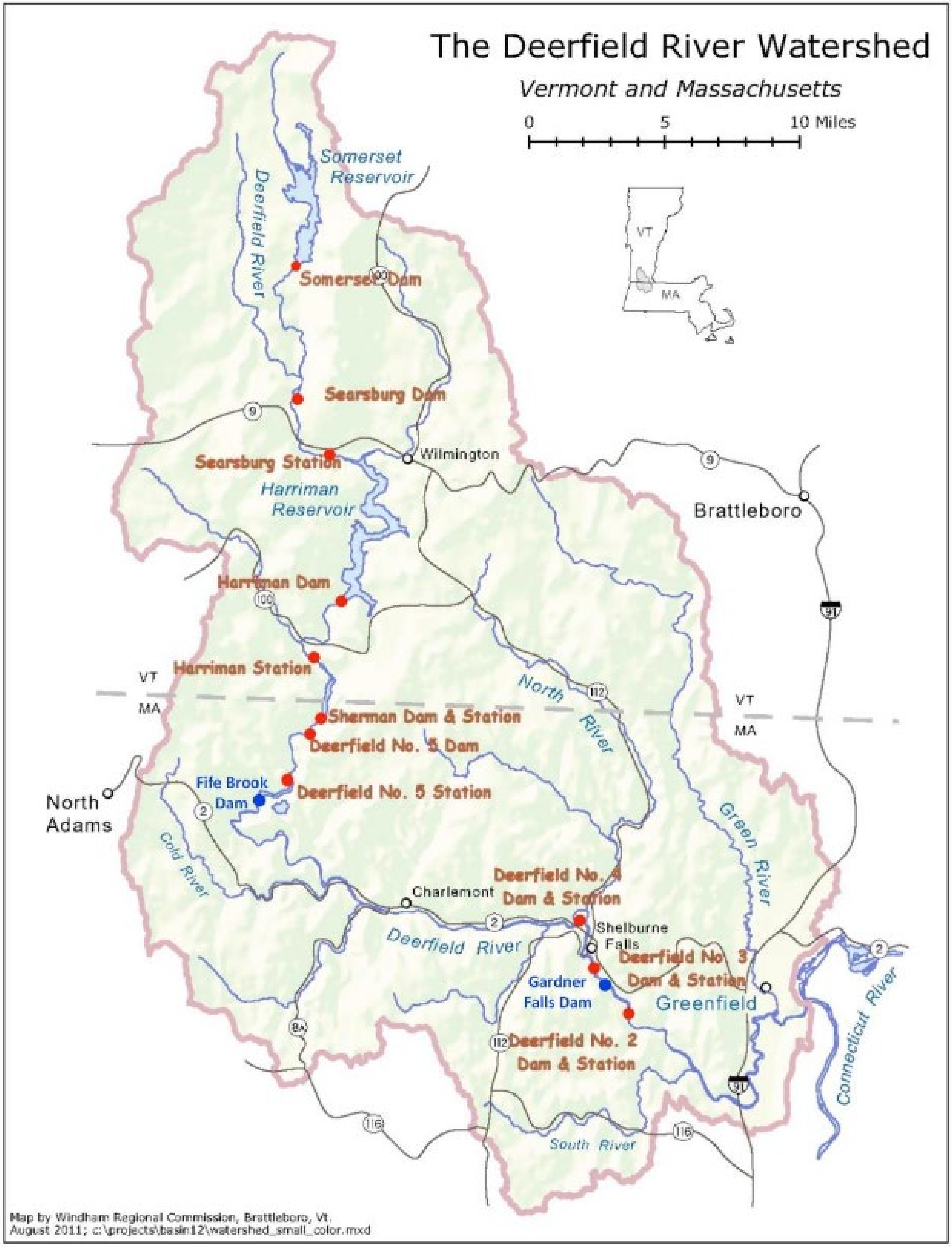

Figure 1 - Overview of Deerfield River Project Locations

The past reviewer's report can be found on the LIHI website[1]. The Project's 2012 certification had two conditions:

- Condition 1: If the U.S. Fish and Wildlife Service (USF&WS) or the State of Massachusetts requests upstream and/or downstream eel passage facilities at the Project, the Project owner shall so notify LIHI within 30 days and shall enter into, and provide LIHI with a copy of, an agreement reached among the Project owner, the USF&WS, and/or the State of Massachusetts to provide both interim (if requested by a Resource Agency) and permanent safe, timely, and effective passage for American eel. The Agreement must be finalized within 120 days of the request for passage and must include a description of the planned passage and protection measures and the implementation schedule for design, installation, and operations. The agreement shall be filed with LIHI within 30 days of its execution.

  As reported to LIHI in GRH's Compliance Statement and Condition Status Reports filed annually with LIHI, no such request has been made.

- Condition 2: If the State of Vermont requests modification of the Project or its operation at Harriman Dam to address temperature and/or dissolved oxygen concerns pursuant to Article 414 of the Project FERC license, the Project owner shall so notify LIHI within 30 days and shall enter into, and provide LIHI with a copy of, an agreement reached among the Project owner and the State of Vermont to address those concerns. The Agreement must be finalized within 120 days of the request for Project modification and must include a description of the planned measures and the implementation schedule for those measures. The agreement shall be filed with LIHI within 30 days of its execution.

  As reported to LIHI in GRH's Compliance Statement and Condition Status Reports filed annually with LIHI, no such request has been made.

See the *General Conclusions and Reviewer Recommendation* section of this report for discussion of these conditions.

[1] https://lowimpacthydro.org/wp-content/uploads/2020/07/FINAL-REV-9-05-2012-Deerfield-Reviewer-Report.pdf

II. RECERTIFICATION PROCESS AND MATERIAL CHANGE REVIEW

Under the current LIHI Handbook (Revision 2.04: April 1, 2020), recertification reviews are a two-phase process starting with a limited review of a completed LIHI application, focused on three questions:

(1) Is there any missing information from the application?
(2) Has there been a material change in the operation of the certified facility since the previous certificate term?
(3) Has there been a change in LIHI criteria since the Certificate was issued?

In accordance with the Recertification Standards, all Projects currently applying for renewal must go through a full review unless their most recent certification was completed using the 2016 version of the Handbook. Thus, this Stage II report was required for the Deerfield River Project.

A review of the initial application, dated July 2020, resulted in a Stage I or Intake Report, dated August 5, 2020. The Stage I report noted that data was missing for a number of criteria that was required to complete a full review, and several material changes have occurred since the last certification.

A revised application was submitted to LIHI in late November 2020. This updated LIHI application provided clear descriptions of this very complex Project, comprehensive discussion of activities and issues important to demonstrating compliance with each criterion, and all-inclusive linking of supporting documents. "Material changes" identified in the updated application included four license amendments associated with fish passage, flow and Environmental Enhancement Fund changes, and one amendment authorizing installation of a new turbine-generator unit in the existing minimum flow structure at Deerfield No. 5 (planned for Spring 2022 operation). These license amendments are summarized in report Section VI and further addressed under the applicable criteria. The following additional "material change" was identified by the Applicant which required approval, but not a license amendment, from FERC:

- In June 2018, the skimmer gate at Deerfield No. 2 was automated, providing remote operation from GRH's Renewable Operations Control Center in Wilder, Vermont, and significantly reducing average time to restore minimum flow when unforeseen outages occur. Prior to automation, operation of the gate required the dispatch, or after-hours call-in, of a mechanic to the site to manually adjust the gate.

While a physical change at the Project, the automation of this gate has a positive impact on the flow regime and ensuring license-required minimum flows are satisfied. This Stage II assessment reviewed the application package, public records in FERC's eLibrary since 2012, follow-up communication with the Applicant, compliance statements, stakeholder comments and other referenced reports.

III. PROJECT'S GEOGRAPHIC LOCATION

The Deerfield River is approximately 70 miles long, with the Deerfield Project encompassing about a 66-mile reach of the River, although some reaches are in other hydropower project boundaries. There are a total of 11 hydroelectric development dams, comprising three separate FERC licensed projects. The Deerfield Project consists of three developments in Vermont (Somerset, Searsburg, and Harriman) and five in Massachusetts (Sherman, Deerfield No. 5, Deerfield No. 4, Deerfield No. 3, and Deerfield No. 2) (see Figure 1). The first of the two other Projects not owned by the GRH, is the Fife Brook Dam, owned/operated by Bear Swamp Power Company (a subsidiary of Brookfield Renewable and Emera, Inc). It impounds the lower reservoir for the Bear Swamp Pumped Storage Project (FERC Project No. 2669). The Fife Brook dam is located between Deerfield No. 5 and Deerfield No. 4 developments, with the impoundment receiving Deerfield No. 5 outflow. The Bear Swamp/Fife Brook Project encompasses about 15.5 miles of the river. Central Rivers Power owns/operates the Gardner Falls Project (FERC Project No. 2234, LIHI #80), located between the Deerfield No. 3 and No. 2 Developments. It is operated as a peaking/daily storage facility and encompasses about 1.8 miles of the Deerfield River.

The Deerfield River mainstem and its tributaries can all be characterized as shallow, rapid flowing "flashy" mountain streams. The headwaters of the Deerfield River are in the Green Mountains in the southern part of Vermont. The lower (Massachusetts) river basin contains prominent features including rocky and stony hills and narrow steep-sided valleys. Most of the upper river basin is in the Green Mountains where land usage is primarily forest land. Agricultural land is mostly concentrated on the western border of the river basin but is also scattered throughout the Green Mountains where topography is level. The majority of the developed land is located in the valley areas and consists of small towns. The only major urbanized region in the lower river basin is Greenfield, Massachusetts located at the confluence of the Deerfield and Connecticut Rivers.

There are no dams upstream of the Somerset Development nor are there any dams on the Deerfield River downstream of the Deerfield No. 2 Development, although the Holyoke Hydroelectric Project, (FERC No. 2004, LIHI #89) is located downstream on the Connecticut River.

IV. PROJECT AND IMMEDIATE SITE CHARACTERISTICS

The entire Project has a total installed capacity of 86 MW. All dam and generation operations are controlled remotely from the Renewable Operations Control Center in Wilder, Vermont. The following summarizes each Development. The application includes photographs in addition to those here. A copy of a spreadsheet containing LIHI application required data for the Project is linked below[2]. The average annual generation values shown below are 2010-2019 values. The following descriptions are excerpted directly from the LIHI application.

In Vermont:

- Somerset – Reservoir and Dam (no hydropower generation)
- Searsburg – Reservoir, Dam, and Powerhouse (5 MW) - Annual generation 17,685 MWh
- Harriman – Reservoir, Dam, and Powerhouse (41 MW) – Annual generation 99,606 MWh

Somerset – The Somerset Development is located on the East Branch of the Deerfield River, and is the furthest upstream. It consists of a storage reservoir, dam, outlet works and spillway. This impoundment is operated as a seasonal storage facility. There are no power generating facilities. Somerset Reservoir is roughly 5.6 miles long and 1.1 miles across at its widest point, with a surface area of 1,514 acres, gross storage of 57,345 acre-feet, and 20,614 acre-feet of usable storage. The earth-fill dam is about 110 feet high and 2,101 feet long. Water can be conveyed from the reservoir at two locations. The main outlet works, located in the gatehouse at the eastern end of the dam has two gated 48-inch diameter pipes used to control reservoir discharge and minimum flow. In addition to the main outlet works, there is a side channel spillway with 3-foot flashboards located at the western end of the dam. The spillway channel is about 800 feet long, 45 feet wide, and from 6 to 30 feet deep. This spillway is used only for extreme flood events.

Figure 2 – Somerset Reservoir and Impoundment

Searsburg – The Searsburg Development is the first development on the mainstem of the Deerfield River, approximately 11 miles downstream of its headwaters, and is the point of confluence with the East Branch. The Searsburg Development is operated on a peaking, daily storage basis. It consists of an earth-fill dam and spillway, intake and penstock, powerhouse, and

[2] https://lowimpacthydro.org/lihi-certificate-90-deerfield-river-hydroelectric-project-vermont-and-massachusetts/

substation. Searsburg Reservoir is roughly 0.9 miles long and 0.16 miles across at its widest point. It has a surface area of 30 acres, 412 acre-feet of gross storage and 197 acre-feet of useable storage. Searsburg Dam is an earth-fill structure about 50 feet high and 475 feet long with a 137-foot-long concrete gravity spillway, penstock intake gate, and sluice gate which is located in the south abutment. Water is conveyed by either the overflow spillway, the 6-foot by 8-foot sluice gate, or the penstock, which leads to the powerhouse housing one vertical 5MW Francis unit. The intake facility includes a penstock intake gate with an 8-foot diameter wood stave conduit that runs 18,412 feet to a steel differential surge tank 50 feet in diameter and 34 feet high, and a steel penstock 6.5 feet in diameter and 495 feet long. Bond Brook, which enters the Deerfield River at RM 58.6, is diverted into the wood stave conduit.

Figure 3 - Searsburg Dam Gatehouse and Penstock

Figure 4 – Searsburg Powerhouse

Harriman – The Harriman Development is operated on a peaking, seasonal storage basis. The facility consists of a storage reservoir, an earth-fill dam, a "morning glory" spillway, intake, conveyance tunnel and penstocks, powerhouse, and substations. Harriman Reservoir is approximately 9 miles long and 0.78 mile across at its widest point and has a surface area of 2,039 acres. It has a maximum depth of 180 feet and a useable drawdown of 86 feet. It has 103,375 acre-feet of useable storage and 117,300 acre-feet of gross storage. Harriman Dam is an earth-fill dam 215.5 feet high and 1250 feet long. The "morning glory" spillway is normally equipped with 6 feet of flashboards. A 21.5-foot-high horseshoe shaped tunnel discharges water from the spillway to the downstream channel. There is also a 4-foot diameter pipe that leads from the original construction diversion tunnel to the morning glory spillway tunnel. In 1998 the outlet pipe was modified to hold a 14-inch diameter fixed cone discharge valve. This valve is used to discharge the minimum flows for the bypass.

The flow of water to the powerhouse intake is controlled by two 8-foot diameter valves. Water is conveyed through these valves to the powerhouse via a 12,812-foot long, 14-foot diameter concrete lined horseshoe shaped tunnel, a steel differential surge tank 34 feet in diameter and 184 feet high, and three steel 620-foot long, 9-foot diameter penstocks to three Francis units of 13.7 MW each.

Figure 5 – Harriman Morning Glory Spillway

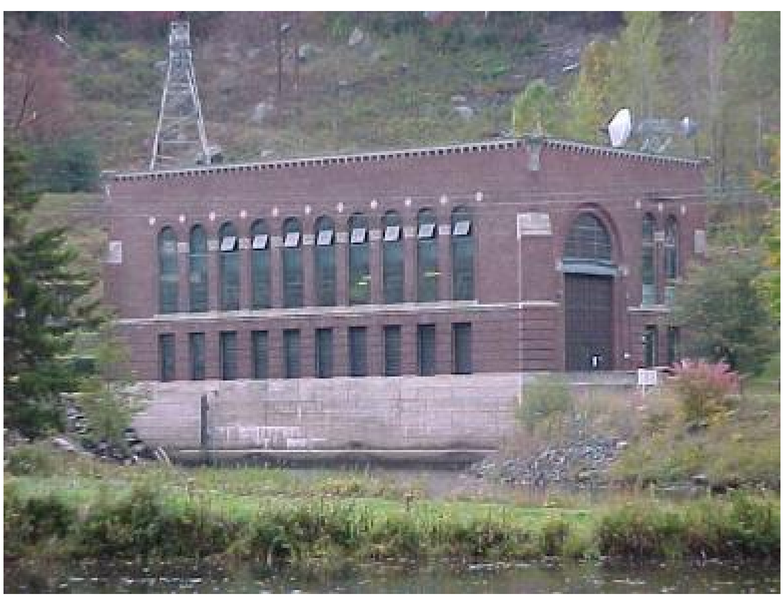

Figure 6 – Harriman Powerhouse

In Massachusetts:

- Sherman – Reservoir, Dam, and Powerhouse (6 MW) – Annual generation 28,596 MWh
- Deerfield No. 5 – Reservoir, Dam, Powerhouse, and Dunbar Brook Diversion Structure (14 MW) – Annual generation 53,534 MWh
- Deerfield No. 4 - Reservoir, Dam, and Powerhouse (6 MW) – Annual generation 15,876 MWh
- Deerfield No. 3 – Reservoir, Dam, and Powerhouse (7 MW) – Annual generation 25,239 MWh
- Deerfield No. 2 – Reservoir, Dam, and Powerhouse (7 MW) – Annual generation 19,740 MWh

Sherman – The Sherman Development is operated on a peaking, weekly storage basis. The facility consists of an earth-fill dam and spillway, intake and penstock, powerhouse, and substation. Sherman Reservoir is roughly 2 miles long and 0.25 miles across at its widest point with a surface area of 218 acres, 1359 acre-feet of useable storage and gross storage of 3593 acre-feet. The impoundment also formerly provided once-through cooling water for the now decommissioned Yankee Atomic Electric Power Company's Rowe Station. Sherman Dam is 110 feet high and 810 feet long with a 179-foot-long concrete gravity spillway and a concrete and brick intake structure. Four feet of flashboards are maintained on the spillway year-round. Water is conveyed from Sherman Reservoir either through spillage, or via the powerhouse intake. Water is conveyed to the powerhouse via a concrete conduit 98 feet in length with a cross-sectional area of 142 square feet, and a steel penstock 13 feet in diameter and 227 feet long. There are no diversion canals or tunnels. There is one vertical 6 MW Francis unit onsite.

Figure 7 – Sherman Dam and Spillway

Deerfield No. 5 – The Deerfield No. 5 Development is operated on a peaking, daily storage basis. The facility consists of two dams, a series of diversion tunnels, canals and penstocks, the powerhouse, and a substation. The impoundment is about 0.75-mile-long and 180 feet across at its widest point with a surface area of 38 acres, and gross storage of 118 acre-feet. It is comprised of a concrete gravity spillway 35 feet high and 90 feet long; a concrete intake structure that directs water to a minimum flow pipe; two low level sluices; and a power tunnel located in the west abutment. Water is conveyed from the impoundment by spillage, the minimum flow pipe, the sluice gates, or by the intake tunnel to the powerhouse. Hydraulically controlled steel flap gates are used to maintain normal reservoir elevation along the entire spillway crest. The control gates in the western abutment intake structure are composed of two 8-foot wide by 7.75-foot-high sluices and a single 12.5-foot by 13-foot intake gate. Two tunnels, two concrete conduits, and three canals crisscross River Road and total 14,941 feet in length. The Deerfield No. 5 tunnel/canal system includes a small concrete gravity diversion structure about 12 feet high and 160 feet long on Dunbar Brook which directs water from the impounded brook (approximately 0.1-mile long and 175 feet across) into the southernmost tunnel. Collectively, these structures convey water from the dam to a 400-foot long, 10-foot diameter steel penstock and then to the powerhouse.

Figure 8 – Deerfield No. 5 Dam

The powerhouse is a steel frame and concrete structure constructed in 1974. It replaced the original station which was removed when the Bear Swamp Pumped Storage Project (P-2669) was built. The powerhouse contains one vertical Francis unit with a capacity of 14 MW. The Dunbar Brook diversion structure was completely redesigned and reconstructed in 1993. Two gates control water level in the canals and can divert flow to the powerhouse or release water into the Deerfield River via Dunbar Brook.

Figure 9 – Deerfield No 5 Powerhouse

Deerfield No. 4 – The Deerfield No. 4 Development is operated on a peaking, daily storage basis. The facility consists of an earth-fill dam, spillway and sluice gates, intake and tunnel, forebay and penstocks, powerhouse, and substation. The impoundment is roughly 2 miles long and 500 feet across at its widest point, with a surface area of 75 acres, gross storage of 467 acre-feet and usable storage of 432 acre-feet. The dam is comprised of an earth-fill embankment (with a concrete core) approximately 50 feet high and 160 feet long, a 241-foot-long concrete gravity spillway, and three sluice gates located in the east abutment. The dam is equipped with flashboards ranging in height from 6 to 8 feet. Water is conveyed from the impoundment either by spillage or by sluice gates located in the eastern abutment. The intake gates include a 10-foot by 10-foot, an 8-foot by 10-foot and a single 10-foot by 14-foot surface sluice. In addition, a 6-foot by 12-foot surface sluice gate is located adjacent to, and downstream of, the power tunnel intake racks. This gate discharges into a 10-foot diameter vertical conduit which in turn, discharges into a 4-foot diameter pipe that

Figure 10 – Deerfield No. 4 Spillway **Figure 11 – Deerfield No. 4 Powerhouse**

discharges into the tailrace. It has an electric operator that is remotely controlled from the River Control Center and used to pass minimum flows and was formerly used for downstream fish passage. The power tunnel conveys water from the intake structure at the impoundment via a 12.5-foot diameter, 1,514-foot-long concrete and brick lined horseshoe shaped tunnel that leads to the powerhouse forebay. The earthen forebay has a 12,000 square foot surface area and a 35-foot depth. From the forebay, water is conveyed through three 10-foot diameter, 154-foot-long steel penstocks to the powerhouse. The powerhouse is a steel frame and brick structure constructed in 1913. It contains three horizontal Francis units each with a capacity of 2 MW.

Deerfield No. 3 – The Deerfield No. 3 Development is operated on a peaking, daily storage basis. The facility consists of a concrete gravity dam and sluice gates, intake, tunnel, forebay and penstocks, powerhouse, and substation.

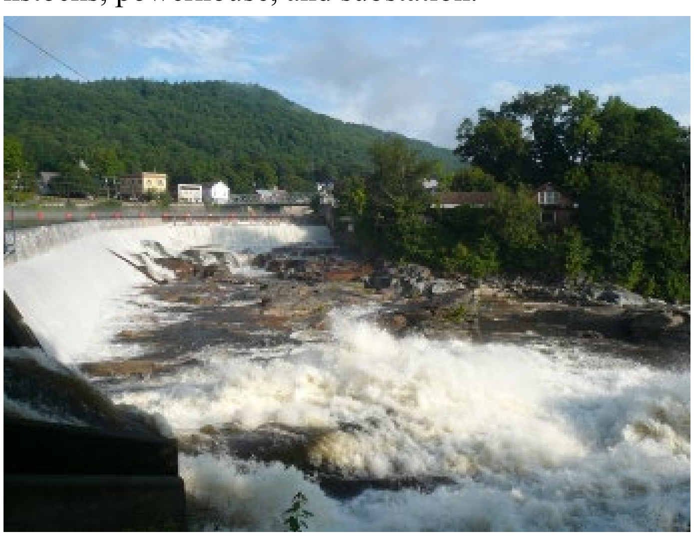

Figure 12 – Deerfield No. 3 Spillway

The impoundment is roughly 1.3 miles long and 300 feet across at its widest point with a surface area of 42 acres, 221 acre-feet of gross storage and 200 acre-feet of useable storage. The dam is composed of a concrete gravity spillway approximately 15 feet high and 475 feet long equipped with 6-foot flashboards, two sluice gates and a power tunnel intake located in the south abutment. The sluice gates in the south abutment include a 10-foot-wide surface sluice and an 8-foot-wide by 4-foot-high submerged sluice. A six-foot by 10-foot surface sluice gate, located adjacent to, and downstream of the power tunnel intake racks, discharges directly into the tailrace. This gate has an electric operator that is remotely controlled from the Renewable Operations Control Center and used to pass minimum flows and was formerly used for downstream fish passage. The power tunnel exiting the gated intake is a 677-foot long, 17-foot wide by 12.5-foot-high concrete conduit. It runs underground to an 880-foot long forebay from which water is conveyed via three 59-foot long, 10-foot diameter steel penstocks to the powerhouse. The powerhouse is a steel frame and brick structure built in 1912. It contains three horizontal Francis units each with a capacity of 2.3 MW. The tailwater for Deerfield No. 3 is formed by the headwaters of the Gardner's Falls Project impoundment (owned by Central Rivers Power, P-2334). The Deerfield No. 3 powerhouse discharges into an impounded section of the river even when Gardner's Falls is maintained at its lowest level.

Figure 13 – Deerfield No. 3 Powerhouse (forebay in the background)

Deerfield No. 2 – The Deerfield No. 2 Development is operated on a peaking, daily storage basis. The facility consists of a concrete gravity dam and sluice gates, an inflatable bladder, trip-able flashboards, intake and penstocks, powerhouse, and substation. The impoundment is roughly 1.5 miles long and 500 feet across at its widest point with a surface area of 63.5 acres, 550 acre-feet of gross storage and 500 acre-feet of useable storage. The dam consists of a concrete gravity spillway approximately 70 feet high and 447 feet long, with the inflatable bladder and trip-able flashboards, sluice gates and an integral powerhouse located at the western end of the spillway. Water can be conveyed from the impoundment by spillage, sluice gates, or through the powerhouse. Ten feet of trip-able flashboards on top of the spillway crest and the inflatable bladder (112 feet long by 10 feet high) are used to maintain normal impoundment elevation. When water is at the top of the bladder, it will deflate automatically if inflow exceeds the powerhouse discharge. The two surface sluices are each 10 feet wide. A six-foot by 16-foot surface sluice gate is located between the two 10-foot-wide sluices and the inflatable bladder. It discharges directly into the tailrace, downstream of the dam. This gate has an electric operator which is remotely controlled from the Renewable Operations Control Center and was formerly used for downstream fish passage.

Figure 14 – Deerfield No. 2 Powerhouse

The powerhouse, constructed in 1913, is integral to the Deerfield No. 2 Dam, and includes a gated intake structure with three steel 11-foot diameter by 35-foot long penstocks. The powerhouse contains three horizontal Francis units each with a capacity of 2.3 MW.

The following images show portions of the Deerfield River within the boundaries of non-GRH companies.

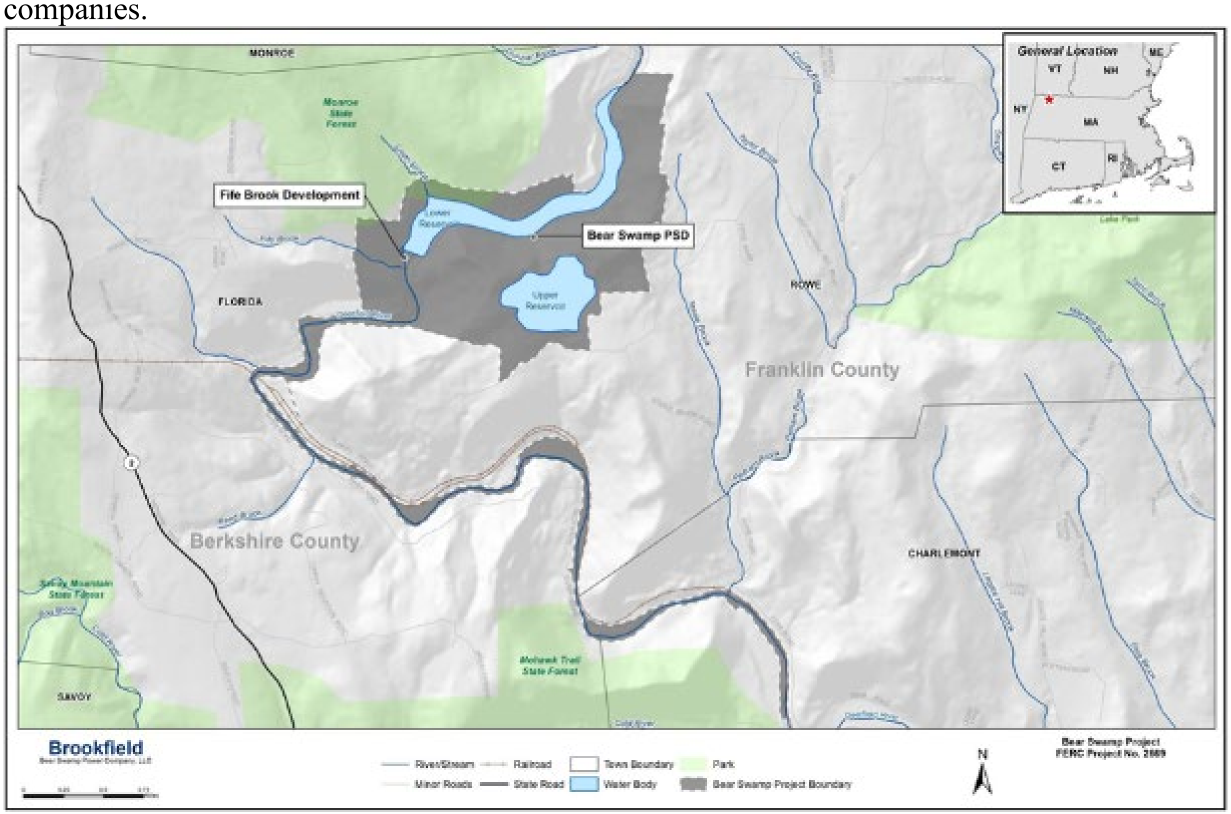

Figure 15 – The Bear Swamp/Fife Brook Project Boundaries[3]

[3] Taken from Bear Swamp LLC November 2017 draft license application.

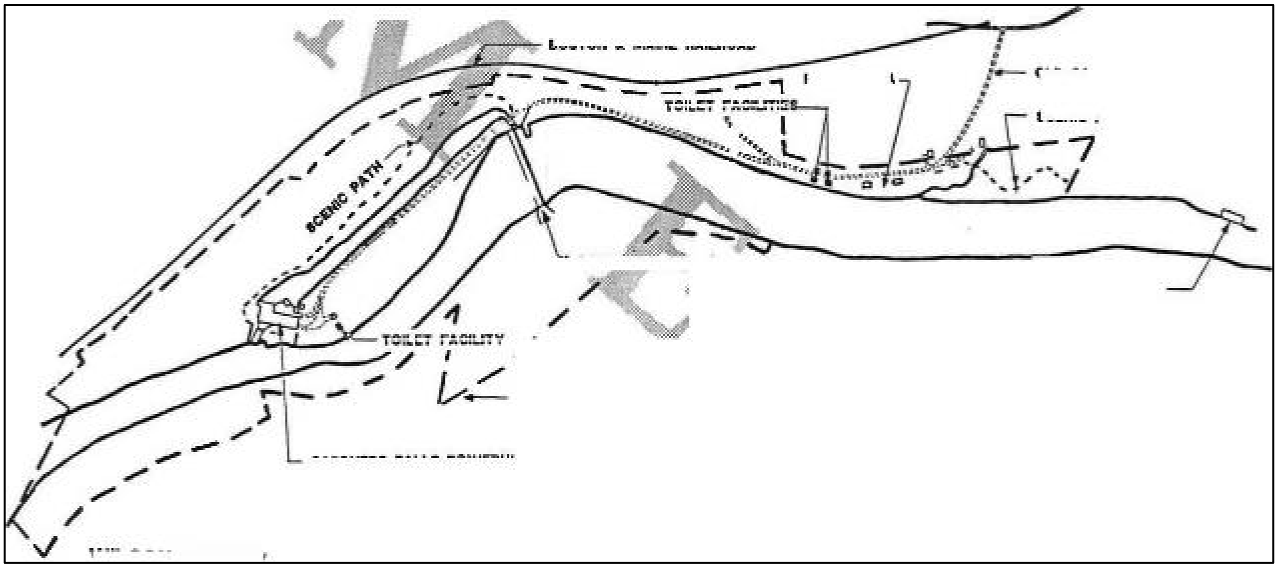

Figure 16 – Gardners Falls Project Boundaries along the Deerfield River[4]

V. ZONES OF EFFECT AND STANDARDS SELECTED

Twenty-two Zones of Effect (ZOE) were designated by the Applicant. Aerial photographs illustrating these ZOEs can be found in Appendix A.

- Zone 1 - Somerset impoundment – from RM 71.6 to the Somerset Dam (RM 66).
- Zone 2 - Somerset downstream reach – from the Somerset Dam (RM 66) to the Searsburg impoundment (RM 61.2).
- Zone 3 - Searsburg impoundment – from RM 61.2 to the Searsburg Dam (RM 60.3).
- Zone 4 - Searsburg bypassed reach – from the Searsburg Dam (RM 60.3) to the Searsburg Powerhouse (RM 56.8).
- Zone 5 - Searsburg downstream reach – from the Searsburg Powerhouse (RM 56.8) to the Harriman impoundment (RM 55.7).
- Zone 6 - Harriman impoundment - from RM 55.7 to the Harriman Dam (RM 48.5).
- Zone 7 - Harriman bypassed reach – from the Harriman Dam (RM 48.5) to the Sherman impoundment (RM 44.1).
- Zone 8 - Harriman tailrace - approximately 430 ft from the Harriman powerhouse to the confluence with the Deerfield River at the Sherman impoundment (RM 44.1).
- Zone 9 - Sherman impoundment - from RM 44.1 to the Sherman Dam (RM 42).
- Zone 10 – Sherman tailrace and Deerfield No. 5 impoundment - from the Sherman Dam (RM 42) to the Deerfield No. 5 dam (RM 41.2).
- Zone 11 - Deerfield No. 5 bypassed reach – from the Deerfield No. 5 dam (RM 41.2) to the Fife Brook impoundment (RM 38.5).
- Zone 12 - Deerfield No. 5 tailrace - within the upper end of the Fife Brook impoundment at the Deerfield No. 5 powerhouse (RM 38.5).
- Zone 13 - Dunbar Brook impoundment (about 400 ft long) - located along the Deerfield

[4] Taken from Central Rivers Power application to LIHI

No. 5 canal system.

- Zone 14 – Dunbar Brook downstream reach (about 0.2 RM long) – from the Dunbar Brook Diversion Structure to the brook's confluence with the Deerfield River at RM 40.

[The Bear Swamp Project, FERC No. 2669, owned by Bear Swamp Power Company LLC encompasses the Deerfield River from RM 38.5 to RM 23.]

- Zone 15 - Deerfield No. 4 impoundment - from RM 22 to the Deerfield No. 4 dam (RM 20).
- Zone 16 – Deerfield No. 4 bypassed reach – from the Deerfield No. 4 dam (RM 20) to the upper end of the Deerfield No. 3 impoundment and Deerfield No. 4 powerhouse (RM 18.5).
- Zone 17 – Deerfield No. 4 tailrace – within the upper end of the Deerfield No. 3 impoundment (RM18.5).
- Zone 18 - Deerfield No. 3 impoundment - from RM 18.5 to the Deerfield No. 3 dam (RM 17).
- Zone 19 – Deerfield No. 3 bypassed reach – from the Deerfield No. 3 dam (RM 17) to the Deerfield No. 3 powerhouse (RM 16.8).
- Zone 20 – Deerfield No. 3 tailrace – within the upper and of the Gardner Falls impoundment (RM 16.8).

  [The Gardner Falls Project, FERC No. 2234, LIHI Certificate No. 80, owned by Central Rivers Power MA, LLC encompasses the Deerfield River from RM 16.5 to RM 14.7.]

- Zone 21 - Deerfield No. 2 impoundment - from RM 14.7 to the Deerfield No. 2 dam and powerhouse (RM 13.2).
- Zone 22 – Deerfield No. 2 downstream reach – from the Deerfield No. 2 dam (RM 13.2) to the project boundary at RM 7.3.

The Standards identified in the final application for each ZOE are shown on the following table below. A PLUS standard was selected for all ZOEs for *Shoreline and Watershed Protection*. It should also be noted that the table in the Application shows a "2" for Ecological Flows for ZOE #10 Sherman tailrace/Deerfield No. 5 impoundment, however the detailed discussion of Ecological Flows shows this as "1" which I believe is more appropriate. Details of compliance with the criteria are presented in Section VIII.

	A	B	C	D	E	F	G	H
Zone No., Zone Name, and Standard Selected (including PLUS if selected)	**Ecological Flows**	**Water Quality**	**Upstream Fish Passage**	**Downstream Fish Passage**	**Shoreline and Watershed Protection**	**Threatened and Endangered Species**	**Cultural and Historic Resources**	**Recreational Resources**
1: Somerset impoundment	1	2	1	1	2+	4	2	2
2: Somerset downstream reach	2	2	1	1	2+	1	2	2
3: Searsburg impoundment	1	2	1	1	2+	1	2	2
4: Searsburg bypassed reach	2	2	1	1	2+	1	2	2
5: Searsburg downstream reach	2	2	1	1	2+	4	2	2
6: Harriman impoundment	1	2	1	1	2+	4	2	2
7: Harriman bypassed reach	2	2	1	1	2+	4	2	2
8: Harriman tailrace	2	2	1	1	2+	1	2	2
9: Sherman impoundment	1	2	1	1	2+	4	2	2
10: Sherman tailrace and Deerfield No. 5 impoundment	~~2~~ (1)	2	1	1	2+	1	2	2
11: Deerfield No. 5 bypassed reach	2	2	1	1	2+	4	2	2
12: Deerfield No. 5 tailrace	2	2	1	1	2+	1	2	2
13: Dunbar Brook impoundment	1	2	1	1	2+	1	2	2
14: Dunbar Brook downstream reach	2	2	1	1	2+	1	2	2
15: Deerfield No. 4 impoundment	1	2	1	2	2+	4	2	2
16: Deerfield No. 4 bypassed reach	2	2	1	1	2+	1	2	2
17: Deerfield No. 4 tailrace	2	2	1	1	2+	1	2	2
18: Deerfield No. 3 impoundment	1	2	1	2	2+	1	2	2
19: Deerfield No. 3 bypassed reach	2	2	1	1	2+	1	2	2
20: Deerfield No. 3 tailrace	2	2	1	1	2+	1	2	2
21: Deerfield No. 2 impoundment	1	2	1	2	2+	4	2	2
22: Deerfield No. 2 downstream reach	2	2	2	1	2+	1	2	2

VI. REGULATORY AND COMPLIANCE STATUS

Copies of the FERC license, amendments (since 2012) and Water Quality Certifications (WQC) referenced below are contained or linked in the LIHI application.

The current 1997 FERC license for the Deerfield River Project was one of the first to adopt terms and conditions applicable to the entire Project, stipulated in a multi-stakeholder, comprehensive Settlement Agreement (SA), filed October 5, 1994[5]. A five-year cooperative consultation process involving state and federal resource agencies, numerous local, regional, and national non-governmental organizations (see table below), and the licensee (at that time New England Power Company) resulted in settlement by the parties. This negotiation process involved examination of the power and non-power tradeoffs and effects of a wide variety of operational scenarios. The SA resulted in a balancing of these issues, and specifies terms relating to minimum flows, fisheries, fish passage, wildlife and botanical resources, water quality, project lands management and control, recreation, and aesthetic resources. The FERC license conditions for the Project consist of the operational and environmental measures defined by the SA. As noted in the original Reviewer's Report, under the terms of the SA, modifications to its terms by FERC in its final license would automatically modify the SA unless any party to the SA objected. FERC did make some changes, and none of the parties objected. The Vermont Agency of Natural Resources was not a party to the SA but did file a WQC.

Signatories to the Settlement Agreement

Federal Agencies	National Park Service
	U.S. Environmental Protection Agency
	United States Fish and Wildlife Service
State Agencies	Massachusetts Division of Fisheries and Wildlife
Non-Governmental Organizations (NGOs)	American Rivers, Inc.
	American Whitewater
	Appalachian Mountain Club
	Conservation Law Foundation
	Deerfield River Compact
	Deerfield River Watershed Association
	New England FLOW
	Trout Unlimited

FERC issued the license on April 4. 1997 with an expiration date of March 31, 2037. Two early amendments, on February 1, 1999 amending Article 404, and on June 6, 2001 amending Article 2, were issued along with the following ones, which were issued since the Project was originally certified by LIHI in 2012. These are further addressed under the applicable criteria.

- On June 22, 2015, FERC issued an order suspending license Articles 409, 410, 411, and

[5] Settlement Agreement

413. These Articles required the Licensee to implement requirements for upstream passage of Atlantic Salmon at the Deerfield No. 2 development (Articles 409 and 410) and monitor effectiveness of both upstream and downstream passage modifications (Article 411). This was in response to the owner notifying FERC, on March 31, 2015, of USF&WS' announcement that they discontinued the Atlantic Salmon stocking program. The owner consulted with both the USF&WS and Massachusetts Division of Fisheries and Wildlife (MDF&W) on this issue and received concurrence documented in a March 31, 2015 filing with FERC.

- On January 5, 2016, FERC issued an order approving an amendment to the Deerfield River Environmental Enhancement Fund (DREEF). The amended terms of the DREEF modernized the investments to a diversified investment strategy and the disbursement calculation that reflects a total return approach that aligns with the type of investment returns produced by a diversified portfolio.

- On March 24, 2016, FERC issued an order (and errata notice) suspending license Article 408. Article 408 required the Licensee to implement a plan to provide downstream fish passage facilities for out-migrating Atlantic salmon smolts at the Deerfield No. 4, Deerfield No. 3, and Deerfield No. 2 Developments. This was in response to the owner's March 2, 2016, March 3, 2016 and March 18, 2016 letters notifying FERC of the USF&WS announcement that they discontinued the Atlantic Salmon stocking program and notification from the Connecticut River Atlantic Salmon Commission (CRASC) that restoration efforts were terminated. These FERC filings noted the concurrence from USF&WS and MDF&W with the owner's request to suspend passage requirements. With the suspension of this Article, structural modifications, including an angled bar rack system at Deerfield No. 3, were removed and seasonal operating constraints lifted.

- On May 18, 2017, FERC issued an order amending license Articles 401, 402, 403, 406, and the Vermont Flow Monitoring and Reservoir Operations Plan. The owner filed an amendment request to address requests from the Vermont Agency of Natural Resources (VANR) and the Vermont Division of Fish and Wildlife (VDF&W) to allow the water elevation and timing changes to benefit loon nesting. The approved changes align operational and reporting requirements at the Somerset Development and avoid a periodic conflict between the flow and elevation requirements at Somerset and the downstream Searsburg Development. Specifically, the approved changes involve: (1) the date at which water level management by gates at Somerset Dam would begin, (2) the date at which collection of stage and outflow data at the Somerset Reservoir to the agencies would begin, (3) the date at which the default maximum ramping rate may be suspended to achieve the target reservoir elevation, and (4) the date at which management of fluctuations in reservoir elevations within +/- 3 inches would begin.

- On August 6, 2019, FERC issued an order amending the license for installation of a new turbine-generator unit in the existing minimum flow structure located at Deerfield No. 5. All work associated with the replacement of the orifice plate with the turbine will occur within the existing footprint of the Deerfield No. 5 dam, intake structure, and service building. The turbine unit will be lowered into the existing minimum flow pipe, without any need for instream work. The addition of ancillary equipment will also occur within the footprint of the previously reconstructed dam and related structures. The turbine has a rated capacity of 230 kW, a hydraulic capacity ranging from 76.5 to 88 cfs, depending upon net head conditions, and is expected to produce approximately 1,270,000 kilowatt-hours each year. Installation and use of the new turbine will not result in any changes to Project operation or minimum flow releases. To address possible stakeholder concerns, meetings were held and attended by the following stakeholders. Attendees and questions raised were:

- USF&WS – possible increase in entrainment
- Massachusetts Department of Environmental Protection (MDEP) – attended meeting to confirm no project changes that might impact water quality
- MDF&W – attended meeting but had no concerns
- Connecticut River Conservancy (CRC) – was uncertain the new unit would modify flow in such a way as to potentially affect minimum flows below the Bear Swamp Project's Fife Brook dam which was undergoing re-licensing (which it would not).

Based on continued consultation with these stakeholders, all determined their concerns were addressed and provided waivers from the need for further consultation. The MDEP did not require a 401 WQC as no work would be done in the river and no changes in flow or water quality was anticipated. This project is expected to be operational in the spring of 2022.

The MDEP issued a WQC on December 14, 1994, for the five developments located in Massachusetts, and the VANR issued one for the three Vermont developments on January 30, 1995. Both largely coincide with the terms of the SA and are included as appendices to the 1997 FERC license. The FERC license included all the conditions of both WQCs except the following:

- Massachusetts' right to approve any modification of Project operation that would affect the state's certification conditions
- Massachusetts' right to review and modify conditions if the Vermont certification (or changes therein) result in noncompliance with the Massachusetts WQC
- Vermont's right to review and approve any changes to the Project that would have a significant or material effect on the certification
- Vermont's right to review and approve any proposals for Project maintenance or repair work involving the river

FERC deemed these requirements either violated Clean Water Act provisions designating FERC as the agency that determines whether proposed license amendments require a new water quality certification or violated FERC's authority to control activities under a federal license.

Appendix B-6.2 of the LIHI application included an email from VANR dated October 8, 2020, stating the WQC issued July 30, 1995 remains valid. Continued validity of the MDEP WQC is evidenced by MDEP's statement in 2018 that the new turbine installation at Deerfield No. 5 would not require an amended WQC.

Twenty-four deviations from FERC license flow-related requirements (minimum flows, headpond elevation, or impoundment ramping rate deviations) occurred since 2012, as identified in the application and from review of FERC's eLibrary. Two of the minimum flow reductions were planned events. The deviations are listed in Appendix B, with a summary discussion under the *Ecological Flow Regimes* criterion. Only one, a minimum flow deviation that occurred on June 16, 2015, associated with Deerfield No. 4 and No. 3 developments, was determined to be a violation by FERC. FERC determined that operator misinterpretation of an alarm, believing the downstream fish passage flow requirement triggered the alarm and not the minimum flow requirement, caused the deviation from the minimum flow requirements. The owner implemented a number of corrective actions to minimize future re-occurrence of such an error.

The most recent Somerset impoundment lower-level deviation in August 2020 was not identified in the application but was available on FERC eLibrary. This deviation was allowed with endorsement from VANR to help ensure safe fledging of baby loons on nests on the Somerset impoundment. I believe that twenty-four deviations over an eight-year period, at eight developments, with all except one being outside of the control of the owner, demonstrates noteworthy attention to regulatory compliance.

VII. PUBLIC COMMENT RECEIVED OR SOLICITED BY LIHI

The deadline for submission of comments on the LIHI recertification application was January 29, 2021. The following stakeholders issued comments, which are contained in Appendix C.

- Trout Unlimited Connecticut River Valley Chapter (TUCRV)
- MDF&W
- VDF&W
- CRC

The table below lists the issues they identified which I believe are related to LIHI review and are discussed under the applicable criteria. Some comment letters included other questions which I believe are unrelated to my review and therefore are not addressed in this report.

Topic	Criteria	Stakeholders			
		TUCRV	MDF&W	VDF&W	CRC
Reservoir drawdowns impacting littoral communities	A			X	
Long bypasses with minimum flows that meet water quality standards but are fluctuating, not natural flow regimes	A		X	X	X
Dunbar Brook downstream reach has no flows except when spilling	A				X
Impact to trout spawning (below Fife Brook dam) from dewatering if redds established during greater base flows	A		X		
Reduced value of minimum flows due to water losses in bypass as a result of peaking flow fluctuations	A				X
Deoxygenated areas of Somerset and Harriman reservoirs are contributing to	B			X	X

elevated mercury in fish tissue					
VT water quality standards now include water fluctuation criteria not existing at time of WQC	B			X	
Cold water below dams below state standards	B	X			X
No fish passage for native fish species or eels	C & D	X	X	X	
Modifications to enhancement fund amount and participation	E	X			X
Suggested enhancements to improve public use of recreational facilities	H				X

Agency outreach via email was made to the following agencies regarding upstream fish passage at the Searsburg Development:

- Vermont Department of Environmental Conservation - Jeff Crocker, Supervising River Ecologist
- Vermont Division of Fish and Wildlife - Lael Will, Fisheries Biologist

Only J. Crocker responded. His response is included in Appendix C and incorporated into the *Upstream Fish Passage* criterion discussion.

It is important to note that many of the concerns raised by the stakeholders address what they suggest are not indicative of "low impact". LIHI's criteria and standards were designed with significant stakeholder input, expressly to meet the criteria and support the criteria goals of what would constitute "low impact". It is my interpretation of the LIHI Handbook, that by complying with the existing and still current agency recommendations (i.e. WQC and license requirements), and complying with the LIHI Handbook "supporting technical basis" requirements, that a Project is satisfying LIHI's requirements for "low impact" certification, despite the fact that there may be real or perceived impact. That is, LIHI's certification only requires a project to be "low impact", not "no impact". Also, both WQCs have re-opener clauses that would allow the respective agencies to request a re-opening of the FERC license, if it was found that license modifications are required to ensure compliance with the specific state water quality standards. The WQCs include requirements that affect multiple criteria, including flows, water quality and fish passage. If either state felt existing requirements are no longer appropriate, they could issue such a request. To date, no such request has been made. My discussions below identify where this "no impact" versus "low impact" dichotomy exists which would require data beyond what is currently available to address.

Finally, I often reference the Final Environmental Impact Statement (FEIS) issued by FERC during the licensing proceedings resulting in the 1997 license, and especially the VT WQC. They include a significant amount of documentation that either discuss the scientific studies performed which support current license and WQC requirements or discuss the rationale by which certain requirements were established by the applicable agencies. The MA WQC does not provide the same level of backup information. However, all three are linked below[6]. I have identified the

[6] https://lowimpacthydro.org/wp-content/uploads/2021/02/01-30-95-DFLD-VT-WQ-Certification.pdf
https://lowimpacthydro.org/wp-content/uploads/2021/02/12-14-94-DFLD-MA-WQ-Certification.pdf

page(s) which include the information I believe support my assessment in the specific criteria discussions.

VIII. DETAILED CRITERIA REVIEW

A. ECOLOGICAL FLOW REGIMES

Goal: The flow regimes in riverine reaches that are affected by the facility support habitat and other conditions suitable for healthy fish and wildlife resources.

Assessment of Criterion Passage

The applicant selected A-1 **Not Applicable/De Minimis Effect** for the nine impoundments, as allowed for by the LIHI Handbook and **A-2 – Agency Recommendation** for the thirteen tailrace, downstream and bypass reaches. However, as the impoundments do have agency water-management requirements, compliance with these are briefly discussed below. Since initial LIHI certification, there has been only one water-management related change, approved by FERC on May 18, 2017, which changed the target elevation level at the Somerset Development impoundment to align with optimal loon nesting habitat. This modification was requested by VANR and VDF&W. All developments operate in a peaking mode with either daily, weekly or seasonal storage. The overall flow regime of the Deerfield River can be generally characterized as having regular flow and stage fluctuations driven by the authorized peaking operation[7]. Constructed between 1911 and 1927, the Deerfield Project has provided for managed flows along the Deerfield River for nearly a century.

Management of the developments is described in the Vermont Flow Monitoring and Reservoir Operations Plan ("Vermont Plan") filed December 10, 1997, approved July 16, 1999, revised April 10, 2017, and approved May 18, 2017 and the Massachusetts Minimum Flow Plan ("Massachusetts Plan") filed December 10, 1997 and approved July 16, 1999. The monitoring plans were prepared in consultation with the VANR, VDF&W, MDF&W, and USF&WS. The purpose of the plans is to ensure operation of the developments is in compliance with the FERC license and as a result, protection of the fishery resources and water quality of the Deerfield River.

The Deerfield River has been a working river for many years, and prior to the Settlement Agreement and issuance of the current license and WQCs, fisheries populations in the river were strained, in large part due to the lack of flows in many of the river reaches below the reservoirs. A key environmental benefit from the settlement negotiations was the agreement to release minimum flows for these reaches that would be set by the state agencies, but which would also allow for compliance with standards for aquatic biota of the reservoirs. When the WQCs were being written, agencies included review of field studies and agency-conducted analysis that would support state water quality standards including both chemical and biological factors for the impoundments and downstream reaches. The Settlement Agreement also required implementation of a program of wildlife enhancements to protect and enhance the wildlife resources affected by the Project, such

https://lowimpacthydro.org/wp-content/uploads/2021/02/FERC_Final_EIS_1996.pdf

[7] The MDF&W comment letter includes recent hydrographs near the USGS gage at Charlemont, MA. See Appendix C.

as maintenance of active beaver flowages and construction of bird nesting structures. Measures employed to support fish and wildlife populations at the impoundments which were established via the Settlement Agreement include:

- stable (or rising) reservoir management requirements which are stipulated for the benefit of littoral spawning where applicable,
- management of the reservoir level at Harriman to support rainbow smelt and small mouth bass spawning and early life stages,
- access to stream habitat for smelt below Searsburg Station,
- construction, maintenance and reporting on loon nesting platforms, and
- impoundment level management for loon nesting protection on the Somerset reservoir

Based on follow-up communications with GRH, while nesting platforms for osprey and nest boxes for wood and black ducks (under license Article 420) were incorporated into the Nesting Plan developed for the Project, their value was questioned and consultation with state wildlife officials resulted in a recommendation to examine whether or not they made sense. The concern agency biologists expressed was that there was plenty of natural habitat that did not need to be augmented, and artificial nests that are installed, due to lack of nesting habitat, tend to be prone to predation. As a result, none were ever recommended or installed. This decision was consistent with the Nesting Plan and therefore, no FERC approval or license amendment was required.

License Article 421, which addressed a possible need for beaver management activities, was incorporated into the existing Forestry Management Plan, required by license Article 422 and approved by FERC. Beaver habitat management would be a consideration when, and if, forestry operations are conducted in the vicinity of those wetlands. Timber management in the vicinity of these wetlands is limited due to access, poor site index (a measure of management response and value to silvicultural prescriptions), and the areas managed are mature beech woods, which are preferred bear habitat. Most of these areas have not be timbered, and the beaver habitat has expanded and continues on its own, absent the need for any active management.

The FERC Environmental and Safety Inspection Reports always examine consistency with environmentally related license articles. The most current inspection report did not indicate that any action is needed for these items.

Impoundment fishery management has historically and continues to rely heavily upon state stocking programs. Sport-fishing on the impoundments is a valuable industry to the local economy.

Water Management at the Impoundments

The Project includes eight main stem impoundments and a small impoundment on Dunbar Brook (ZOE#13) associated with the Deerfield No. 5 Development. The Deerfield No. 5 impoundment and the Sherman tailrace (ZOE#10) are treated as a single reach due to the limited impoundment fluctuation and short length.

The Somerset impoundment (ZOE#1), which has no generation, is the largest reservoir, having a storage capacity of 20,614 acre-feet, and is operated as seasonal storage. It has mandated fluctuation restrictions and elevation limits and is additionally managed for common loon nesting and aquatic biota, as well as summer recreation. Somerset reservoir is drawn down in winter to augment downstream flows and create storage capacity for spring runoff and snowmelt. Somerset is the only reservoir with specified ramping rates, namely:

- Increases are limited to 100 cfs or less over 24 hours from August 1 and April 30,
- Decreases are limited to 50 cfs over 24 hours from August 1 and April 30, and
- Maximum gate release of 312 cfs or instantaneous in-flow.

Somerset's specific elevation limits are

- August – November 1st: shall not fall below 2,120 feet msl
- November 2 – April 30th: shall not fall below 2,107 feet msl
- May 15 – July 31st: shall limit fluctuations to +/- 3 inches, and not draw down below 2,128.23 feet msl

Somerset's normal fluctuation range is about five feet, between 2125 feet msl and 2130 feet msl. As noted above, in winter it can be drawdown as much as 23 feet from its normal high elevation of 2130 feet msl to 2107 feet msl.

The other two larger storage reservoirs (Harriman, and Sherman) provide weekly and seasonal storage capacity, and are managed through minimum flow requirements of the upstream developments with seasonal reservoir elevation limits that regulate drawdowns, regulated minimum flow release (at Harriman), and regulated outflow dependent on inflow. Both also have generation. The impoundment elevation limits for Harriman are noted below. There are no limits for the Sherman reservoir.

Harriman

- April 1 – November 1st: shall not fall below 1,475 feet msl
- November 2 – March 31st: shall not fall below 1,440 feet msl
- April 1 – June 15th: maintain rising or stable water levels
- June 16 – July 15th: shall limit maximum drawdown to 1 foot/day

The Harriman impoundment functions as a seasonal storage reservoir that captures spring runoff and fall rains and releases the captured water to augment downstream flows during the summer and winter dry periods. Minimum flows are released through a low-flow valve at the base of the intake tower into the lower portion of the spillway tunnel that exits at the base of the earthen dam into the 4.4-mile-long bypassed reach which also receives flows from the West Branch of the Deerfield River. Typically, the impoundment fluctuates about eight feet in summer between 1483 feet msl and 1491 feet msl, and as much as 51 feet, between 1440 feet msl and 1491 feet msl in winter when the water is drawn down to capture snow melt and spring runoff/precipitation.

The Sherman Development, with usable storage of 3,593 acre-feet, is operated to modulate river flows downstream using weekly impoundment storage. There are no regulatory elevation level limits, but normal elevations are noted as 1103.66 feet msl and 1107.66 feet msl, a 4-foot change. Sherman reservoir is supplied by regulated releases from the Harriman Development and from unregulated flows entering the Deerfield River from its West and South Branches, as well as Tower

Brook and Wheeler Brook. The Sherman powerhouse discharges directly into the Deerfield No. 5 impoundment, which backwaters to the base of the Sherman powerhouse. Sherman has no specified instantaneous minimum flow requirement but due to the limited storage in the Deerfield No. 5 impoundment and its minimum flow requirement, Sherman operates frequently in order to provide downstream minimum flow for the Deerfield No. 5 Development and inflow to the downstream Fife Brook station (owned by Bear Swamp Power Company).

The small impoundments (Searsburg, Deerfield No. 5 including Dunbar Brook, Deerfield No. 4, Deerfield No. 3, and Deerfield No. 2), each have less than 500 acre-feet of usable storage, that provide daily storage capacity, are managed through minimum flow requirements of upstream developments, have reservoir elevation limits, minimum flow limits and regulated outflow dependent on inflow.

Searsburg minimum flows are discharged to a bypassed reach through a sluice gate or over the fixed elevation concrete crest and provide flows to the downstream Searsburg station by means of a wood stave conduit 8 feet (ft) in diameter and 18,412 ft long. Searsburg reservoir elevation limits are below. The application notes these limits as the typical operating elevations and fluctuation range.

- May 1 – October 31st: shall not be drawn down below 3 feet below the crest of the dam, below elevation 1,749.66 feet msl, or exceed 1,755.66 feet msl
- November 1 – April 30th: shall not be drawn down below 1,746.66 feet msl

The Deerfield No. 5 Development has a small impoundment with direct hydraulic connectivity to a series of canals and tunnels that collectively provide limited, daily operating storage above the powerhouse. Water flows through the impoundment to a concrete intake structure, which directs water to a minimum flow pipe, two low level sluices, and a 3-mile-long power tunnel-canal system to the powerhouse, bypassing the river. Water to the bypassed reach is conveyed by the minimum flow pipe or alternatively by the two sub-gates or two spillway flap gates.

The Dunbar Brook diversion structure is located within the Deerfield No. 5 Development immediately above the confluence of Dunbar Brook and the bypassed reach. The concrete structure is located at the downstream end of Deerfield No. 5's Canal #1, which runs parallel to the bypassed reach. The Dunbar Brook diversion is an integral part of the canal/tunnel system, and creates a small, 1-acre pool for the purpose of passively providing water into the canal system when available. Overflow that is not needed or capable of diversion into the canal is spilled over a concrete crest into the Deerfield No. 5 bypassed reach downstream of the structure. There are no specific operational requirements for this impoundment in the license. As discussed in greater detail on page 31 of this report, water is not typically stored behind the Dunbar Brook structure. but instead is only filled when needed to prevent overfilling of the canal/tunnel system which could potentially breach the canal wall.

Deerfield Nos. 4, 3, and 2 Developments are closely aligned in operation because the impoundments hold little storage and flows from each upstream development are necessary to maintain operating and minimum flows at the next downstream development. Inflows to these developments is provided from Deerfield No. 5's discharge passing through the Fife Brook

Development (lower impoundment) of the Bear Swamp Pumped Storage Project (owned by Bear Swamp Power Company).[8] Water from Deerfield No. 4 impoundment is used for minimum flow and daily cycle generation. Flows in excess of the station capacity and required minimum flow are spilled at the dam through either three manually operated sluice gates or over the spillway crest into the 1.5-mile-long bypassed reach. Water from the Deerfield No. 4 impoundment is diverted to the Deerfield No. 4 Station via a concrete and brick lined horseshoe-shaped tunnel to an earthen forebay before passing through the station and back into a free-flowing stretch of river.

The Deerfield No. 3 Development is operated in a coordinated manner with Deerfield No. 4. Flow into the Deerfield No. 3 impoundment is from Deerfield No. 4 station discharge, the bypassed minimum flow, and unregulated inflow primarily from the North River, which enters the bypassed reach of the Deerfield River just below Deerfield No. 4 dam. Like the Deerfield No. 4 impoundment, Deerfield No. 3 operates on a daily cycle using minimal reservoir storage that is replenished by inflow. Flow in excess of station capacity and the required minimum flow are spilled through one of two sluice gates or over the dam crest into the bypassed reach. At the dam, water is diverted via a concrete conduit to an 880-foot-long earthen forebay before passing through the station and into a section of the Deerfield River that is impounded by the Gardner Falls Project (Central Rivers Power).

The Deerfield No. 2 Development is operated in a coordinated manner with Deerfield No. 3. It operates on a daily cycle using reservoir storage that is replenished from inflow. A portion of the storage is also used to pass the guaranteed minimum flow requirement that is significantly greater than the Deerfield No. 3, Deerfield No. 4, and Gardner Falls minimum flow requirements. Flows in excess of the station capacity are spilled. Minimum flow is typically provided by unit discharge as there is no bypassed reach associated with this development.

Based on data provided in the application and review of FERC eLibrary records, there were nine headpond elevation deviations and one exceedance of the ramping rate limit at Somerset reservoir associated with the impoundments. None were considered violations by FERC as the causes of the deviations were beyond the owner's control. (See Appendix B.)

Comments and Assessment - Impoundments

A comment raised by CRC was that the LIHI application did not discuss how impoundment water management was developed to support fisheries and wildlife, which GRH subsequently provided. I believe the information included above demonstrates that the water management requirements established through the Settlement Agreement and WQC included consideration of what would be supportive of fishery and wildlife resources determined to be important at that time. Also, the VT WQC (pages 24–31) discusses the species of concern and their expected ability to survive in the impoundments, and the reservoir discussions on pages 34-35, 37, and 42-46, identify the management goals for the three impoundments in Vermont used in developing the VT WQC conditions. The FERC FEIS on pages 4-6 through 4-34 discusses the finding relative to impacts to fisheries of all of the Project reservoirs, as well as discussions of the technical study findings for all Project tailraces and bypasses. The MA WQC did not address this issue in detail.

[8] As discussed later in this report, water from the Bear Swamp upper reservoir is used to supplement the minimum flow requirements at Fife Brook, which are greater than those required at Deerfield No. 5.

VDF&W commented that regular drawdowns of the impoundments are negatively impacting littoral vegetative and macroinvertebrate communities. Based on data provided by GRH, there are few if any such shallow riparian shorelines at Harriman due to the steepness and rocky nature of the shorelines. Wetlands were evaluated at Somerset and a number of adjacent large wetlands are unaffected by reservoir drawdowns. They exist year-round yet lie immediately adjacent to the main body of water. In addition, the areas that were identified as large beaver meadows and ponds in the adjacent woodlands continue today and are noted to be expanding naturally without any intervention.

I believe it is important to note that the seasonal winter drawdowns provide much needed water to sustain downstream flows in the river and ensure the Project meets its minimum flow requirements. Flow in the reach below Fife Brook dam, noted by TU and MADF&W in their comments as needing a higher winter flow to support trout spawning than required at the Project, is largely augmented by water released from Harriman Reservoir storage, aligned with the timing of the winter drawdown of Harriman Reservoir in preparation of the annual spring runoff and recharge. While LIHI's reviews do not address public safety, I believe it is nonetheless important to recognize that the winter drawdown and store-and-release function of these major impoundments serve the downstream public by providing critical flood control benefits by absorbing flash flooding emergencies, such as Tropical Storm Irene in 2011. Irene dumped as much as 11 inches of rain on parts of Vermont and caused $733 million in damage, based on public information sources. In 1987, the 11-mile-long Harriman reservoir rose a total of 44 feet within a 1-2 day period in the spring, which would not have been possible without the standard operating protocol to lower the reservoir elevation during the winter.

CRC wondered about the lack of ramping rates or rate of drawdown limits on all but the Somerset Reservoir. In fact, there are also drawdown limits for the Harriman Reservoir, but not the others. Establishment of the WQC and license requirements, which mandate the impoundment management, involved negotiations with the various stakeholders including state and federal agencies, resulting in the current requirements. While VANR was not party to the Settlement Agreement, they (Department of Environmental Conservation, Water Quality Division) issued a WQC that recognized and accepted these littoral area impacts. On pages 2-3 of Appendix B of the VT WQC, VANR specifically states that such impacts, while they exist, would not result in non-compliance with the state standards for Class B waters, in response to concerns raised by the Vermont Natural Resource Council in their comments on the draft WQC. More recently, VANR issued an email to GRH, dated October 8, 2020, stating that the WQC remains valid and in effect. It is also important to note that while the LIHI Handbook currently states that all impoundments can automatically assume a "Not Applicable/De Minimis Effect" standard of A-1, I have reviewed the Deerfield River Project impoundments against all applicable WQC and license requirements, as though they were rated as Standard A-2.

Thus, while some loss of littoral habitat may be occurring, the extent of impact is likely limited. By complying with the existing and still current agency recommendations (i.e. WQC and license requirements), this assessment found that the impoundment water management is meeting the goal of low impact despite there being some impact at some reservoirs.

Regulated and Bypass Reaches

Current ecological minimum flow regimes were established in the April 4, 1997 FERC Order issuing a new 40-year license. Instream flow incremental methodology (IFIM) as well as qualitative instream flow assessments (teams of stakeholder experts in the river evaluating flows and habitat) were used during re-licensing to identify basin-specific seasonal and annual aquatic base flows where appropriate, and to assess habitat flows for all Project developments. All minimum flows established were for the purpose of benefiting aquatic biota, particularly resident fish species, and to maintain state water quality standards.

The following Project bypasses, lengths and flows are:

Development	Length (miles)	Flows
Searsburg	3.5	35 to 55 cfs or inflow if less, seasonal minimum flows
Harriman	4.4	57 to 70 cfs seasonal minimum flows only
Deerfield No.5	3.0	73 cfs or inflow if less, and seasonal whitewater flows
Deerfield No. 4	2.0	100 to 125 cfs, or inflow if less, seasonal minimum flows plus North River flows
Deerfield No. 3	0.2	100 cfs or inflow if less

At Somerset, seasonal minimum flows are provided to the 6-mile East Branch of the Deerfield River downstream reach to support a cold-water fishery, primarily wild brook trout. Seasonal reservoir storage and discharge augments downstream natural flow, supporting both operation of the downstream hydro developments as well as various ecological and recreation resource requirements. The seasonal minimum flows below Somerset Dam are:

- 30 cfs from Oct 1 to Dec 15
- 48 cfs from Dec 16 to Feb 28 (29)
- 30 cfs from March 1 to April 30
- 12 cfs from May 1 to July 31, or inflow if less than 12 cfs, but not less than 9 cfs
- 12 cfs from Aug 1 to Sep 31

Discharge increases are limited to 100 cfs or less over 24 hours from August 1 to April 30, and discharge decreases are limited to 50 cfs over 24 hours from August 1 to April 30.

At Searsburg, 35 cfs or inflow if less, is passed to the 3.5-mile bypassed reach from June 1 to September 30, and 55 cfs or inflow if less, from October 1 to May 31. In the 1.1- mile downstream reach of the Searsburg station, 175 cfs or inflow if less, is provided from April 20 to May 15 to provide riverine spawning habitat for smelt originating from the Harriman Reservoir.

At Harriman, 70 cfs is passed to the 4.4-mile bypassed reach from October 1 to June 30, and 57 cfs from July 1 to September 30. The bypassed flow plus natural inflow and Harriman powerhouse discharge provide inflow into the Sherman impoundment.

At Sherman, flow and water below the dam is maintained by a combination of station discharge and backwater above Deerfield No. 5 dam. There are no gates or controlled spill capability at Sherman dam. Sherman station discharge capacity is less than that of Harriman and provides a regulation function. Additionally, cyclical discharge throughout each day provides water to maintain the minimum flow requirements at Deerfield No. 5, guaranteed minimum flow at Fife Brook (Bear Swamp Pumped Storage Project), and supports downstream operation of Deerfield No.'s 4, 3, and 2. There are no minimum flow requirements at Sherman dam because the tailrace forms the upper end of the small Deerfield No. 5 impoundment.

Below the Deerfield No. 5 dam, a flow of 73 cfs or inflow, whichever is less but not less than 57 cfs, is passed to the 3-mile bypassed reach all year. White water releases are passed at this location during summer as described in Section VIII.H.

At Deerfield No. 4, 100 cfs or inflow, whichever is less, is passed to the 2-mile bypassed reach between the dam and the station tailrace from October 1 to May 31, and 125 cfs or inflow, whichever is less, from June 1 to September 30. The North River flows into the bypassed reach at about mid-reach.

At Deerfield No. 3, 100 cfs or inflow, whichever is less, is provided year-round into the 0.2-mile bypassed reach between Deerfield No. 3 dam and the station tailrace, year-round.

At Deerfield No. 2, there is no bypassed reach and station discharge provides the downstream reach minimum flow of 200 cfs year-round. This flow is a guaranteed flow provided by upstream impoundment storage as needed.

There were twelve unplanned and two planned minimum deviations from FERC license flow-related requirements to the bypasses or regulated reaches since 2012, and only one, a minimum flow deviation that occurred on June 16, 2015, associated with Deerfield No. 4 and No. 3 developments was determined to be a violation by FERC (See Appendix B). Operating staff misinterpreted the minimum flow alarms as fish passage flow alarms, and as a result, the minimum flows at Deerfield No. 3 and 4 developments did not occur for a period of 5 hours and 13 minutes, and 5 hours and 52 minutes, respectively. Mitigative measures were implemented, and as a result, such an error has not re-occurred.

Comments and Assessment - Regulated and Bypass Reaches

The following concerns were raised by stakeholders regarding the bypass reaches in their comment letters:

- Long bypasses with minimum flows that meet water quality standards but are fluctuating, and not natural flow regimes;
- Impact to trout spawning (below Fife Brook dam) from dewatering if redds were established when greater base flows were released;
- Dunbar Brook downstream reach has no flows except when spilling, and
- Reduced value of minimum flows due to water losses in bypasses as a result of peaking flow fluctuations.

The hydrograph data provided by VANR and MDF&W demonstrates that the flows the Project reaches do not represent natural flow conditions due to the peaking operations of the various developments, resulting in year-round fluctuating conditions. VANR, CRC and/or MDF&W identify the potential that such unnatural flows may be having such as changes in river morphology due to loss of natural floods, river bank scouring or fish displacement where high flows occur, or that current minimum flows may not be as supportive of fish populations by limiting suitable habitat or overall ecological integrity of the river as in unaltered streams. A related concern, identified by MDF&W, was potential impacts to trout spawning (below Fife Brook dam) from dewatering of spawning areas (established during peaking flow conditions) when normal base levels are restored.

Pages 34-54 of the VT WQC and FEIS pages 4-6 through 4-34 discuss the technical studies of Project tailraces and bypasses which evaluated the appropriate minimum flows that would provide suitable habitat supportive of fish populations for the species of interest. Such studies included licensee-conducted USF&WS Flow Recommendation Policy for the New England Area (February 1981) (i.e. aquatic base flow) and in-field Flow Demonstration Studies conducted jointly by the licensee, and agency and stakeholder experts. For Vermont waters, VANR performed their own flow study using their Interim Procedure for Determining Acceptable Minimum Stream Flows (July 1993) methodology in lieu of the aquatic base flow results along with the IFIM and field studies to establish the minimum flow requirements believed to support high quality habitat for aquatic biota. Page 2 of the MA WQC identifies the same licensee-conducted studies as their basis for establishing their minimum flow requirements. These past analyses also appeared to consider the issue of fish displacement and erosion along river banks, without identifying either as a significant concern. Finally, regarding erosion, other than impacts from Tropical Storm Irene, there is no evidence in the FERC record nor has GRH reported any issues or concerns.

The re-licensing aquatic studies recognized de-watering of recent spawning areas after peak flows have dissipated as an expected impact, as noted in the FEIS. The study MDF&W referenced was conducted in the reach below the Fife Brook Dam, which is part of Brookfield Renewable's Bear Swamp Project, not the Deerfield River Project. However, the 2019 Bear Swamp draft Environmental Assessment (DEA) issued by FERC (page 65 and 66) prepared for the Bear Swamp re-licensing proceedings, notes that flow fluctuations at the Fife Brook development are primarily the result of flows received from Deerfield No. 5, as Fife Brook is generally operated as run-of-river (ROR)[9]. Fife Brook/Bear Swamp's normal operating scheme involves some storage of some inflows in either the lower or upper reservoir, to ensure that required minimum flows at Fife Brook can be met, which are greater than required Deerfield No. 5 minimum discharge during lower flow seasons. Thus, Fife Brook is not an "instantaneous" ROR operation and FERC refers to it in that Project's DEA as "run-of-release".

It appears that the fall trout spawning dewatering impacts MDF&W noted are at least in part, due to peaking flows from Deerfield No. 5 operations. However, based on follow-up communications with GRH, they noted average releases from Harriman are largely in the 300-350 cfs range during most, if not typically all of November through March. Thus, dewatering occurrences may not be common. Nonetheless, neither the MA WQC nor FEIS found such impacts to be so detrimental as to compromise compliance with state standards addressing suitable flows for aquatic biota.

[9] Taken from Bear Swamp Power Company, LLC' November 2017 draft FERC License Application.

CRC commented that the lack of required minimum flows to Dunbar Brook results in the brook having no flow except when flow is spilled over the diversion. Based on information provided by GRH (see Appendix C), the short portion of the Dunbar Brook below the Dunbar Brook structure was never an issue of concern or considered by agency and NGO stakeholders as requiring a protected flow. The reasons noted by GRH are:

- The short reach below the structure has little habitat diversity as it is largely composed of large boulders and material. The length of stream bed between the structure and the River Road culvert is 440 feet in length. The length below the culvert to the Deerfield River confluence is similarly 450 feet in length, and steep and rocky.
- The (non-Project) River Road culvert, between the confluence and the structure is 225 feet long and perched above the stream bed on the downstream end.
- Flow in Dunbar Brook, due its steepness, is typically very low, except it can be very high following a rain event, thus washing away much of the finer materials. Maintaining a conservation flow in this short reach would be unlikely to support or provide significant habitat or provide tributary access from the bypassed reach.
- The passive water control structure is not a typical dam-impoundment structure that stores and releases water as its purpose. Its primary function is to allow high Dunbar Brook flows to bypass the canal and shed water from the canal if the canal elevation is too high due to sidehill runoff inflow. Water levels above the structure in the small pool match elevations in the No.1 canal and impoundment above the Deerfield No. 5 dam. The water behind the structure is not managed nor is it significant in terms of storage. The structure's purpose is primarily to enable high Dunbar Brook flows to safely pass through the canal/tunnel system at Deerfield No. 5 and prevent overfilling of the canal/tunnel system and a potential breach the canal wall. It has the capability to pass high Dunbar Brook flow and serves as a safety valve or fuse plug should too much water end up in the canal/tunnel system from sidehill inflow directly into the canals in addition to inflow at the dam. When flows are low in Dunbar Brook, they are simply absorbed into to the canal system and as a result, no flow is present below the structure. Figure 17 illustrates some of these features:

Figure 17 – Key Features at Dunbar Brook

CRC also provided a 2015 report that found that "The combination of hydropeaking and resultant water table mounding adjacent to dam-controlled rivers may mean that even in humid areas, licensed minimum flow requirements may be insufficient to meet desired goals if substantial losses occur within the reach of concern." While this may be true, it is unknown how much, if any loss, might occur in the Deerfield bypasses, and as such LIHI is not in a position to determine if such impacts would adversely affect compliance with the flows criterion. I believe this phenomena would require site-specific analysis that is well beyond the scope of this review.

Conclusion

While some or all of the impacts identified by the commenters may be occurring to some level, as previously noted, LIHI's program assesses a Project's operations against very specific goals, criteria and standards. Where regulatory requirements issued by resource agencies exist, and the Project has demonstrated compliance with these requirements, which I believe the Deerfield Project has with very minor deviations, a Project is then found to satisfy the criterion. LIHI also considers science-based agency recommendations not incorporated into final requirements where such information exists. This approach to evaluating "low impact" is not unique to this particular certification review and has been employed by LIHI in a number of other peaking projects receiving LIHI certification. Based on review of the application, follow-up data from GRH, comment letters and FERC eLibrary, I believe that the Project continues to satisfy this criterion.

The Project Passes Criterion A – Ecological Flow Regimes

B. WATER QUALITY

Goal: Water Quality is protected in waterbodies directly affected by the facility, including downstream reaches, bypassed reaches, and impoundments above dams and diversions.

Assessment of Criterion Passage

The Applicant appropriately selected **Standard B-2 Agency Recommendation** for all ZOEs as Project operations are governed by water quality conditions included in the two WQCs. The Vermont and Massachusetts WQCs were issued January 30, 1995 and December 14, 1994, respectively. In both cases, conditions related to water quality, flow and reservoir management and aquatic and terrestrial resources are included as 1997 FERC license articles and remain in effect. GRH has not received any Notices or Letter Notifications of Non-Compliance from Massachusetts, Vermont or the FERC. None of the material changes since last LIHI certification have had an effect on water quality.

Vermont

The designated use classifications for the 88.7 miles of the Upper Deerfield River and its tributaries in Vermont are noted below. The current VT standards are linked in the LIHI application. It is important to note that changes in the VT standards have occurred since the WQC was issued. Current standards include hydrology criteria for not only streamflow protection (§29A-304(b)) but also water level fluctuations (§29A-304(d)). These were applicable to only a subset of state areas, but became applicable to the waters affected by this Project in 2017, based on communication between M. Fischer of LIHI and H. Harris of VTANR[10].

(§29A-304(d)) - Water Level Fluctuations:

(1) Class A(1) and B(1) Waters for Aquatic Habitat. Manipulation of the water level of lakes, ponds, reservoirs, riverine impoundments, and any other waters shall result in no more than a minimal deviation from the natural flow regime.
(2) Class A(2) and B(2) Waters for Aquatic Habitat or Recreation – Boating. Lakes, ponds, reservoirs, riverine impoundments, and any other waters may exhibit artificial variations in water level when subject to water level management, but only to the extent that such variations ensure full support of uses. The following classifications in Appendix F of the VT standards[11] are applicable to the Upper Deerfield River including tributaries:

Classification A(1) for:

- Aquatic biota and wildlife that may utilize or are present in the waters
- Aquatic habitat to support aquatic biota, wildlife, or plant life
- Fishing and related recreational uses

Classification B(2) for:

[10] See Appendix C emails
[11] https://dec.vermont.gov/sites/dec/files/documents/wsmd_water_quality_standards_2016.pdf

- Swimming and other primary contact recreation
- Boating and related secondary contact recreational uses
- The use of waters for the enjoyment of aesthetic conditions
- Public water source
- Irrigation of crops and other agricultural uses

VT standard § 29A-104 states that a water body may be assigned different classifications for different uses, and that all waters shall be managed to support their designated and existing uses. However, Map 4 in Appendix F of the standard shows the Project's waters being classified as only B(2) waters.

While the LIHI application addressed the Vermont Department of Environmental Conservation Watershed Management Division (VDEC WMD)'s *State of Vermont 2018 303(d) List of Impaired Waters*, 2020 lists are also now available and were also reviewed.

Impairment has an approved total maximum daily load (TMDL) (corresponds to Category 4a of EPA's Consolidated Assessment Listing Methodology).

On both lists, the Somerset Reservoir, East Branch Deerfield River below Somerset Dam, Searsburg Reservoir, Upper Deerfield River below Searsburg Dam, Harriman Reservoir, and the Sherman Reservoir are impaired for mercury in fish tissue. GRH denotes that the mercury impairment is described as entering water from polluted runoff and from precipitation containing mercury (atmospheric deposition). The Somerset Reservoir is also listed as impaired for pH, noting atmospheric deposition, and that it is extremely sensitive to acidification and experiences episodic acidification.

Impairment in need of a TMDL (prepared in accordance with the Vermont Surface Water Assessment and Listing Methodology, current EPA Guidance and the Environmental Protection Regulations 40 CFR 130.7.

In 2018 and 2020, river segments below Somerset and Searsburg reservoirs are listed as impaired from acidification, caused by atmospheric deposition, and are noted to be critically and chronically acidified. The 2020 list also denotes low temperature as an impairment for these same two river reaches, with the cause listed as low temperature release from the reservoirs.

Altered Waters[12] (corresponds to Category 4c of EPA's Consolidated Assessment Listing Methodology).

On the 2020 list, the Lower Deerfield River below Harriman Reservoir is also listed as impaired due to low temperature hypolimnetic water release from the reservoir and notes that VTDF&W is evaluating the effects of such releases on fishery resources.

[12] Defined on the 2020 list as "Alterations arise from flow fluctuation, obstructions, or other manipulations of water levels that originate from hydroelectric facilities, dam operations or water withdrawals for industrial or municipal water supply or snowmaking purposes."

Massachusetts

The Deerfield River from the VT/MA state line to the confluence with the Connecticut River is Class B, with a qualifier of Cold Water for the upper portion (from the state line to the confluence with the North River) and Warm Water for the lower portion (from the North River confluence to the Connecticut River). Massachusetts describes Inland Class B waters:

> 4.*05(3)(b) Class B. These waters are designated as a habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. Where designated in 314 CMR 4.06, they shall be suitable as a source of public water supply with appropriate treatment ("Treated Water Supply"). Class B waters shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.*

Massachusetts water quality standards are linked to the LIHI application.

The current list of impaired waters for Massachusetts, published in 2019, is the *Massachusetts Year 2016 Integrated List of Waters Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act* (found here). It separates waters into five different categories of impairment with only Category 5 waters on the 303(d) list, requiring a TMDL for the causative impairment. Of the Massachusetts portion of the Deerfield River, three of five segments are Category 5: the Sherman Reservoir, listed for mercury in fish tissue (page 191 of the 303(d) list); and two contiguous sections from the confluence with the North River to the confluence with the Connecticut River, listed for *Escherichia Coli* (*E. coli*; page 191 of the 303(d) list). Neither impairment is attributable to Project operations. As stated in the report, the majority of mercury pollution in the Northeast derives from atmospheric deposition (p. 36). The *Massachusetts Consolidated Assessment and Listing Methodology (CALM) Guidance Manual for the 2016 Reporting Cycle* (found here) identifies the following sources for *E. coli* impairment (page F6): municipal point source discharges, combined sewer overflows, municipal (urbanized high density area), discharges from municipal separate storm sewer systems (MS4), unspecified urban stormwater, wet weather discharges (non-point source), illicit connections/hook-ups to storm sewers, urban runoff/storm sewers, waterfowl, introduction of non-native organisms (accidental or intentional), and sources unknown.

Comments, Assessment and Conclusion

The following concerns were identified by one or more stakeholders in their comments:

- Deoxygenated areas of Somerset and Harriman reservoirs are contributing to elevated mercury in fish tissue
- VT water quality standards now include water fluctuation criteria not existing at the time of WQC issuance
- Cold water released below some dams are below state standards

Scientific studies provided by CRC and VANR strongly suggest that increases in mercury (Hg) uptake by fish in deep lakes occur from sediments contaminated by atmospheric mercury deposition, and especially those having oxygen-limited waters as a result of certain chemical absorption variables[13]. Bioaccumulation of mercury then occurs through the food chain, to species such as loons. The reports suggested release of deoxygenated waters from deep lakes, such as Somerset and Harriman, can then allow methylated mercury (meHg) to be mobilized downstream. However, studies conducted for re-licensing did not find this to occur at Harriman and Somerset[14].

Fish advisories are issued where fish mercury levels exceed state limits. As previously noted, several Deerfield impoundments and downstream reaches are included on state lists of impaired waters, having approved TMDLs for fish mercury levels, including the 2007 EPA-approved Northeast Regional Mercury TMDL[15]. A June 13, 2003 study by Vermont Department of Environmental Conservation, entitled Biogeochemistry of Mercury in Vermont and New Hampshire Lakes, An Assessment of Mercury in Waters, Sediments and Biota of Vermont and New Hampshire Lakes, was designed specifically to determine the generalized level of mercury contamination in sediment, water, and biota of multiple trophic levels across the VT-NH region. Using field studies from 1998 through 2000, mercury was detectable in waters of all 103 lakes sampled. The study indicated that increased deep water Hg and meHg concentrations suggest accumulation in bottom waters, either due to loss from upper waters by sedimentation, release from deep water sediments, or a combination of both. Evaluation of the accumulation of Hg in the tissues of yellow perch, a common species found in all of the lakes analyzed, found that concentrations increased, not surprisingly, with age and size. Results of the loon tissue analyses suggest that across the region, 50% of Vermont lakes and 70% of NH lakes had loons with tissue Hg concentrations that placed those animals in a "moderate" or higher risk category. The study showed sediment Hg concentrations were most elevated in lakes occupying the most remote and forested regions of VT and NH, and were lowest in lakes with the greatest levels of watershed development, which has also been suggested by other New England studies.

GRH has noted that as the state's largest body of water at elevation, Somerset, and additionally Harriman at a slightly lower elevation, capture atmospheric deposition mercury as well as nitrous oxides and sulfur oxides through direct rainfall and drainage area runoff. At Somerset, old growth red spruce stands have all largely died, suffering from a combination of acid rain deposition (needle yellowing) and a root transmission fungus (shoestring root rot) due to adjacent National Forest logging. This seems to align with the study finding that the source of mercury in lakes in undeveloped areas is larger due to greater influx of mercury from environmental deposition, in the same fashion that the forest around the Deerfield reservoirs are being damaged by other atmospheric pollutants. GRH also reports that at the Moore reservoir on the Connecticut River in VT/NH, mercury in fish tissue has been monitored for many years. The highest concentrations have occurred in fish occupying areas at the upstream end of the reservoir, which does not stratify, and based on opinions presented by Biological Research Institute staff, this likely reflects mercury loading into the reservoir that stems from inflow from upstream basin runoff from the White Mountains[16].

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[13] Hydropeaking induces losses from a river reach: observations at multiple spatial scales, 2015, B. Yellen and D.F. Boutt,

[14] Finding 79 on page 20 and Finding 87 on page 21 of the VT WQC found that water released downstream from both Somerset and Harriman reservoirs appears to become reoxygenated by the discharge mechanisms.

[15] https://neiwpcc.org/wp-content/uploads/2020/08/FINAL-Northeast-Regional-Mercury-TMDL.pdf

[16] See GRH email in Appendix C

One conclusion that can be derived from past studies is that mercury in fish is not a unique concern to the Deerfield Project waters. Granted, releases from the deep hypoxic zone of the Somerset and Harriman reservoirs could contribute to mercury accumulation in fish in those waters. Review of publicly available data published by the US Environmental Protection Agency only includes three samples taken in 1994 and 1995 in Harriman reservoir[17]. Fish from other, more shallow lakes in the same area had comparable mercury levels in the sampled fish. However, Somerset and Harriman reservoirs provide a valuable sport fishing industry, and in fact, are stocked with game species by the state regularly to support this industry. Similarly, Somerset Reservoir has specific water level limitations, strictly adhered to by GRH, during loon breeding season to help ensure the success of nesting. Often at the request of state biologists, the time period in which the water levels are held steady is extended to support successful loon nesting. Given these facts, it does not seem appropriate that LIHI review of the Project should consider a situation primarily caused by atmospheric deposition, even if potentially exacerbated by current reservoir environmental conditions, to be a violation of its criteria.

Another concern raised by VANR is that as of 2017, state water quality standards now include water fluctuation criteria, not existing at the time of the WQC, but applicable to the Deerfield Project. These standards state that Class B waters "may exhibit artificial variations in water levels when subject to water level management, but only to the extent that such variations ensure full support of uses". They also raised a concern about the potential for impacts from cold water releases. Review of the Vermont 2020 Priority List of Altered Waters only listed the Harriman Reservoir, denoting the impairment as "cold temperatures" and noted that the VDF&W is "evaluating the effects of such releases on fishery resources". Similarly, cold water temperatures were listed for river segments below Somerset and Searsburg reservoirs (on the 2020 303(d) impaired list requiring a TMDL). It is true that GRH did not specifically demonstrate in their application that the facilities do not contribute to this impairment. Obviously, the Project operations are the cause of such releases. However, these same cold temperatures help mitigate warm water temperatures downstream during summer months. GRH has reported that it is not uncommon for state representatives to request additional releases of such cold waters during unusually hot periods. The TUCRV noted that such releases may in fact benefit cold water fisheries. It is also important to note that Article 414 of the Project FERC license and Condition H of the WQC require, if requested by VANR, that GRH implement measures to raise water temperature in Harriman releases. To date, no agency request has been made. Given that the VDF&W appears to be studying such impacts, that at least one stakeholder identified possible benefits of such releases, and that no agency request has been issued to FERC or GRH, I believe the logical path would be to allow these VDF&W study evaluations to progress to understand effects at the Deerfield River Project.

Based on my review of all of the information described above, I believe the Project continues to satisfy the requirements for this criterion.

The Project Passes Criterion B – Water Quality

[17] https://fishadvisoryonline.epa.gov/FishTissueDetails.aspx?STATION_ID=VT-Hg-5119

C. UPSTREAM FISH PASSAGE

Goal: The facility allows for the safe, timely, and effective upstream passage of migratory fish. This criterion is intended to ensure that migratory species can successfully complete their life cycles and maintain healthy populations in areas affected by the facility.

Assessment of Criterion Passage

The Applicant selected **C-1 - Not Applicable/De Minimis Effect** for all ZOEs except Deerfield No. 2 (ZOE#22), which is the river reach downstream of Deerfield No. 2, the most downstream development. **C-2 – Agency Recommendation** was selected for this ZOE.

Species Present in the Deerfield River

Based on information identified by the MDF&W, the Deerfield River System in MA includes over 100 recognized Cold Water Fishery Resource waters including many of the Deerfield's major tributaries such as the North, South, Cold, Bear, and Chickley Rivers. The Deerfield River supports a diverse fish community of both resident species, and in the lower reaches below Deerfield No. 2, some migratory fish as identified below. American eel are present in reaches even further upstream.

Migratory species in the Connecticut River Basin are managed by the Connecticut River Atlantic Salmon Commission (CRASC), which was established in 1983 by Congress, to promote restoration of Atlantic salmon to the Connecticut River basin. Agency representation includes: USF&WS, National Marine Fisheries Service (NMFS), Connecticut Department of Environmental Protection, MDF&W, New Hampshire Department of Fish and Game (NHDF&W) and VDF&W. In 2013, the USF&WS formally announced that its Atlantic salmon stocking efforts in the Connecticut River basin had not achieved restoration levels and that stocking efforts were discontinued. The CRASC expanded their mission to include all diadromous species in the Connecticut River basin and they developed management plans, focused on the mainstem Connecticut River, for American shad, river herring (i.e., blueback herring and alewife), and sea lamprey.

As noted in the LIHI application, historically, Atlantic salmon used the Deerfield River for spawning and records show they reached Shelburne Falls, where the Deerfield No. 3 and Deerfield No. 4 Developments are located. MDF&W's efforts to re-establish Atlantic salmon in the river basin included stocking fry in tributaries above Deerfield No. 4 since before the Deerfield River Project was relicensed in the late 1990s.

Migratory species currently in the Connecticut River with access to the Deerfield River include American shad, blueback herring, sea lamprey, American eel, and shortnose sturgeon[18]. American eels enter the Connecticut River as juveniles and move upstream and into tributaries. They have few habitat preferences and can move around most obstructions, allowing them to inhabit most

[18] MDF&W comment letter dated January 26, 2021 states American shad were historically but not currently present. See Appendix C.

aquatic habitats including within the Deerfield River. Sea lamprey entering the lower Deerfield River may find suitable spawning habitat; however, American shad and blueback herring, migrating up the Connecticut River to spawn in deep, slow moving water, are unlikely to be found in the relatively shallow, swift moving water of the lower Deerfield River. A naturally reproducing population of shortnose sturgeon inhabits the Connecticut River between the Cabot Project, located on the Connecticut River just above the mouth of the Deerfield River, and the downstream Holyoke Project, and may opportunistically forage in the Deerfield River. However, as noted in the LIHI application, and the FEIS for Deerfield River Project, fisheries agencies from Vermont and Massachusetts indicated that shortnose sturgeon have not been identified at the Deerfield No. 2 Development.

Based on data in the LIHI application, both states stock trout species in the Project area. Vermont stocks both brown and brook trout in the mainstem Deerfield River, brook trout in the Somerset and Searsburg reservoirs, brown trout in Sherman reservoir, and in Harriman reservoir, brook, brown, rainbow and lake trout are stocked as well as landlocked salmon. In the Massachusetts reach of the Deerfield River, brown, brook and rainbow trout are stocked in various locations.

Other resident fish species reported to occur in the upper Deerfield River include blacknose dace, bluegill, brown bullhead, chain pickerel, common shiner, creek chub, fallfish, golden shiner, largemouth bass, longnose dace, longnose sucker, mimic shiner, pumpkinseed, rainbow smelt, rock bass, slimy sculpin, smallmouth bass, white sucker, and yellow perch.

Resource Agency Fish Passage Requirements

The 1997 FERC license included upstream passage initiatives, pursuant to a Federal Power Act Section 18 Mandatory Prescription issued for Deerfield No. 2 (Articles 409, 410, 411, and 413) as summarized below. The US Department of Interior also reserved their authority to require additional facilities in the future under License Article 407. These Article requirements for Deerfield Nos. 2, 3 and 4 align with those included in the MA WQC.

- Article 409 required the development and implementation of a plan to construct, operate, and maintain a permanent upstream fish passage facility at Deerfield No. 2 in order to provide upstream passage for adult Atlantic salmon. Because the requirement was intended to take effect only after upstream migrating salmon reach viable levels, Article 409 did not require the licensee to draft a plan until recording 12 adult Atlantic salmon below the dam for two consecutive years, as determined by radio-tracking required by Article 413. The upstream passage facilities, when constructed, must be operated according to a schedule determined by the USF&WS and the MDF&W.

- Article 410, as amended on February 25, 1998, required the development and implementation of a plan to capture migrating salmon that reach Deerfield No. 2 and transport them to river reaches above the dam or to hatchery facilities, until the permanent upstream passage facilities required by Article 409 are completed. The Commission's March 27, 1998 Order Modifying and Approving an Atlantic Salmon Radio-Tagging Plan,3 in part, approved the licensee's trap and transport plan.

- Article 411 required the development and implementation of a plan to monitor movement of Atlantic salmon smolts to assess the effectiveness of the upstream and downstream passage facilities and associated operational flows, in consultation with the USF&WS and MDF&W. As a result of implementing this plan, the facilities were modified in order to improve effectiveness, as approved in FERC's August 21, 2002 Order on Downstream Fish Passage Effectiveness.

- Article 413 required the development and implementation of a plan to radio-tag Atlantic salmon and release them at the Holyoke Project on the Connecticut River downstream of the confluence with the Deerfield River. Under the Atlantic Salmon Radio-Tagging Plan, the Licensee was required to monitor the tagged salmons' migration upstream to the Deerfield River Project. The results of the Radio-Tagging Plan were intended to trigger implementation of Article 409, when 12 adult Atlantic salmon are recorded below the dam for two consecutive years.

In light of the 2013 USF&WS decision to halt Connecticut River basin salmon restoration efforts, on March 31, 2015, the Project owner filed a license amendment request to suspend or remove those Articles associated with upstream passage of Atlantic salmon. In its filing, the owner included correspondence from USF&WS and MDF&W stating that "…upstream passage for Atlantic salmon on the Deerfield River is no longer a concern." On June 22, 2015, FERC issued Order Suspending License Articles 409, 410, 411, and 413 for the Deerfield River Project (see linked copy in the LIHI application).

It should be noted that the corresponding Conditions in the MA WQC remain in the WQC, although activities associated with them have also been halted. LIHI conducts certification assessments relative to "resource agency recommendations", which would include WQC conditions, and the MA WQC Conditions do not appear to have been formally suspended, as no MA WQC amendments have been issued. That said, it has been demonstrated by the Applicant that cessation of fish passage activities at these developments was found acceptable to the MA resource agencies.

The FERC license also incorporates by reference, but not through a specific Article, Condition M of the Vermont WQC, which requires that a plan be developed and approved for upstream fish passage at the Searsburg Development, within four months of a request by VDF&W, and that following Plan approval, the facility be installed within 18 months from the request. The purpose of these efforts was primarily to support Harriman Reservoir salmon management. However, the request for installation cannot be issued before 20 years from the WQC issuance (01/30/1995) so a request could have been issued starting in January 30, 2015. No request has been made to date.

<u>Fish Passage Compliance</u>

Requirements for upstream passage at Deerfield No. 2 were tied to Atlantic salmon restoration and fry stocking efforts by MDF&W upstream in the basin. The requirements of the four Articles were tied to a trigger of returning adult salmon to the base of Deerfield No. 2 dam, and a formal request by the USF&WS or CRASC. Monitoring occurred from 2004 through 2013, but was halted with the concurrence from MDF&W and USF&WS. Trap/truck would have been an interim upstream passage measure to provide upstream passage while permanent facilities were constructed, but as no upstream passage facilities were ever requested, such a program was not implemented.

Regarding the requirements for upstream passage at the Searsburg Development contained in the VT WQC, GRH reported that, to date, there have been no requests for providing upstream fish passage by either Vermont or Federal fishery management agencies, so no activities have been implemented. Outreach to VANR confirmed that no fish passage or protection requests have been issued. (See Appendix C).

Comments, Assessment and Conclusion

VANR commented that GRH should develop upstream passage at Searsburg dam to allow resident species such as brook and brown trout[19] to access to the Deerfield River headwaters. TUCRV noted that the lack of both up and downstream passage for resident species and American eels challenges their movement and habitat access. MDF&W specifically stated that up and downstream passage for American eel may be warranted since eels are present in the watershed.

LIHI's Handbook includes both potamodromous species and diadromous species in the discussion of standards associated with both up and downstream passage. However, the second standard in both criteria also includes that compliance with "Agency Recommendations" in legal proceedings such as FERC licenses and WQCs, is a path to demonstrating compliance with these criteria. At the time of WQC development and renewal of the FERC license, the fish passage requirements focused only on Atlantic salmon. As noted in the original 2012 LIHI reviewer's report, the Settlement Agreement only addressed development of downstream fish passage facilities at the Deerfield Nos. 2, 3, and 4 developments, and phased development of upstream passage at Deerfield No. 2 triggered by the number of adult Atlantic salmon returning to the Deerfield River. Upstream passage was never constructed and the license article requiring upstream passage was eliminated with concurrence of the USF&WS and MDF&W when the Connecticut River salmon restoration program was halted.

Since the Project has shown it is in compliance with current fish passage requirements, this assessment must find that it has satisfied the Upstream Passage Criterion.

However, as a result of the original 2012 certification review, LIHI established a certification Condition that read:

> Condition 1: *If the U.S. Fish and Wildlife Service (USF&WS) or the State of Massachusetts requests upstream and/or downstream eel passage facilities at the Project, the Project owner shall so notify LIHI within 30 days and shall enter into, and provide LIHI with a copy of, an agreement reached among the Project owner, the USF&WS, and/or the State of Massachusetts to provide both interim (if requested by a Resource Agency) and permanent safe, timely, and effective passage for American eel. The Agreement must be finalized within 120 days of the request for passage and must include a description of the planned passage and protection measures and the implementation schedule for design, installation, and operations. The agreement shall be filed with LIHI within 30 days of its execution.*

[19] Riverine species such as these may use various reaches for foraging shelter, etc. but they are not true potamodromous species.

This past certification condition was found to be consistent with those incorporated into other recent LIHI certifications at New England projects, and reflects the fact that eel passage is in place at Holyoke Dam, the first development below the confluence of the Deerfield and Connecticut Rivers. However, as previously noted, neither USF&WS or the State of Massachusetts has formally requested such passage. Given that interest in eel passage continues, I am recommending a modification of this condition as noted in *Section IX, General Conclusion and Reviewer Recommendations* of this report. LIHI's criteria currently do not include upstream passage requirements for non-potamodromous resident species.

Based on my review of the application, FERC eLibrary review, stakeholder comments and follow-up Applicant communications, I believe that the Project continues to conditionally satisfy this criterion.

The Project Conditionally Passes Criterion C – Upstream Fish Passage

D. DOWNSTREAM FISH PASSAGE AND PROTECTION

Goal: The facility allows for the safe, timely, and effective downstream passage of migratory fish. For riverine (resident) fish, the facility minimizes loss of fish from reservoirs and upstream river reaches affected by Facility operations. Migratory species are able to successfully complete their life cycles and maintain healthy populations in the areas affected by the Facility.

Assessment of Criterion Passage

The Applicant has selected **D-1 – Not Applicable / De Minimis Effect** for all ZOEs except Deerfield No. 4 impoundment (ZOE#15), Deerfield No. 3 impoundment (ZOE#18) and Deerfield No. 2 impoundment (ZOE#21). These three ZOEs were noted as **D-2 – Agency Recommendation,** as the license has specific requirements for downstream passage. However, as discussed below, these requirements were suspended in 2015 or never requested.

Species present in the Deerfield River are listed above under *Upstream Fish Passage.*

Resource Agency Fish Passage Requirements

In addition to the reservation of authority included under License Article 407, the 1997 FERC license also included the following downstream passage and protection requirements:

- Article 408 required the Licensee to develop and implement a plan to provide downstream fish passage facilities for out-migrating Atlantic salmon smolts at Deerfield Nos. 2, 3 and 4 developments. The plan must be developed in consultation with the USF&WS and the MDF&W. It also identifies operational periods for such passage.

- Article 411 required the development and implementation of a plan to monitor movement of Atlantic salmon smolts to assess the effectiveness of the upstream and downstream passage facilities and associated operational flows.

- Article 418 required a study of the effectiveness of the existing trashracks at the Searsburg Development within 18 months of license issuance, and if additional measures are deemed necessary to protect fish from entrainment and impingement by the USF&WS and/or MDF&W, implementation of appropriate measures.

The license also incorporates by reference, but not via a specific Article, the following downstream passage requirements under the Vermont WQC relative to the Searsburg development:

- Condition K requires development and approval of a plan to install/operate downstream fish passage. Installation is required such that operation is started within 18 months of a request from VDF&W of its need.

- Condition L requires development and approval by USF&WS and VDF&W, of a plan to install impingement/entrainment measures within seven years and four months from WQC issuance (which was January 30, 1995) and installation of the measures within one year of VDF&W Plan approval. Condition L also provides additional deadline requirements relative to License Article 418 mandates.

Fish Passage Compliance

As noted by GRH in a follow-up email, (see Appendix C), a number of downstream passage facilities and methods were installed, tested, monitored and modified for the primary purpose of passing smolts previously stocked as fry in the basin upstream of Deerfield No. 3 and 4 dams.

The following are the most recent methods that provided the highest survival and passage when the salmon restoration program was still in place:

- At No. 4 dam, smolts were either passed via spill into the bypass or through the intake, forebay and turbines. Smolts were guided in the forebay by nets suspended from overhead. Nets are no longer installed, since the license was amended in 2015, but the means for providing passage remains as it is through station discharge due to the high survival through the slow horizontal turbines that are identical to No. 3 and No. 2 stations.

- At No. 3 dam, smolts were passed primarily into the bypass though a gate and guided by an angled bar rack. Fish that enter the forebay and pass via the turbines have a high survival but were thought to have been delayed potentially by the longer forebay.

- At No. 2 dam, although a fish gate and sluiceway were constructed, it was never effective in attracting significant numbers of downstream migrating smolts. Alternatives were to use submerged gates or the turbines, as minimum flow is provided through unit discharge. Turbine survival was high, and in the end was the most effective means of passing smolts.

Relative to VT WQC Condition L and License Article 418 applicable to the Searsburg development, in a follow-up email[20], GRH reported that an assessment of the impingement/

[20] See Appendix C for this email.

entrainment at the intake was not required and therefore not made, as it was tied to providing downstream passage for Harriman salmon management, a goal which was abandoned. The following findings were noted in the final 1998 Searsburg Trash Rack Plan[21]:

> Section 3.2 - "*Both USFWS and VANR agree that deferring the planning and implementation of any monitoring makes good sense and should clearly wait until VDFW determines management objectives and determines the need for downstream fish passage requirements.*"
>
> Section 2.1(6) - "*Existing trashrack configuration and approach velocity data for Searsburg dam suggests that significant protection is currently available to the native non-migratory fishery above the dam. Current bar spacing is 1.25 inches; average approach velocity is 1.2 ft./sec.; and maximum flow is 345 cfs. These are relatively low values.*"

Typically, USF&WS does not recommend any measures to protect fish from entrainment if velocities are less than or equal to 2 ft./sec. To date, neither the USF&WS nor VDF&W have required changes to the trashracks, nor have they requested downstream passage measures to be initiated.

Comments, Assessment and Conclusion

VANR questioned the status of compliance with License Article 418, which was addressed above. Analysis of the comments from VANR, MDF&W and TUCVR regarding the need for downstream passage for American eel and potamodromous species is included above under the *Upstream Fish Passage Criterion*. Also as noted above, I am recommending that a condition be included to address downstream eel passage. Based on my review of the application, FERC eLibrary review, stakeholder comments, and follow-up communications with the Applicant, I believe that the Project continues to conditionally satisfy this criterion.

The Project Conditionally Passes Criterion D – Downstream Fish Passage and Protection

E. SHORELINE AND WATERSHED PROTECTION

Goal: The Facility has demonstrated that sufficient action has been taken to protect, mitigate and enhance the condition of soils, vegetation and ecosystem functions on shoreline and watershed lands associated with the facility.

Assessment of Criterion Passage

The Applicant has appropriately selected **Standard E-2, Agency Recommendation** and **PLUS** credit to pass the Shoreline and Watershed Protection criterion for all Project ZOEs. There has been no change in the shoreline and watershed protection requirements for the Project since it was last certified by LIHI. There are no Shoreline Management Plans or similar protection requirements for the Project and no agency recommendations or management plans for shoreline management. In large part this is due to the fact that the vast majority of the shoreline is owned in

[21] https://elibrary.ferc.gov/eLibrary/filedownload?fileid=52263

fee, undeveloped, available for day-use only, with a number of resource specific management plans to address resources, and most importantly, the shorelines are also protected by the perpetual conservation easement holders.

The LIHI application provides the following description of the Deerfield River watershed:

> *"Overall, land use within the predominately rural Deerfield River watershed is classified as 81% forested, 13% agriculture/open land, 4% urban, and 2% water (MA DEP 2000). Approximately half of the Deerfield River watershed is in southern Vermont (318 mi^2) and half is in western Massachusetts (347mi^2). In the northern and western areas of the watershed the topography is mountainous and the river's profile is steep, making it attractive for hydroelectric power generation. The Vermont Department of Environmental Conservation (VDEC)'s 2020 Deerfield River & Lower Connecticut River Tactical Basin Plan characterizes the Vermont portion of the Deerfield River basin as the second most forested, the least developed, and the least cultivated basin in the State of Vermont. Forested land covers the greatest area at 82%, open water covers 2% (due to the large areas covered by the Harriman and Somerset reservoirs), wetlands 5%, agricultural crop land 4.6%, and developed land 4.7%. Over 27% of the Basin is part of the Green Mountain National Forest which covers most of the western basin, including almost all of the Upper Deerfield [basin], and most of the East and West Branches. Only 40% of the Vermont portion of the basin lacks some form of conservation protection (VT DEC 2020).*
>
> *The Massachusetts portion of the watershed contains most of the population and the land use, although still heavily forested, contains more of a mix of agricultural, residential, and industrial uses. The largest and only city in the watershed is Greenfield, MA, at the confluence with the Connecticut River. In 2003 it contained almost half the population of the entire watershed (MA DEP 2004)."*

GRH owns approximately 17,707 acres of forest land in Vermont and Massachusetts adjacent to the Deerfield River which has been under professional forest management since 1962. The current Forest Management Plan emphasizes the multiple-use of various forest resources, production of higher quality timber for saw logs and other wood products, passive recreation, and wildlife management.

The Settlement Agreement and License Article 427 include protection from development of 17,098 acres of land through permanent conservation easements (see Figures 18 to 20). The Vermont Land Trust holds the easement on land in Vermont and the Massachusetts Department of Environmental Management holds the easement in Massachusetts. Collectively, these easements cover primarily undeveloped land, some of which is in agricultural and forestry use. These lands provide wildlife habitat, natural resource protection, and recreational and scenic opportunities. The easements preserve the protected properties associated with the Project in their natural state, while allowing for the continued operation of Project facilities. The protected lands cannot be used for purposes other than agricultural, forestry, educational, non-commercial recreation, open space, and the present and future operation of electric transmission and hydroelectric generation facilities.

In accordance with License Article 429, GRH created the Deerfield River Basin Environmental

Enhancement Fund, in the amount of $100,000. The fund's purpose is to finance watershed conservation; development of low impact recreational and educational projects and facilities; and the planning, design, maintenance and monitoring of such facilities and projects. The Vermont Community Foundation is the Fund Trustee, and they administer grants distributed under the fund. To date, over $56,000 has been distributed, and as of June 2020 the fund balance was $120,465. Review of FERC eLibrary documents indicates that GRH is complying with the review and approval process established to ensure appropriate use of these funds.

To be eligible for an extra three years of certification, the application must:

- "Provide documentation that the facility has a formal conservation plan protecting a buffer zone of 50% or more of the undeveloped shoreline that the facility owns around its reservoirs and river corridors; or
- In lieu of a formal conservation plan, provide documentation that the facility has established a watershed enhancement fund for ecological land management that will achieve the equivalent land protection value of an ecologically effective buffer zone of 50% or more around undeveloped shoreline."

Comments, Assessment and Conclusion

CRC and TUCRV commented that GRH should increase its contribution to the Fund, and as noted by TUCRV, increase their engagement with projects initiated by the Fund to provide greater opportunity to address the remaining adverse impacts in those locations in the watershed in need of conservation measures. The funding decision making process was set up and developed through agreement among various parties and is stipulated in the Enhancement Fund Plan, which was established in 1997. Recommendations for project funding are made by a unanimous decision of the three Fund Advisors, who include a representative of the Licensee, VANR, and a designee from the MA Executive Office of Environmental Affairs. The funding amount was established through the Settlement Agreement. While additional monies donated to this fund would further enhance the benefits that can be achieved, I do not believe that satisfaction of this criterion requires additional contribution.

The Project clearly satisfies the conservation buffer zone requirement of at least 50% of the shoreline buffer. The Enhancement Fund further adds to satisfaction of meeting the goal of watershed protection. Based on my assessment of the noted materials, I believe the Project continues to satisfy this criterion and meets the requirements for three extra years of LIHI certification.

The Project Passes Criterion E and PLUS Credit – Shoreline and Watershed Protection

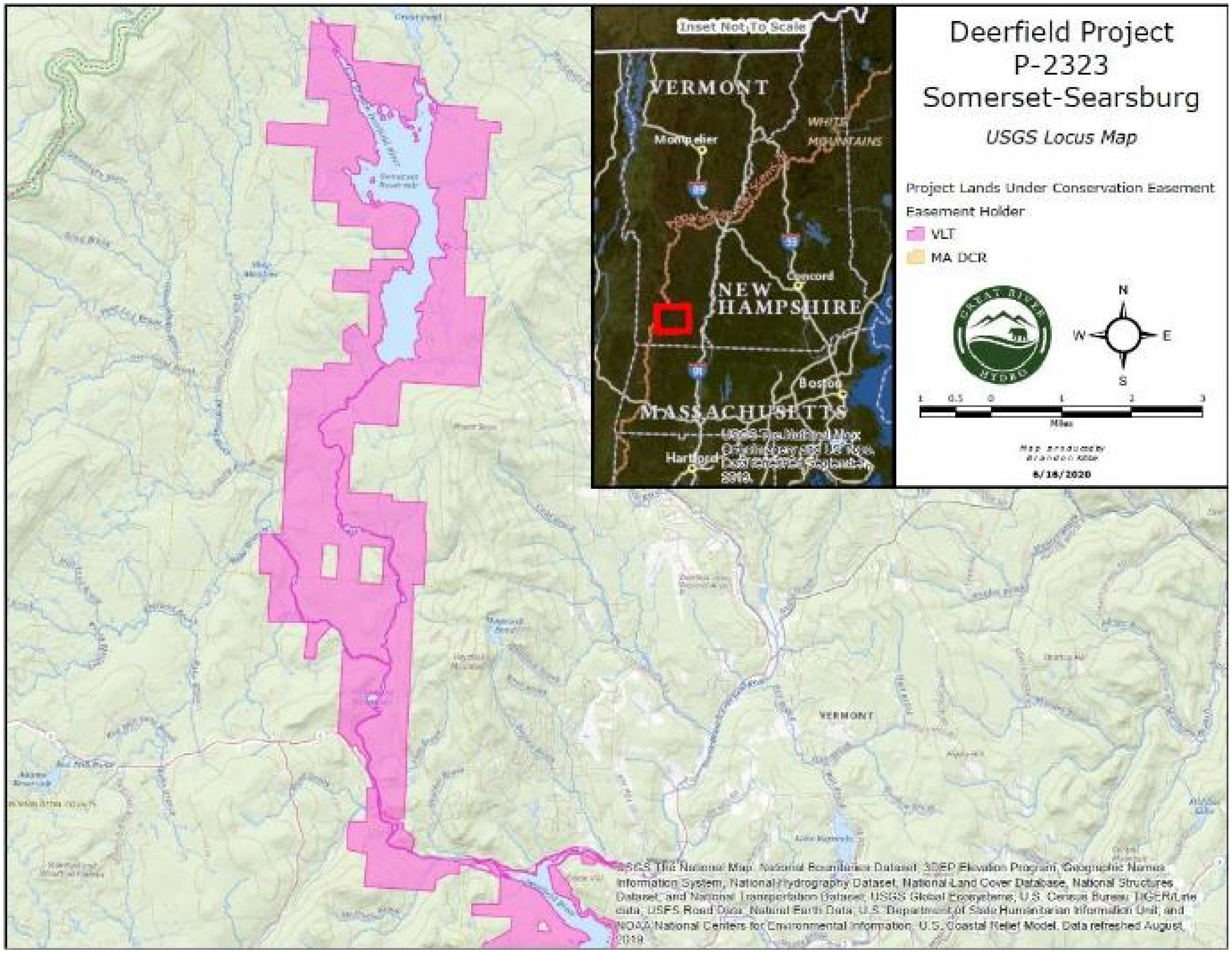

Figure 18 - Deerfield River Project (P-2323) lands around the Somerset and Searsburg Developments under Conservation Easement

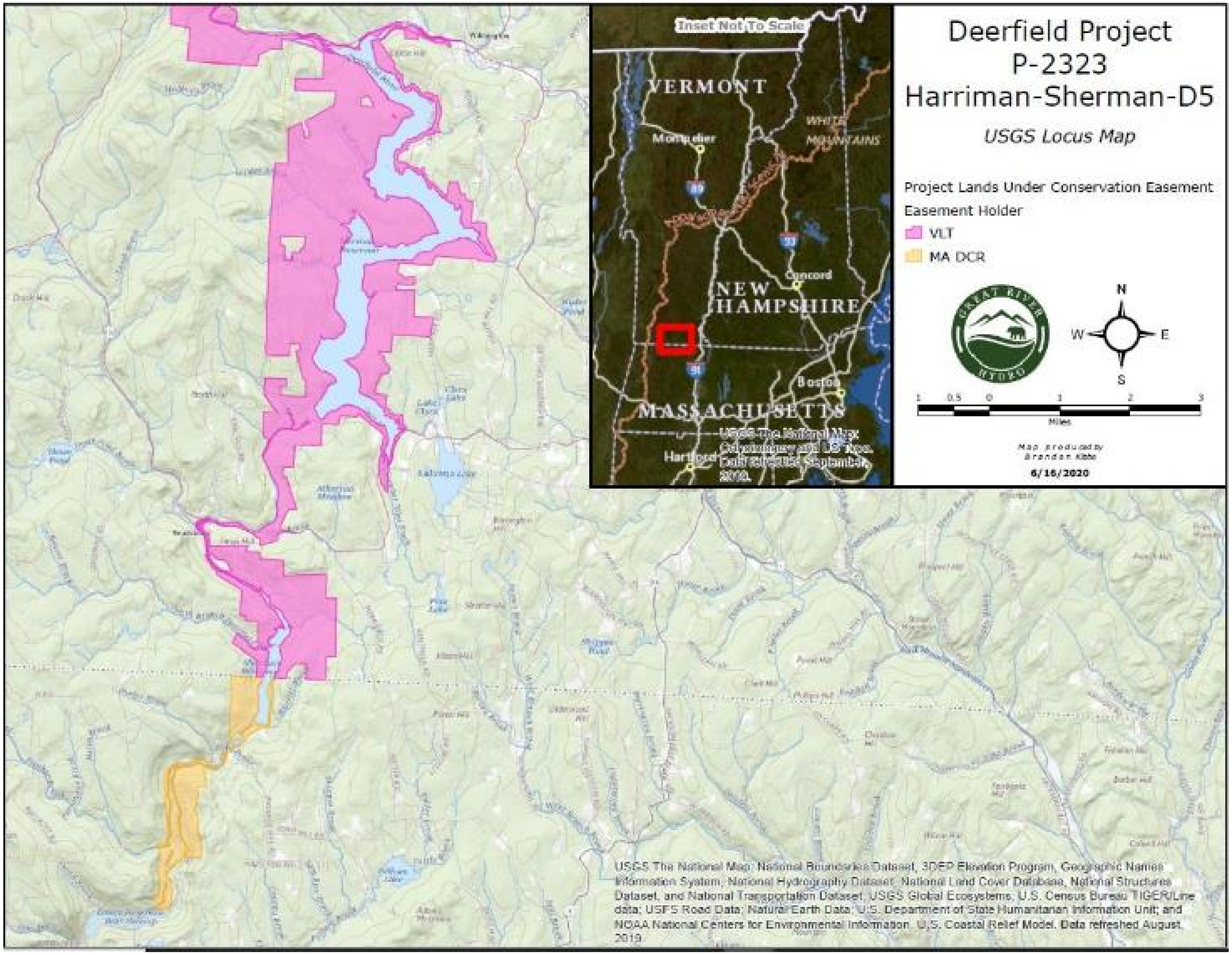

Figure 19 - Deerfield River Project (P-2323) lands around the Harriman, Sherman, and Deerfield No. 5 Developments under Conservation Easement.

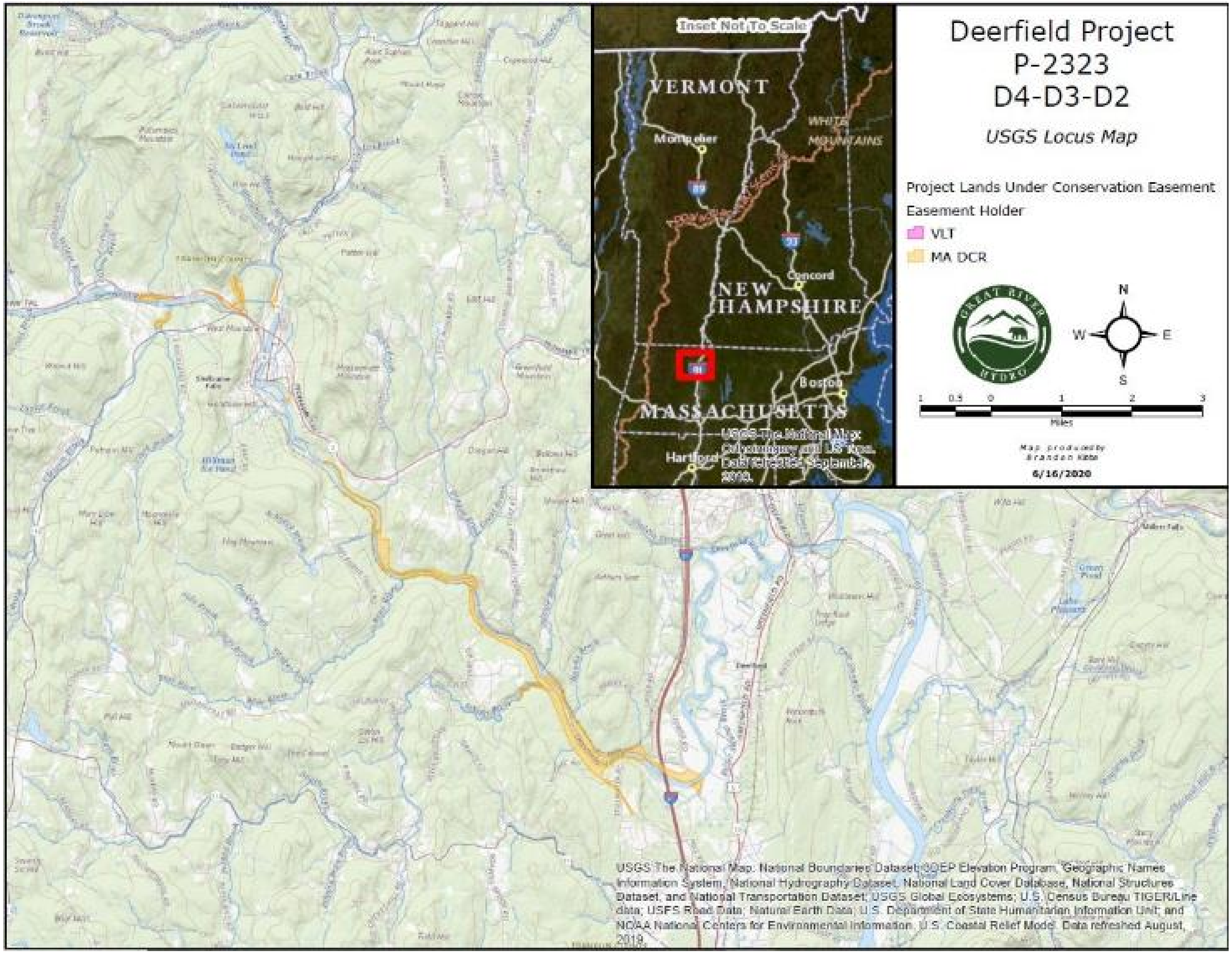

Figure 20 - Deerfield River Project (P-2323) lands around the Deerfield No. 4, 3, and 2 Developments under Conservation Easement.

F. THREATENED AND ENDANGERED SPECIES PROTECTION

Goal: The Facility does not negatively impact federal or state-listed species.

Assessment of Criterion Passage

Standard F-1 Not Applicable / De Minimis Effect was selected for the following ZOEs:

- ZoE 2 – Somerset Downstream Reach
- ZoE 3 – Searsburg Impoundment
- ZoE 4 – Searsburg Bypass Reach
- ZoE 8 – Harriman Tailrace
- ZoE 10 – Sherman Tailrace and Deerfield No. 5 Impoundment
- ZoE 12 – Deerfield No. 5 Tailrace
- ZoE 13 – Dunbar Brook, above
- ZoE 14 – Dunbar Brook, below
- ZoE 16 – Deerfield No. 4 Bypass Reach
- ZoE 17 – Deerfield No. 4 Tailrace
- ZoE 18 – Deerfield No. 3 Impoundment
- ZoE 19 – Deerfield No. 3 Bypassed Reach
- ZoE 20 – Deerfield No. 3 Tailrace
- ZoE 22 – Deerfield No. 2 Downstream Reach

This Standard is appropriate since no endangered or threatened species were identified as occurring within these ZOEs.

Standard F-4 – Acceptable Mitigation was selected for the remaining eight ZOEs, each of which has one or more listed species records in the ZOE:

- ZoE 1 – Somerset Impoundment
- ZoE 5 – Searsburg Downstream Reach
- ZoE 6 – Harriman Impoundment
- ZoE 7 – Harriman Bypassed Reach
- ZoE 9 – Sherman Impoundment
- ZoE 11 – Deerfield No. 5 Bypassed Reach
- ZoE 15 - Deerfield No. 4 Impoundment
- ZoE 21 - Deerfield No. 2 Impoundment

Standard F-4 is defined in the LIHI handbook as:

> *"If a newly listed species has been determined to be present by an appropriate resource agency subsequent to the establishment of environmental requirements at the facility, and no incidental take permit or statement, biological opinion, habitat conservation plan, or similar government document relevant to the facility exists, and the facility is implementing significant, agency-approved measures to avoid or minimize the impact of the facility on that listed species."*

The state endangered or threatened species identified as being onsite are not "newly listed" (i.e. only recently classified as such). However, they are species which have been identified onsite "*subsequent to the establishment of environmental requirements at the facility*" (i.e. no requirements in the SA, FERC license or WQCs), and GRH is implementing agency-approved measures to minimize impacts to these species, which are other descriptors in LIHI's definition for Standard F-4. However, Standard F-3, defined below, may also be considered appropriate for those in Massachusetts, since there is an existing approved plan for Best Management Practices (BMPs) developed by state specialists for those onsite activities. I believe the state-developed BMPS could be considered "*similar government documents*" that address the items noted below.

> *"The facility is in compliance with relevant conditions in a species recovery plan, with relevant conditions in an incidental take permit or statement, biological opinion, habitat conservation plan, or similar government document and the incidental take document and/or biological opinion issued relevant to the facility was designed to be a long-term solution for protection of the listed species*."

In either case, I believe that GRH is conducting the activities that meet the intent of either Standard. As discussed later, while a PLUS credit was not part of GRH's application, my review suggests that the activities currently being performed at the site to minimize impacts to endangered, threatened **and** species of special concern appear to satisfy PLUS standard requirements for ZOEs as explained further below. Supplemental data provided by GRH is included in Appendix C.

When the Deerfield River Project was licensed in 1997, the common loon (*Gavia immer*) was listed as endangered in Vermont and operating constraints were established at Somerset Reservoir, where approximately 14 mating pairs were known to nest. Though the loon was removed from the VT endangered list in 2005, it is currently listed as a "vulnerable" species with a "moderate risk of extinction\extirpation due to restricted range, relatively few populations or occurrences (often 80 or fewer), recent and widespread declines, or other factors."[22] In Massachusetts, it is a species of special concern, although loon currently are not nesting on the lower reservoirs. GRH continues to manage the reservoir for loon nesting. The loon population in Vermont has grown from a range of 13 to 16 breeding pairs in 1989, to just over 100 currently, and there are estimated to be 300 to 500 adult loons in the state during the summer months (VDF&W 2020)[23]. On Somerset Reservoir, while the number of mating pairs recently has been less than when the management activities were developed and approved, now two to four breeding pairs nest each year and have produced 45 loons since 1978 (personal communication Eric Hanson, Vermont Center for Ecostudies, included in the LIHI application). Nonetheless, GRH continues the same activities in close coordination with VDF&W to support the nesting that continues to occur. Based on verbal communication with GRH, the Project has even been extending the time period from early July to the end of July at the request of VDF&W, that the impoundment elevation is being specifically managed to support successful fledging of the loon chicks.

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[22]https://vtfishandwildlife.com/sites/fishandwildlife/files/documents/Learn%20More/Library/REPORTS%20AND%20DOCUMENTS/NONGAME%20AND%20NATURAL%20HERITAGE/ENDANGERED%2C%20THREATENED%20AND%20RARE%20SPECIES%20LISTS/Rare%20and%20Uncommon%20Animals%20of%20Vermont.pdf

[23] Copies of these communications are included in the LIHI Application.

Prior to the 1997 relicensing, the tubercled orchid (*Platanthera flava var. herbiola*), a threatened species in Vermont, occupied the Searsburg and Harriman bypassed reaches. Increased minimum flows to the reaches, as required by License Article 405, would negatively impact the plants survival. In accordance with License Article 419, a Tubercled Orchid Mitigation and Monitoring Plan to protect the orchid and its habitat from the effects of increased flows was prepared in consultation with VANR. The Plan included provisions for: 1) relocating and maintaining populations of the orchid affected by the increased flows; 2) monitoring the success of the relocated plants; 3) a monitoring schedule; 4) mapping the specific transplant and monitoring locations in relation to project features; and 5) conducting follow-up work if the relocated orchid populations fail to survive. All provisions of the Plan were successfully carried out and the Project owner at the time, filed its final report on December 31, 2002. The report provided a summary of monitoring methods and results for the five-year effort, which indicated that, as a result of transplanting, monitoring, seeding, and identification of new plants over the five years, the orchid had successfully repopulated within the monitoring sites. On March 13, 2003, the VDF&W, Nongame and Natural Heritage Program filed a letter thanking and commending the owner and their consultant on their efforts. On May 9, 2003, FERC acknowledged the report and VDF&W's letter, and concluded that no further action was required.

Review of USF&WS IPAC website for Vermont and Massachusetts counties in the Project area indicate that Northern long-eared bat, a federally threatened species, may occur throughout the Project area and that the Indiana Bat, a federally endangered species, may also be in the Vermont sections. Both bats are endangered on Vermont and Massachusetts lists. Both bat species hibernate in caves and migrate to their summer habitat in wooded areas where they usually roost under loose tree bark of dead or dying trees, and forage in or along the edges of forested areas.

Project operational activities that may involve periodic tree trimming are conducted following the procedures adopted in the Project's NHESP Operations and Management Compliance Plan (NOMCP) developed for Project lands in Massachusetts (further detail is presented later), In Vermont, the VTDF&W is consulted as harvest layouts under the Timber Management Plan are developed as part of the Forest Management Plan wildlife consideration element. In particular in the vicinity of Harriman, where most of the active forestry takes place of late, Northern long-eared bats were discussed specifically. Thus, in both situations, protocols are followed that address protection of these species should they be found onsite.

The tubercled orchid, is one of four state of Vermont threatened or endangered species currently identified by the Vermont Fish and Wildlife's Natural Heritage Inventory as occurring in the area of one or more Zones of Effect. The other species, little brown bat (*Myotis lucifugus*), tricolored bat (*Perimyotis subflavus*), and bald eagle (*Haliaeetus leucocephalus*) are endangered, though the bald eagle has been recommended for down-listing to threatened. One bald eagle nest is identified in the Project area. GRH works with VDF&W via the Audubon Society to monitor the site.

Regarding state-listed species, VANR listed the little brown bat and tricolored bat as endangered due to high mortality caused by white-nose syndrome, a fatal fungus that infects the skin of bats and spreads between individuals in hibernating bat colonies. Both species are categorized as cave bats, hibernating in caves and mines during winter. Management in Vermont is focused on studying the population in relation to white-nose syndrome. The status of the species is not impacted by operation of the Project.

The Atlantic salmon (Gulf of Maine Distinct Population Segment) is a federally endangered species that was extirpated from the Connecticut River and reintroduced through stocking in the 1960's. As previously discussed, resource agency efforts to restore the population were unsuccessful and the program was discontinued in 2013. In 2016, with resource agency concurrence, FERC suspended Atlantic salmon passage efforts associated with the Deerfield River Project.

The shortnose sturgeon is a federally and state (Massachusetts) listed endangered species found in the Connecticut River. The population is thought to be divided between two areas: one landlocked between Turners Falls and Holyoke Dam, and the other below Holyoke Dam to Long Island Sound. The former population has access to the Deerfield River. Tagging studies conducted in the early to mid-1990's, indicate that shortnose sturgeon occasionally use the lower portions of the Deerfield River as a resting area - as a refuge or place to escape from the high flows occurring during April and May in the Connecticut River as they travel up the Connecticut River toward their spawning sites located about 3 miles upstream from the mouth of the Deerfield River (FERC 1996). Sturgeon that entered the Deerfield River generally spent less than a week before returning to the Connecticut River and did not move upstream as far as the Deerfield No. 2 dam.

Three threatened species protected under Massachusetts Endangered Species Act (MESA) are associated with one or more Project facilities. All are vascular plants: American bittersweet (*Celastrus scandens*), muskflower (*Mimulus moschatus*), and sandbar cherry (*Prunus pumila var. depressa*). In accordance with Massachusetts rare species and habitat regulatory requirements, GRH consults with MassWildife's Natural Heritage Endangered Species Program (NHESP) annually to update the Project's NHESP Operations and Management Compliance Plan (NOMCP). The NOMCP specifies routine operations and maintenance tasks undertaken by GRH in the Project area, maps Project areas and the activities that occur within each area, discusses avoidance and minimization of impacts, and identifies control measures in place to mitigate. Areas of impact are minimized, approved methods are employed, and updated tools and techniques are used. Erosion and siltation control measures are used as needed to protect regulated resources. Timing restrictions or seasonal work windows may be developed if there are any species-related requirements. Adaptive management measures would be implemented to protect a resource if needed and would comply with state and federal regulations. Approval of such a plan by NHESP exempts an organization's listed activities from additional regulatory review. To attain approval, the operation and maintenance activities must comply with the Massachusetts Endangered Species Act for state-listed rare species and habitats, as regulated by the NHESP. Should GRH be found in non-compliance with the program, each of its activities would be subject to individual review by the State. GRH has been involved with this program for a number of years and has never been found to be in non-compliance. The non-public version of the LIHI application includes several privileged documents associated with this program, which were reviewed as part of my assessment.

In addition to the three MA-listed threatened species discussed above, Priority Habitat for four species of special concern is managed under the NOMAP. The four species are mountain alder (Alnus viridis ssp. crispa), a vascular plant; ocellated darner (Boyeria grafiana), a dragonfly;

longnose sucker, (Catostomus catostomus) a fish; and the twelve-spotted tiger beetle (Cicindela duodecimguttata). Within the Project area, Priority Habitat mapped for these four species totals 42.5 acres, and for the three threatened species 14.7 acres. The species of concern are found in ZOE #10 (Sherman tailrace), ZOE #11 (D5 bypassed reach), ZOE #15 (D4 impoundment) and ZOE #21 (D2 impoundment). The threatened species are also found in three of these four zones.

GRH's NOMACP is implemented for all three classes of species protected under Massachusetts Law, while LIHI's criterion standard addresses only endangered and threatened species. The LIHI requirements to qualify for PLUS stated in Section 3.2.6 include the following. I added the numbers to emphasize my interpretation.

> *"The facility has 1) established an enforceable agreement with resource agencies to operate the facility in support of rare and endemic species, 2) is implementing proactive measures to substantively minimize impacts on species which are at risk of becoming listed species in the vicinity of the facility in the future, or 3) the facility is a significant participant in a species recovery effort."*

My interpretation of this is that there are three alternative pathways to meeting this standard. Based on review of the LIHI application and follow-up data provided by GRH, I believe that by implementing their NOMACP for species of special concern, which are so designated as they are at "risk", in addition to listed species, the Project satisfies the second pathway. However, LIHI Handbook Table B.2.6 suggests that an "enforceable agreement" is required for all three pathways Even with this inconsistency, I believe that agency approval of the agreement to implement the NOMACP for the Massachusetts ZOEs for Species of Special Concern is an "enforceable agreement. Thus, I believe the Project satisfies this criterion and qualifies for extra years of certification for the activities conducted in affected ZOEs.

The Project Passes Criterion F and PLUS Credit – Threatened and Endangered Species Protection

G. CULTURAL AND HISTORIC RESOURCE PROTECTION

Goal: The Facility does not inappropriately impact cultural or historic resources that are associated with the Facility's lands and waters, including resources important to local indigenous populations, such as Native Americans.

Assessment of Criterion Passage

The Applicant has selected **Standard G-2 – Regulatory Recommendations** for all ZOEs as the Project is required to comply with License Article 428, which provides for cultural resources protection, via implementation of a Programmatic Agreement (PA) executed in 1996 between FERC, the Advisory Council on Historic Preservation, the Vermont State Historic Preservation Officer (VTSHPO) and the Massachusetts State Historic Preservation Officer (MASHPO). The PA specified that a Cultural Resources Management Plan (CRMP) be developed by the Project owner. The CRMP was completed and approved in 1999.

The hydroelectric facilities are considered eligible for listing in the National Register of Historic Places (Register). While not officially on the National Registry, having an "eligible" determination appears to carry the same compliance requirements. Forty standing structures were identified as eligible for the Register based on a survey conducted in 1994, as noted in the CRMP. During the archeological surveys, twenty-five documented and two undocumented historic sites were identified at six Project developments, consisting of nineteenth and twentieth century residences, mill/factory complexes, mining complexes, schoolhouses, bridge abutments, and one family cemetery. An historical summary of the Project prepared for the owner by the Public Archeology Laboratory Inc. is provided in Appendix B-6.5 in the LIHI application.

The CRMP includes mitigation measures for the historic properties, including an evaluation of any site that will be impacted by an activity. The LIHI application, Appendix B-6.6, provides a tabulated summary of consultation for activities within Project Zones of Effect for which the MA or VT SHPO was consulted, in accordance with the CRMP. The table also includes a summary of the findings and links to comments from the SHPOs. Most activities were deemed to have no impact on cultural resources, and any follow-up actions were completed, with the except of one. The outstanding activity, removal of a storage building at Deerfield No. 2 development planned for early 2021, is still awaiting comments from the Town of Conway Historical Commission (CHC) in order to complete the MA SHPO's recommended actions, including execution of a MOA incorporating any CHC comments. As also required by the CRMP, all of the archeological sites were monitored to establish a condition baseline. A Historic American Building Survey/Historic American Engineering Record of the historic buildings and structures was also conducted. This baseline information is updated at 10-year intervals, through visual inspections by a qualified professional architectural historian; the last 10-year report was filed in December 2011 and was linked to the LIHI application.

The CRMP also integrates cultural resource management into the GRH's master planning process for the Project. Cultural resources are evaluated during planning for any alterations to Project facilities, and consultation with the appropriate SHPO is initiated if activities could impact those resources. Annual reports filed with FERC and the two SHPOs summarize these evaluations and document consultation. The 2020 report was linked to the LIHI application. Others are available on the FERC eLibrary and were reviewed as part of this assessment.

Based on my review of the application materials and FERC eLibrary data, it is clear that GRH is committed to ensuring Project operations and onsite activities are performed in careful compliance with the requirements established for the Project to ensure protection of onsite archaeological and historical resources. I believe the Project continues to satisfy this criterion.

The Project Passes Criterion G – Cultural and Historic Resource Protection

H. RECREATIONAL RESOURCES

Goal: The facility accommodates recreation activities on lands and waters controlled by the facility and provides recreational access to its associated lands and waters without fee or charge.

Assessment of Criterion Passage

The Applicant has selected **Standard H-2, Agency Recommendation** for all Project ZOEs.

There are three FERC license articles associated with recreational needs. These were based on agreements made during the Settlement Agreement negotiations and using the proposed Comprehensive Recreation Plan filed in 1991 as part of the re-licensing.

- Article 423 - required filing of a supplemental recreation information document to the project's Comprehensive Recreation Plan.
- Article 424 - required filing of a plan to construct, operate and maintain a canoe portage facility at the Searsburg dam and put-in area below the dam.
- Article 425 - required filing of an Instream Recreation Safety Study Plan to examine gradual rates of change in river flow (ramping rates) for the safety of recreational users.
- Article 426 - required filing of a plan to implement specified releases at the Deerfield No. 5 dam for whitewater boating.

In the LIHI Application, GRH provided a link to the Final Completion Status Report for the Deerfield River Project Comprehensive Recreation Management Plan, which documents completion of all facilities required by the license articles. Safety devices such as signage, warning lights, sirens, and recorded messages are in place to ensure that recreational users, particularly fishermen, are properly warned of sudden changes in discharge flows. The location of each safety device is specified in the Company's Public Safety Plan filed with FERC and updated when changes are made or at least every 10-years.

In total, GRH maintains 16 trails, 15 picnic areas, eight boat launches, four carry-in/out put-in and take-out access areas, one angler access area at Deerfield No. 4, whitewater put-in and take-out facilities at Deerfield No. 5, and F. J. Malley Park located between Deerfield No. 3 and No. 4. (See Appendix D). Originally, five informal campsites at the Somerset Reservoir were proposed for limited upgrading, however due to the potential disturbance to nesting pairs of loons that nest largely on the same islands that were designated for this enhancement, at the request of VTDF&W, and with the support of the loon restoration program managers (now Vermont Center for Ecostudies), plans for camping on Somerset were eliminated**.**

Photographs of many of the recreational facilities can be found in the Final Completion Status Report. In addition, the Company maintains minimum reservoir levels for open water recreation (e.g., boating) at Somerset and Harriman reservoirs. These reservoir restrictions have been incorporated into the Project's water management and operations protocols. Access to Project lands and the river is allowed without fee, however access to areas close to the powerhouses is prohibited due to public safety concerns. Recent safety measure changes at two locations identified by CRC are discussed below.

GRH provides a 24-hour telephone and website (http://h2oline.com) that lists the anticipated schedule for the next day flows, generally posted by the afternoon after the ISO-NE releases the anticipated generation schedule. GRH also provides real-time (within last 10 minutes) flow or discharge information in addition to the anticipated schedule. The information is available by phone or through its FlowCast website hosted by H2Oline.com. The information provided is typical for the hydropower industry.

Scheduled releases from the Deerfield No. 5 Dam are provided for whitewater boating. Releases occur for at least four continuous hours on Fridays starting at 11:00 a.m., at least five continuous hours on Saturdays starting at 10:00 a.m., and at least four continuous hours on Sundays starting at 10:00 a.m. The schedule provides for 26 weekend days or holidays and six Fridays from May 1 to October 31 annually. GRH meets annually with representatives of citizens groups, including New England FLOW, before January 1 of each year, in order to collaboratively develop the whitewater release schedule for the coming summer. An annual schedule is published by April 1 each year following further consultation with these citizens groups. The release schedule is developed several months prior to the first release date and distributed to all interested boating and fishing groups that disseminate it, or publish it as they see fit. GRH publishes it on the same Waterline site for D5 used to provide scheduled and real-time flow information at all its facilities.

FERC conducted an environmental and public use inspection of the Deerfield Project on August 2 and 3, 2018, which included inspection of all Project recreational facilities. As stated in FERC's October 1, 2018 letter "the project was found to be in compliance with the license articles related to fish and wildlife, recreation, public safety, and cultural resources. No follow-up items or non-compliance matters were identified during the inspection of the project."

Comments, Assessment and Conclusion

Only CRC commented on recreational features at the Project. One comment raised concern about two locations, near Deerfield No.3 powerhouse and the Stillwater Bridge, in which CRC claimed GRH had restricted access to the river on sections of its lands and reduced parking spaces. In response to my inquiry, GRH provided a detailed explanation of the reasons for the changes at Deerfield No. 3 powerhouse and the Stillwater Bridge (see Appendix C). They noted that the fencing at Deerfield No. 3 blocked access to the forebay, essentially a steep-sided canal not the river itself, and is something common to all other Project powerhouses. Regarding the guard rail issue at the Stillwater Bridge, GRH reported that this access is not a formal recreational area and is in part, owned by the Commonwealth of MA. They also noted that recently at the request of the Town of Deerfield police and with town official knowledge, GRH installed a cable that limited areas that were being used improperly or illegally This did not reduce legal parking spaces, but simply cut off unauthorized access including driving of vehicles into the Deerfield River or parking in the shallow shoals exposed under low flow conditions. In short, both were done for public safety reasons and/or to prevent illegal activities.

CRC raised questions about publication of flow information for river users and suggested certain additional flow information should also be provided, including historical data from the past day. New information provided to LIHI by GRH has been incorporated into this report's description of the posted public information, noted above. I believe since GRH provides real-time flow data typical for the hydropower industry, no changes to the published data are needed to satisfy this criterion.

CRC also questioned if FERC inspected all facilities and suggested LIHI should require GRH to provide a checklist and photographs of each recreational feature to confirm compliance. While the FERC inspection report did not include photographs of each facility, GRH confirmed in follow-up communication that in fact all were inspected and found in compliance. It is not LIHI's protocol to require independent confirmation of FERC's findings, and LIHI has traditionally accepted FERC inspections as sufficient evidence of compliance but would consider additional information provided either by the Applicant or stakeholders.

CRC also made several suggestions on ways to improve public knowledge of the many recreational facilities at the Project to enhance their use. A condition has been recommended to address the majority of the suggestions made by the CRC.

Based on my review, I believe that the Project continues to conditionally satisfy this criterion.

The Project Conditionally Passes Criterion H – Recreational Resources

IX. GENERAL CONCLUSIONS AND REVIEWER RECOMMENDATION

Based on my review, I believe that this Project conditionally continues to meet the requirements of a Low Impact Facility. I have recommended three conditions. The first two are recommended to confirm satisfaction of the *Upstream and Downstream Fish Passage* and *Recreational Resource* Criteria. As I reviewed the documents associated with the turbine replacement project at Deerfield No. 5, planned for the spring of 2022, I consider that unit to be included in this Certification. However, Condition #3 is recommended to confirm compliance with the requirements of that replacement.

I also believe it satisfies the requirements for PLUS credit for the *Shoreline and Watershed Protection* and *Endangered and Threatened Species Protection* criterion, as discussed under these criteria. If both PLUS credits are approved, such satisfaction would qualify the Project for five extra years of certification for a total of 10 years.

The original certification of the Deerfield Project had two conditions, both of which were based on agency-driven requests. My recommendation is that the second one, noted below, should not be carried forward as it is a standing FERC license requirement under by Article 414 and the VT WQC Condition H. GRH's good compliance record and completeness of their LIHI annual compliance submittals would ensure LIHI's knowledge of its implementation. However, I have incorporated the original first Condition into Condition #1 below.

- *Former Condition 2: If the State of Vermont requests modification of the Project or its operation at Harriman Dam to address temperature and/or dissolved oxygen concerns pursuant to Article 414 of the Project FERC license, the Project owner shall so notify LIHI within 30 days and shall enter into, and provide LIHI with a copy of, an agreement reached among the Project owner and the State of Vermont to address those concerns. The Agreement must be finalized within 120 days of the request for Project modification and must include a description of the planned measures and the implementation schedule for those measures. The agreement shall be filed with LIHI within 30 days of its execution.*

I recommend the following conditions to confirm criteria satisfaction (note: conditions were modified and approved as modified below by the Technical Committee of the LIHI Governing Board):

- Condition 1 – If the USF&WS or state resource agencies request upstream and/or downstream American eel passage facilities at the Project during the certification term, the Project Owner shall notify LIHI within 60 days of the request(s). LIHI will review the request to determine whether it meets the LIHI definition of “science-based agency recommendation”. If so, the Project Owner shall initiate consultation with the relevant agency(ies) within 90 days to develop a mutually acceptable plan and schedule for phased implementation at one or more of the Project developments. The Project Owner shall provide LIHI with documentation that includes a description of the passage facility(ies), any additional protection measures, and the implementation schedule for design, installation, and operation. The agreement, and subsequent status of passage implementation, shall be provided to LIHI in annual compliance statements.

- Condition 2 – By April 30, 2022, the Project Owner shall provide and maintain information on available recreation opportunities at the Project on the company website including but not limited to one or more maps showing the locations and types of facilities as well as additional information such as permissible times of use and both permissible and restricted activities (if appropriate). The annual whitewater release schedule for Deerfield No. 5 Dam will also be posted to the website as well as links to anticipated and real-time flow information below Project dams. The Project Owner shall post and maintain conspicuous signs, where permissible, at access points that identify and direct people to project recreation facilities. The status of these actions shall be reported to LIHI in the annual compliance submittal in 2022.

- Condition 3 – The Owner shall provide a status update of the Deerfield No. 5 minimum flow unit installation and initial operation in the first annual compliance statement after the unit becomes operational. The update shall identify any deviations from the expected design or operating conditions approved by FERC. LIHI reserves the right to require additional information and conduct additional review of impacts if changes in design or operation occur that could affect one or more LIHI criteria.

- Condition 4 – In order to retain the PLUS standard for Threatened and Endangered Species, the Owner shall report to LIHI within 60 days of any instances of non-compliance or any agency compliance concerns with the Massachusetts NHESP Operations and Management

Compliance Plan (NOMCP). The Owner shall also report within 60 days if the NOMCP is no longer in effect. In either event, LIHI will review the information and determine if the PLUS award is still applicable.

Appendix A

Mapping of Zones of Effect

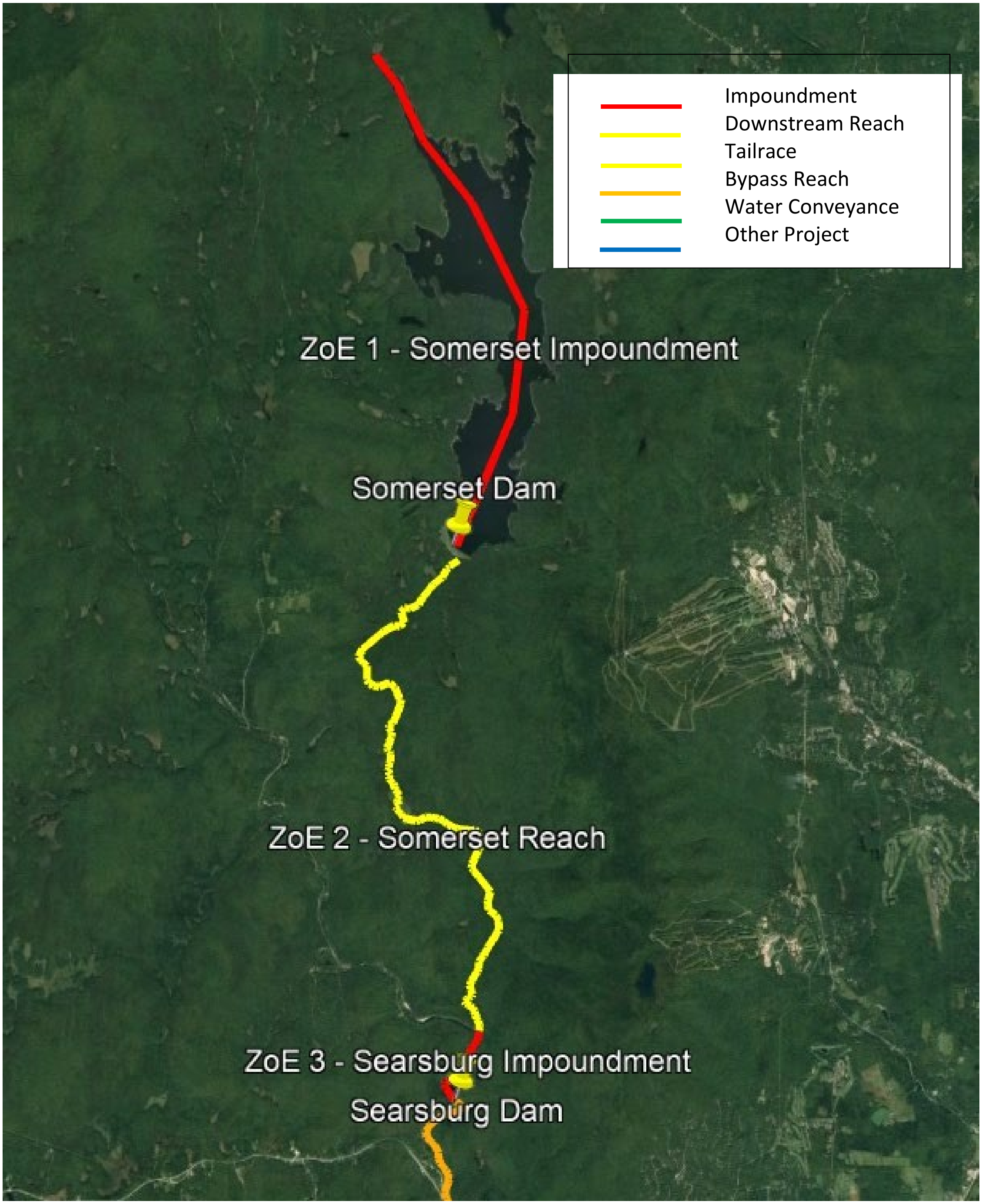


Figure A-1 – Somerset Development

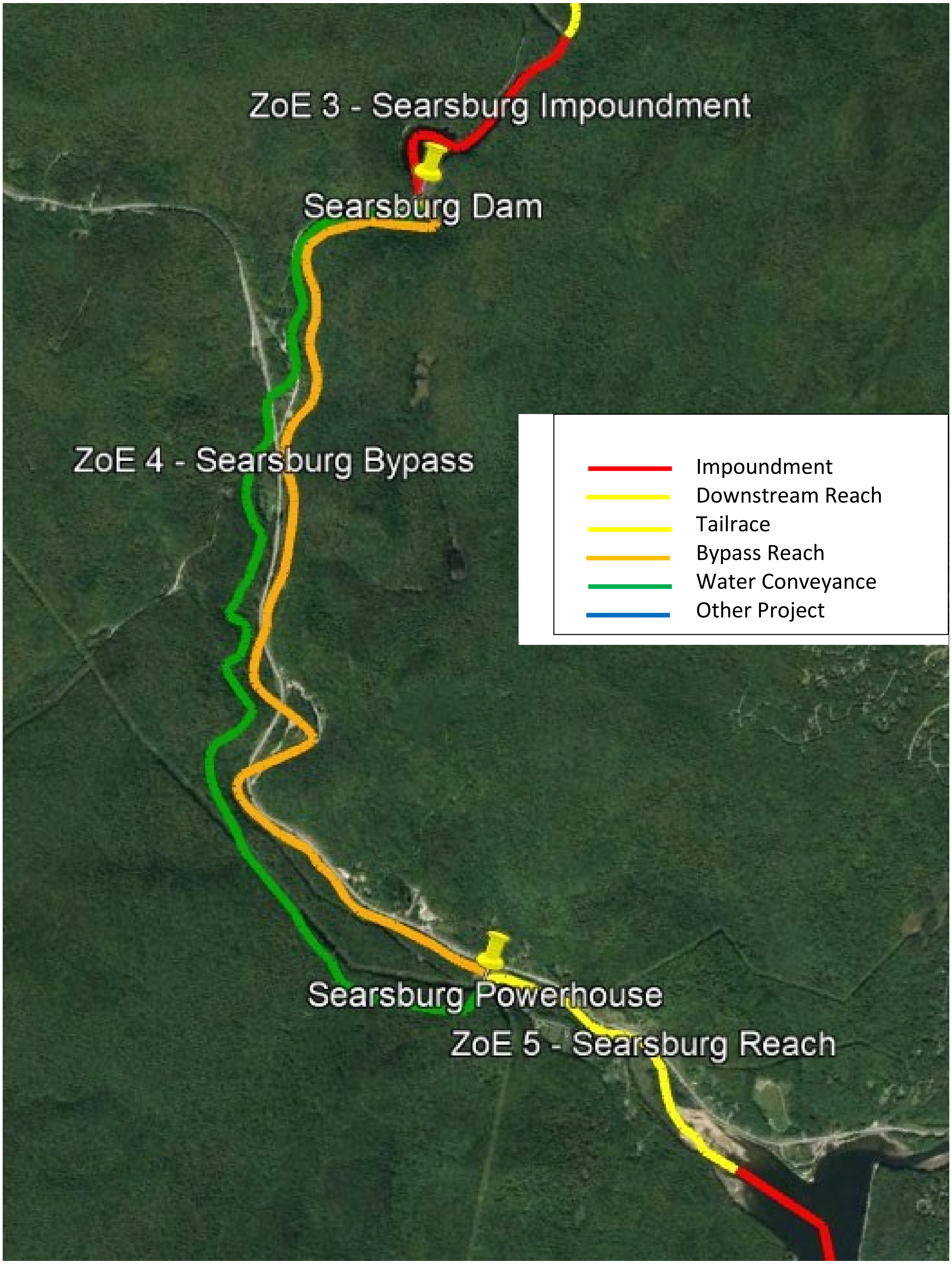


Figure A-2 – Searsburg Development

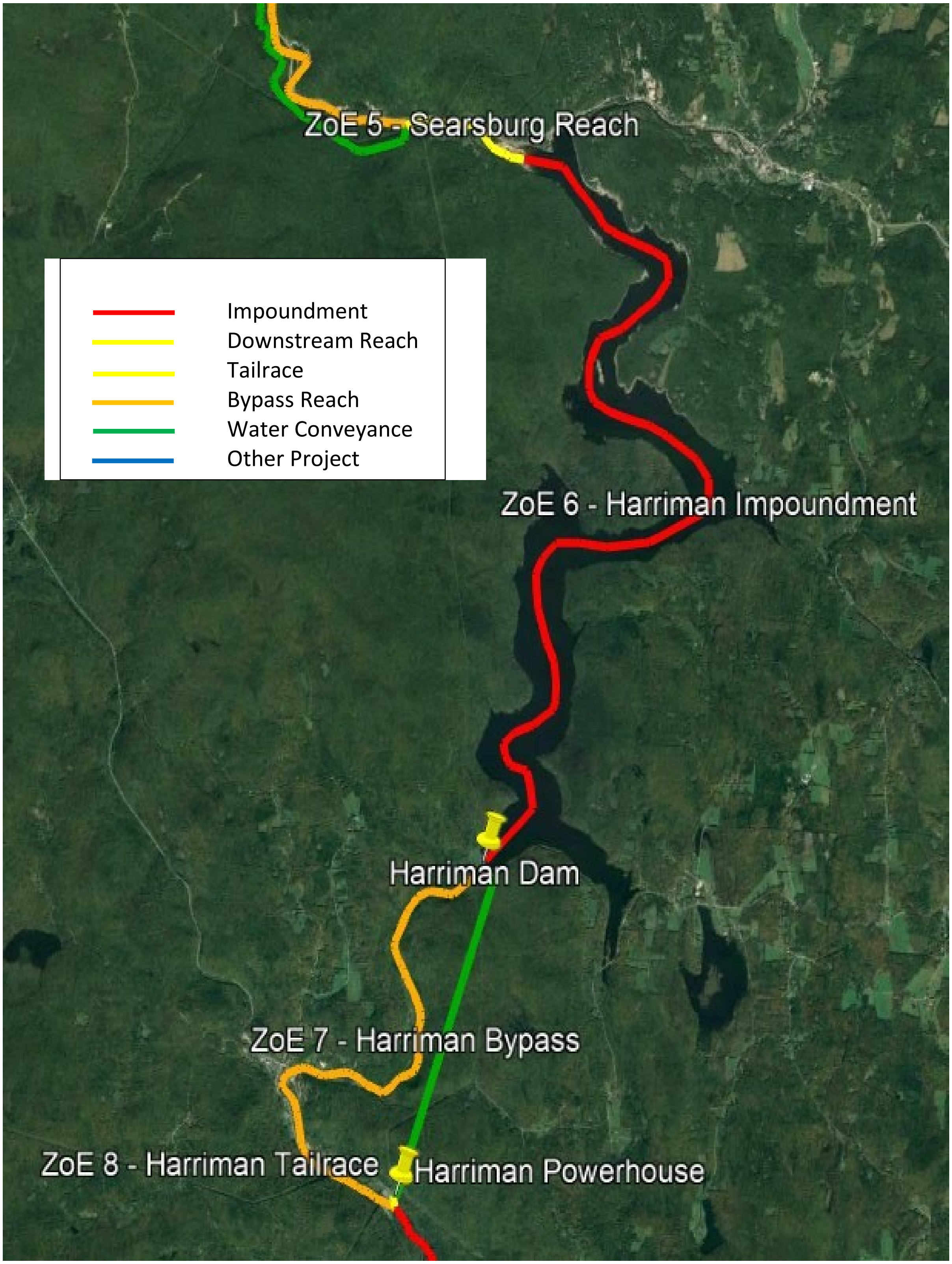


Figure A-3 – Harriman Development

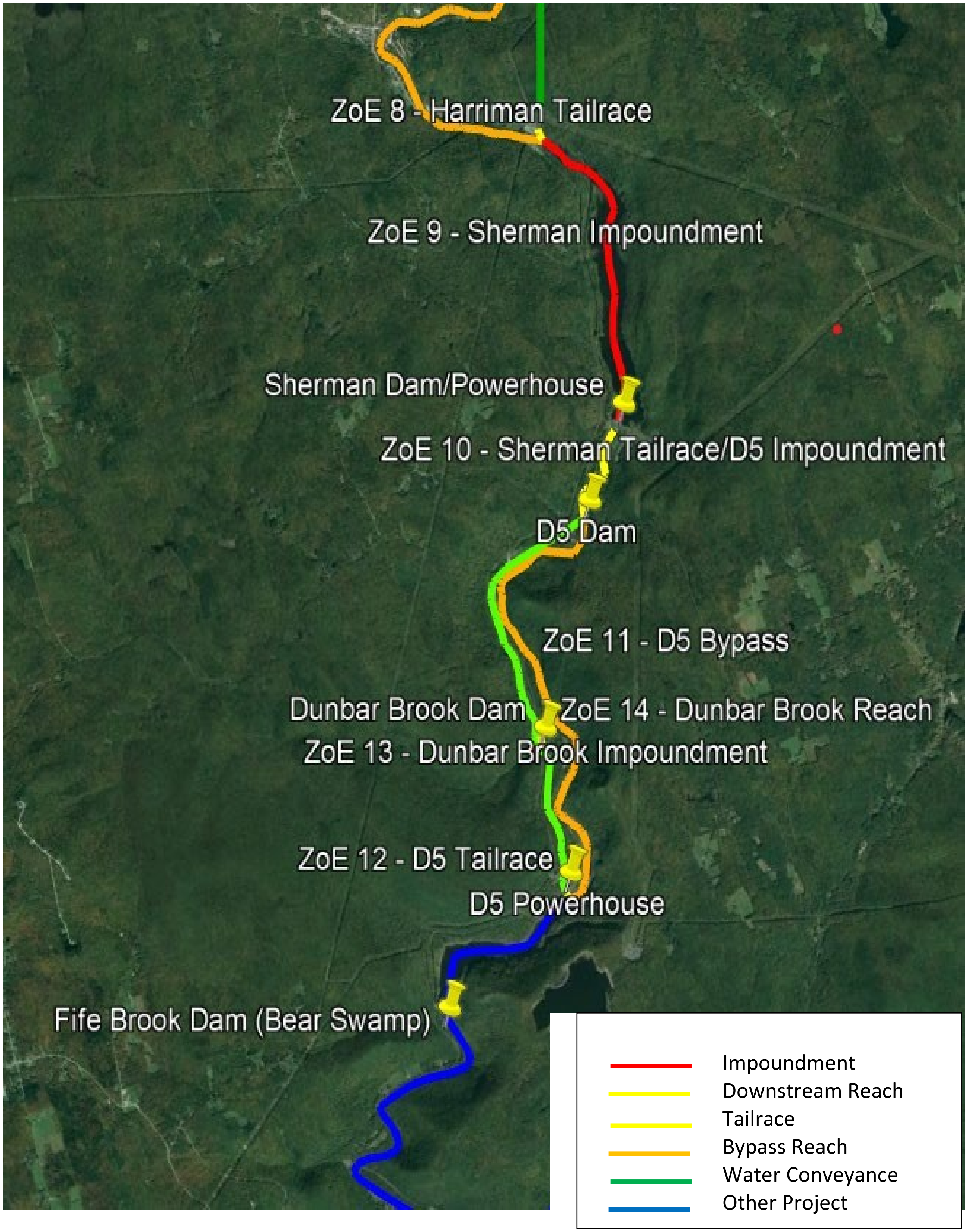


Figure A-4 - Sherman and Deerfield No. 5 Developments

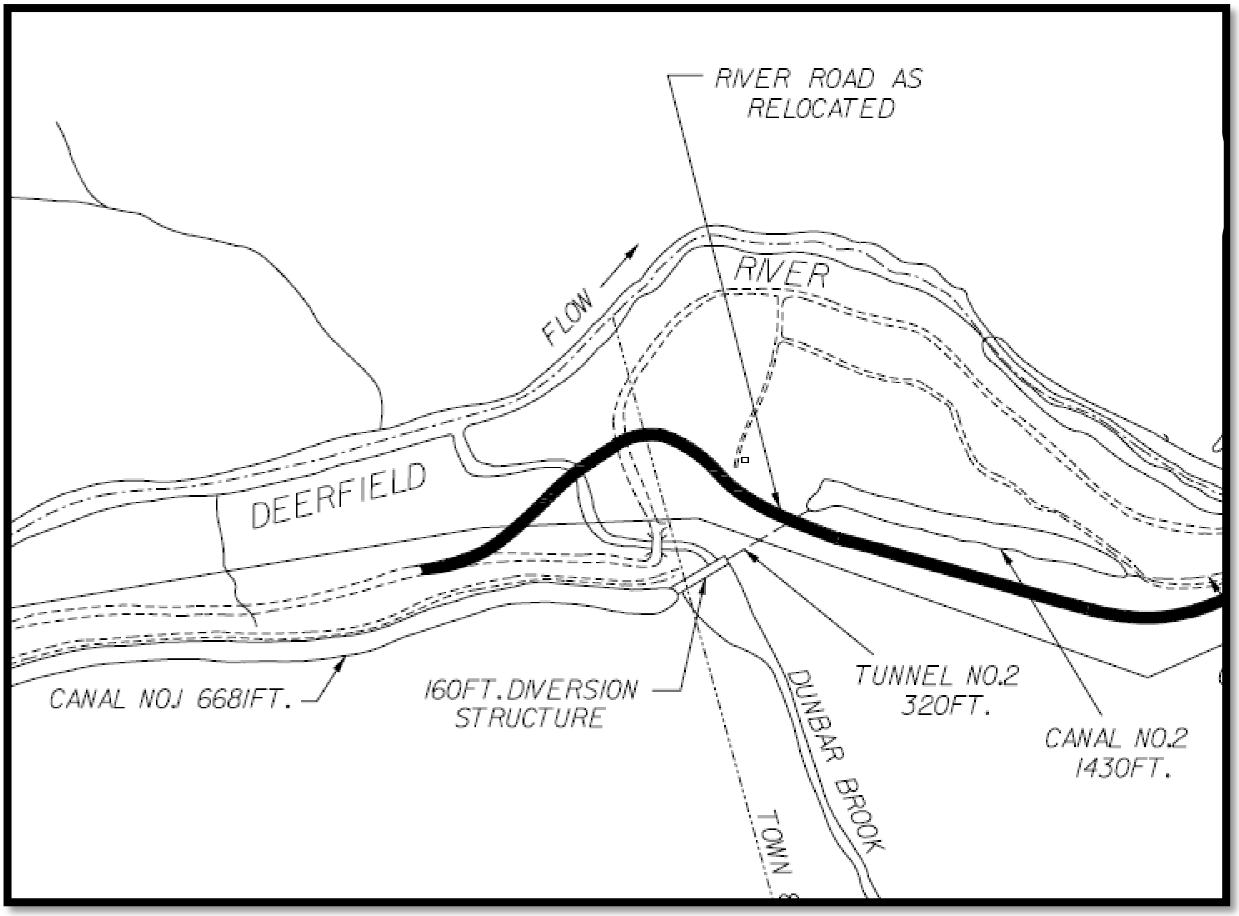


Figure A-5 - Dunbar Brook

Integration of Dunbar Brook with Deerfield No. 5 canal and tunnel structure. The system is such that water surface elevation in Dunbar Brook remains the same as that in the adjacent canal and tunnel.

Figure A-6 - Fife Brook Development

Development is under the Bear Swamp Pumped Storage Project, FERC No. 2669, owned by Bear Swamp Power Company and not part of GRH's Deerfield River Project.

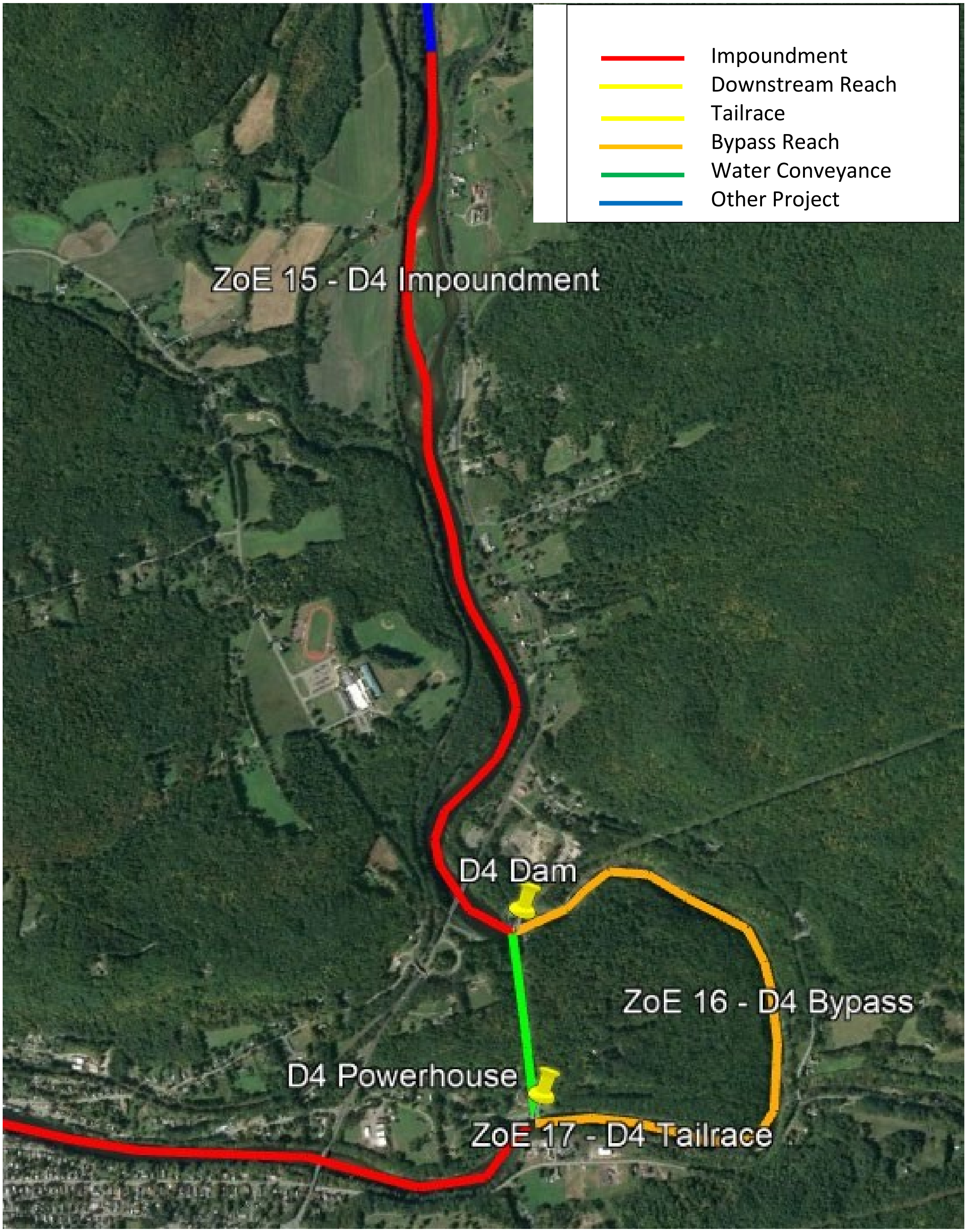


Figure A-7 - Deerfield No. 4 Development

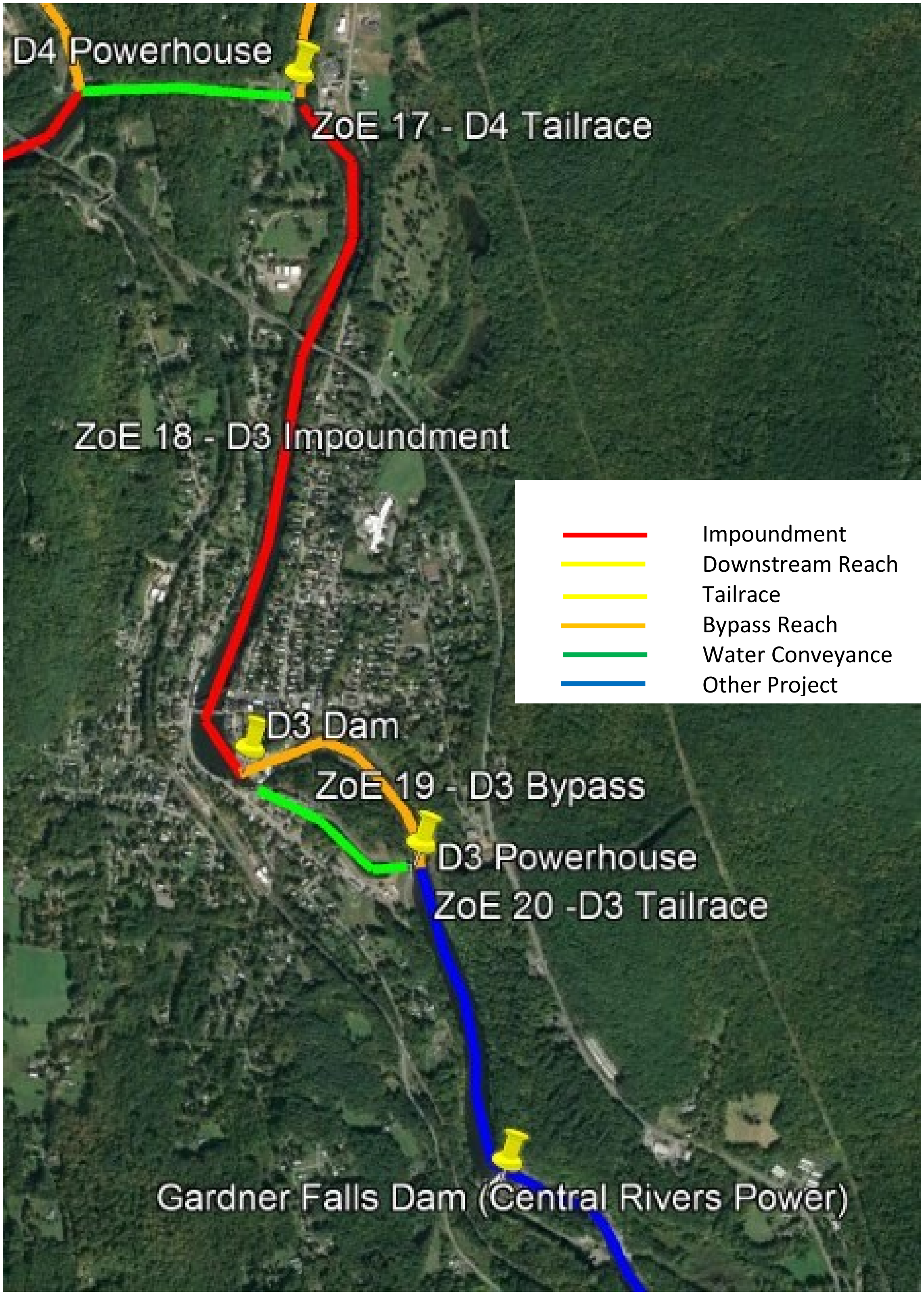


Figure A-8 - Deerfield No. 3 Development

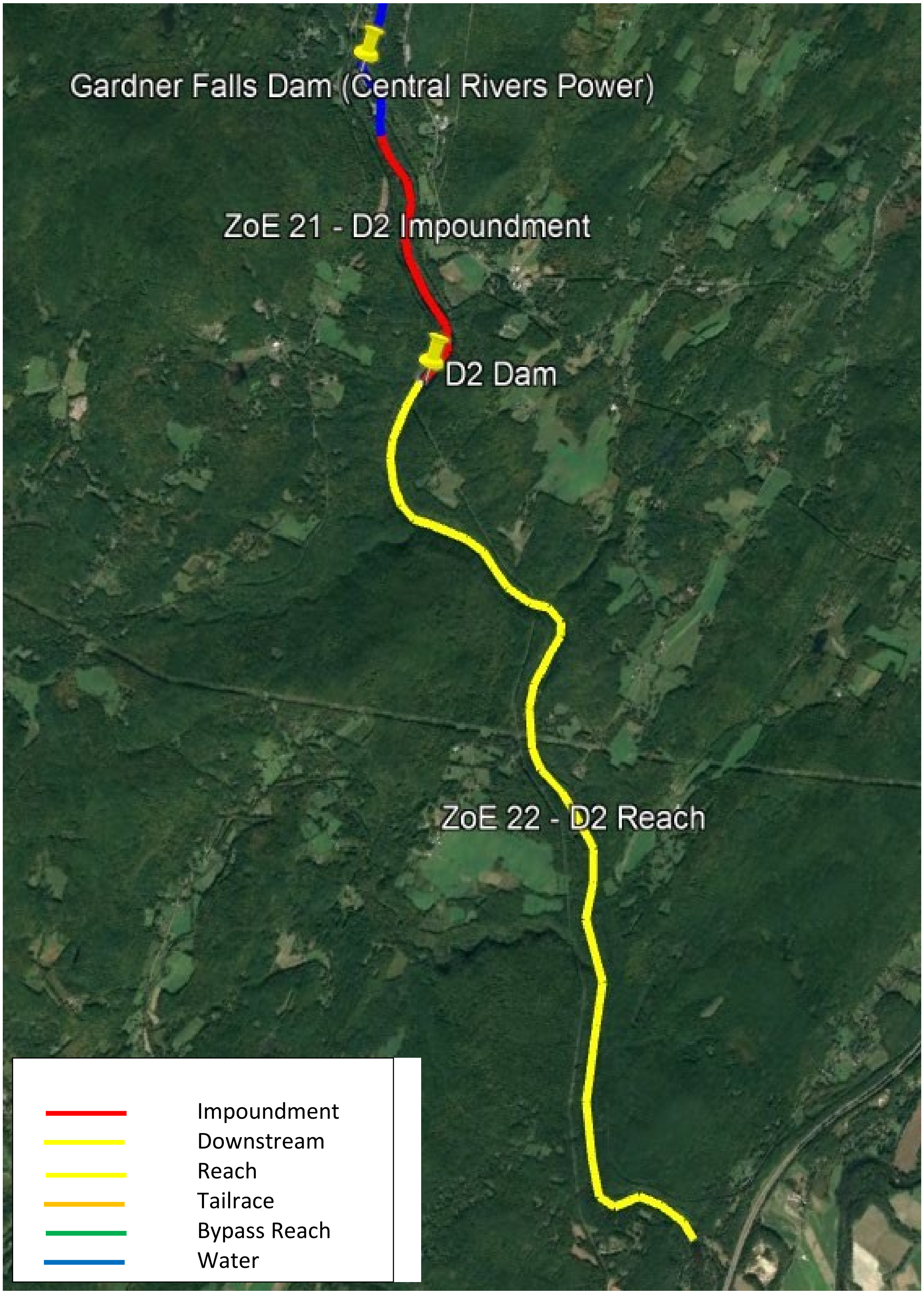


Figure A-9 - Deerfield No. 2 Development

Appendix B

License Deviations Since 2012

Event Date	Project - Event	GRH Filing	FERC response letter	FERC decision	Notes
6/12/2013	Somerset - elevation deviation	6/21/2020	11/25/2013	No violation	A storm event produced heavy inflows that surpassed the discharge capacity of the dam. Inflows eventually exceeded gate capacity and the reservoir surcharged slightly above the allowable loon nesting elevation limit before inflows receded.
6/12/2013 6/14-15/2013	Harriman - elevation deviation	6/21/2013	11/25/2013	No violation	High flow during the stable or rising constraint period resulted in inflow exceeding station capacity which resulted in spill at the “Glory Hole” spillway. During active spill over the crest (there are not operating gates at the spillway), as inflows drops so does the reservoir elevation.
7/2/2013 7/8/2013	Harriman - pre-planned min flow reduction	7/11/2013	11/25/2013	No violation	Pre-planned minimum flow reductions for less than 2 hours each day, to facilitate dam safety inspections of the spillway tunnel at Harriman Dam.
8/29/2013 8/30/2013	Harriman - pre-planned min flow reduction	9/9/2013 10/15/2013	No letter issued	No letter issued	Pre-planned minimum flow reductions for less than 2 hours each day, to facilitate dam safety inspections of the spillway tunnel at Harriman Dam.
4/20/2014	Searsburg - minimum flow reduction	4/30/2014	7/1/2014	No violation	The single station generator tripped off-line due to a plugged cooling water strainer and minimum flow was interrupted before flow from the dam reached the station tailrace.
8/19/2014	Deerfield No. 4 - minimum flow reduction	8/28/2014	1/26/2015	No violation	Flow was reduced to facilitate re-installation of 4-foot high flashboards.

Event Date	Project - Event	GRH Filing	FERC response letter	FERC decision	Notes
10/3/2014	Deerfield No. 2 - minimum flow reduction	10/14/2014	1/26/2015	No violation	Unit 1 went off-line and minimum flow was interrupted due to equipment malfunction.
5/25-6/1/2015	Harriman - elevation deviation	6/4/2015	No letter issued	No letter issued	Natural inflow was insufficient to maintain conflicting license constraints of 'stable or rising' and guaranteed minimum flows from storage through the basin. Elevation deficit was less than 0.22 ft.
6/16/2015	Deerfield No. 4 and No. 3 - minimum flow reduction	6/24/2015	9/21/2015	Violation - no enforcement action taken	The seasonal fish passage flow requirement ended at midnight on 6/15. The gates providing both fish and minimum flows were shut. When the minimum flow alarm signaled, it was misinterpreted as a fish passage flow alarm. The following mitigation measures were implemented to prevent a similar deviation from happening in the future: (a) changes made to the SCADA alarm controls to add a second alarm distinct from all other alarms, specific to each minimum flow requirement. The minimum flow alarms cannot be cleared until flow rates are adequately provided; (b) instituted new Site Specific Instructions for scheduling and terminating license required operations such as downstream passage termination; and (c) reviewed this incident with all control center operators for quality management and best practices improvements.
8/4/2015	Deerfield No. 2 - minimum flow reduction	8/4/2015	9/21/2015	No violation	The station tripped off-line due to a transmission line fault and minimum flow was interrupted.

Event Date	Project - Event	GRH Filing	FERC response letter	FERC decision	Notes
9/6/2016	Deerfield No. 2 - minimum flow reduction	6/20/2016	9/1/2016	No violation	The station tripped off-line due to a transmission line fault. Line is owned and operated by National Grid.
8/13/2016	Deerfield No. 2 - minimum flow reduction	8/19/2016	11/16/2016	No violation	The station tripped off-line due to a transmission line fault. Line is owned and operated by National Grid.
12/18/2016	Somerset - down ramping rate exceeded	12/18/2016	2/2/2017	No violation	A 2.5-hour, pre-mature timing of the reduction was operator oversight in an attempted to manage downstream flow and reduce spill at Searsburg Dam as river flow increased rapidly due to heavy rain occurring earlier than forecasted.
4/30/2017	Searsburg - minimum flow reduction	5/10/2017	6/29/2017	No violation	An operating emergency beyond our control - a rapid build-up of debris on the trash racks caused a decrease in generation, and therefore minimum flow. The unit automatically backed down to 1 MW, a programmed safety measure to ensure the stability of the trash racks. Flow was maintained at 75% of required flow and was promptly restored to 100%.
6/6-8/2017	Somerset - reservoir elevation fluctuation deviation	5/16/2017	9/20/2017	No violation	Multiday rain event caused inflow to exceed gate capacity and our ability to limit elevation within the fluctuation restriction. Operators made every attempt to maintain the elevation within the allowable range (matching discharge to inflow), until inflow exceeded gate capacity.
8/3/2017	Deerfield No. 2 - minimum flow reduction	8/10/2017	10/19/2017	No violation	Lightning caused a transmission line fault that tripped the power station.

Event Date	Project - Event	GRH Filing	FERC response letter	FERC decision	Notes
9/9/2017	Deerfield No. 2 - minimum flow reduction	9/19/2017	10/9/2017	No violation	Lightning caused a transmission line fault that tripped the power station.
5/9/2018	Searsburg - minimum flow reduction	5/21/2018	7/12/2018	No violation	An operating emergency beyond our control when a rapid build-up of debris on the trash racks caused a decrease in generation, and therefore minimum flow. The unit automatically backed down to 1 MW, a programmed safety measure to ensure the stability of the trashracks. Flow was maintained at 75% of required flow and was promptly restored to 100%.
6/9-15/2018	Harriman - elevation deviation	6/25/2018	7/26/2018	No violation	Sustained natural dry conditions resulting in low inflow to the reservoir. The only outflow was to maintain required minimum flow from storage.
6/4/2019	Harriman - reservoir elevation, stable or rising deficiency	6/14/2019	8/1/2019	No violation	Caused primarily by inaccurate estimation of instantaneous inflow from the 180-mile drainage basin. Operators managed elevation and flow constraints upstream with ISO-NE flow schedules while natural inflow dropped rapidly overnight.
6/9/2019	Harriman - reservoir elevation, stable or rising deficiency	6/14/2019	8/1/2019	No violation	Caused by a combination of factors including inaccurate estimation of instantaneous inflow from the 180-mile drainage basin, uncalculated flashboard leakage, and lack of anticipated elevation correction after brief operation.

Event Date	Project - Event	GRH Filing	FERC response letter	FERC decision	Notes
6/8-15/2020	Harriman - reservoir elevation, stable or rising deficiency	6/26/2020	9/14/2020	No violation	With state agency concurrence, and due to emergency low water conditions in the Deerfield River, downstream minimum flows were maintained by allowing Harriman reservoir elevation to drop slightly.
7/28/2020	Deerfield No. 2 - minimum flow reduction	8/11/2020	10/2/2020	No violation	The station tripped off-line due to a transmission line fault and minimum flow was interrupted.
7/30/20 thru 8/4/20	Somerset – reservoir lower elevation limit deviation	8/20/20	None as of 01/16/21		Lower elevation limit for loon nesting period dropped 2.5 inches due to lack of rain and continued release of minimum flows. Done with support of VANR to ensure successful nestling fledging.

Appendix C

Stakeholder Inquiry Responses and Comment Letters and Email Communications with GRH

From: "Crocker, Jeff" <Jeff.Crocker@vermont.gov>
To: "PBMwork@maine.rr.com" <PBMwork@maine.rr.com>
Cc: "Will, Lael" <Lael.Will@vermont.gov>
Bcc:
Priority: Normal
Date: Wednesday January 20 2021 10:07:23AM
RE: Question On Deerfield Project Searsburg Development

Pat,

Thank you for your inquiry regarding Condition M of the Water Quality Certification for the Deerfield hydroelectric project. To date, the Agency has not requested upstream fish passage at the Searsburg dam. However, the Agency may request upstream passage in the future depending on the fishery management needs. The Agency will provide further comments on the application by the January 29 deadline.

Please don't hesitate to contact us if you should have any additional comments.

Thank you,

Jeff

VERMONT

Jeff Crocker | Supervising River Ecologist

Vermont Department of Environmental Conservation

Watershed Management Division // Rivers Program

Davis 3, 1 National Life Dr | Montpelier, VT 05620-3522

802-490-6151 (cell)

https://dec.vermont.gov/watershed

Due to the coronavirus (COVID-19) we are taking additional safety measures to protect our employees and the public and are now working remotely while focusing on keeping our normal business processes fully functional. Please communicate with our staff electronically or via phone to the greatest extent possible since our processing of postal mail may be slowed during this period.

Division staff contact information can be found online here: https://dec.vermont.gov/watershed/contacts.

Thank you for your patience during this challenging time. We wish you and your family the best.

From: PBMwork@maine.rr.com <PBMwork@maine.rr.com>
Sent: Tuesday, January 19, 2021 11:51 AM
To: Crocker, Jeff <Jeff.Crocker@vermont.gov>; Will, Lael <Lael.Will@vermont.gov>
Subject: Question On Deerfield Project Searsburg Development

Hi Lael and Jeff

I am the independent reviewer for the Low Impact Hydropower Institute (LIHI) assigned to Great River Hydro's application to LIHI for recertification of their Deerfield Hydropower Project. As you have previously been notified directly by email, LIHI is seeking comments on this application. The deadline for submittal is January 29, 2021.

However, I do have one question that I am hoping to hear back from one or both of you. I just wanted to confirm that no request has yet been issued for the implementation of the passage or impingement/entrainment protection measures at the Searsburg development identified in Condition M of VT the Water Quality Certification.

If you have any other comments or concerns you wish to share with me regarding this Project, please feel free to also identify those in your response. I appreciate any and all information you can share. If you would prefer to discuss any comments, please let me know when it would be a good time for me to call you.

Thanks again for any input you can share with me.

Pat McIlvaine

From: mfischer@lowimpacthydro.org
To: "Pat McIlvaine" <pbmwork@maine.rr.com>
Cc:
Bcc:
Priority: Normal
Date: Friday February 12 2021 4:22:07PM
Deerfield VANR clarification

Hi again, probably and hopefully for you – my last email of the day. I inquired of VANR when the WQ standards changed relative to water level fluctuation. Here is their response:

Hi Maryalice,

The Hydrology Criteria was added to the Vermont water quality standards in 2000. Originally the Hydrology Criteria for water level fluctuations applied to a subset of water classifications that did not include the waters affected by the Deerfield project. The water quality standards that became effective in 2017 modified how all waters statewide were classified and at that time the water level fluctuation criteria became applicable to the class of waters affected by the Deerfield project (e.g. Class B2 waters). Feel free to reach out if you have additional questions.

Thank you,

Hannah

Hannah Harris | Streamflow Protection Biologist (she/her)

Vermont Agency of Natural Resources

Department of Fish & Wildlife

Fish Division

1 National Life Drive, Davis 2 | Montpelier VT 05620-3522

802 279-7913 cell

hannah.harris@vermont.gov

www.vtfishandwildlife.com

DIVISION OF
FISHERIES & WILDLIFE

1 Rabbit Hill Road, Westborough, MA 01581
p: (508) 389-6300 | f: (508) 389-7890
MASS.GOV/MASSWILDLIFE

January 26, 2021

Ms. Shannon Ames, Executive Director
Low Impact Hydropower Institute
34 Providence Street
Portland, ME
04103

RE: Deerfield River Hydroelectric Project
FERC No. P-2323

Dear Ms. Ames:

The Department of Fish and Game ("DFG") hereby submits the following comments on the Low Impact Hydropower Institute's ("LIHI") Pending Application for the proposed LIHI certification of the Deerfield River Hydroelectric Project located in Bennington and Windham Counties, Vermont, and Berkshire and Franklin Counties, Massachusetts.

DFG is submitting these comments to LIHI in order to fulfill the requirements of the Massachusetts Department of Energy Resources ("DOER") Renewable Energy Portfolio Standard Regulations (225 CMR 14.00; "RPS I" and 225 CMR 15.00; "RPS II"). The RPS I and RPS II regulations were promulgated by DOER on January 1, 2009 and require that any hydroelectric project wishing to qualify as either a RPS I or RPS II generator first obtain LIHI certification. These regulations also require all relevant regulatory agencies to comment on the pending LIHI application.

The Department does not support Great River Hydro's application for LIHI Re-Certification of the Deerfield River Project for the reasons outlined below.

PROJECT

The project consists of eight developments: Somerset, Searsburg, Harriman, Sherman, Deerfield No. 5, Deerfield No. 4, Deerfield No. 3 and Deerfield No.2, having a total installed capacity of 86 megawatts.

The Project area encompasses about a 65-mile reach of the river, including reservoirs. Two other Hydroelectric developments not part of this project are also located within this area. They are Brookfield Renewable Power's Bear Swamp Project and Fife Brook Dam located downstream of the Deerfield No. 5 development; and Consolidated Edison's Gardner Falls Project located downstream of the Deerfield No. 3 development. Bear Swamp/Fife Brook (FERC No. 2669) are currently in the process of federal relicensing.

Project Developments - In Vermont, the Project facilities are located in the Towns of Somerset, Searsburg, Wilmington, Whitingham, and Readsboro. They consist of:

- Somerset Dam at River Mile (RM) 66, a reservoir with no generation.

- Searsburg Dam at RM 60.3 and Searsburg Powerhouse at RM 56.8
- Harriman Dam at RM 48.5 and Harriman Powerhouse at RM 44.1

In Massachusetts, the Project facilities are located in the Towns of Monroe, Rowe, Florida, Charlemont, Buckland, Shelburne, and Conway. They consist of:

- Sherman Dam and Powerhouse at RM 42
- Deerfield No. 5 Dam at RM 41.2 and Deerfield No. 5 Powerhouse at RM 38.5
- Deerfield No. 4 Dam at RM 20 and Deerfield No. 4 Powerhouse at RM 18.5
- Deerfield No. 3 Dam at RM 17 and Deerfield No. 3 Powerhouse at RM 16.8
- Deerfield No. 2 Dam and Powerhouse at RM 13.2.

In 1994 an agreement on relicensing the various dams with the Federal Energy Regulatory Commission (FERC) and the Massachusetts and Vermont state authorities that regulate water quality led to comprehensive coordinated water release and power generation schedules to enable more recreational use of the river, with minimum water flow measures to mitigate the dam impact on riverine habitat.

FISH AND WILDLIFE RESOURCES

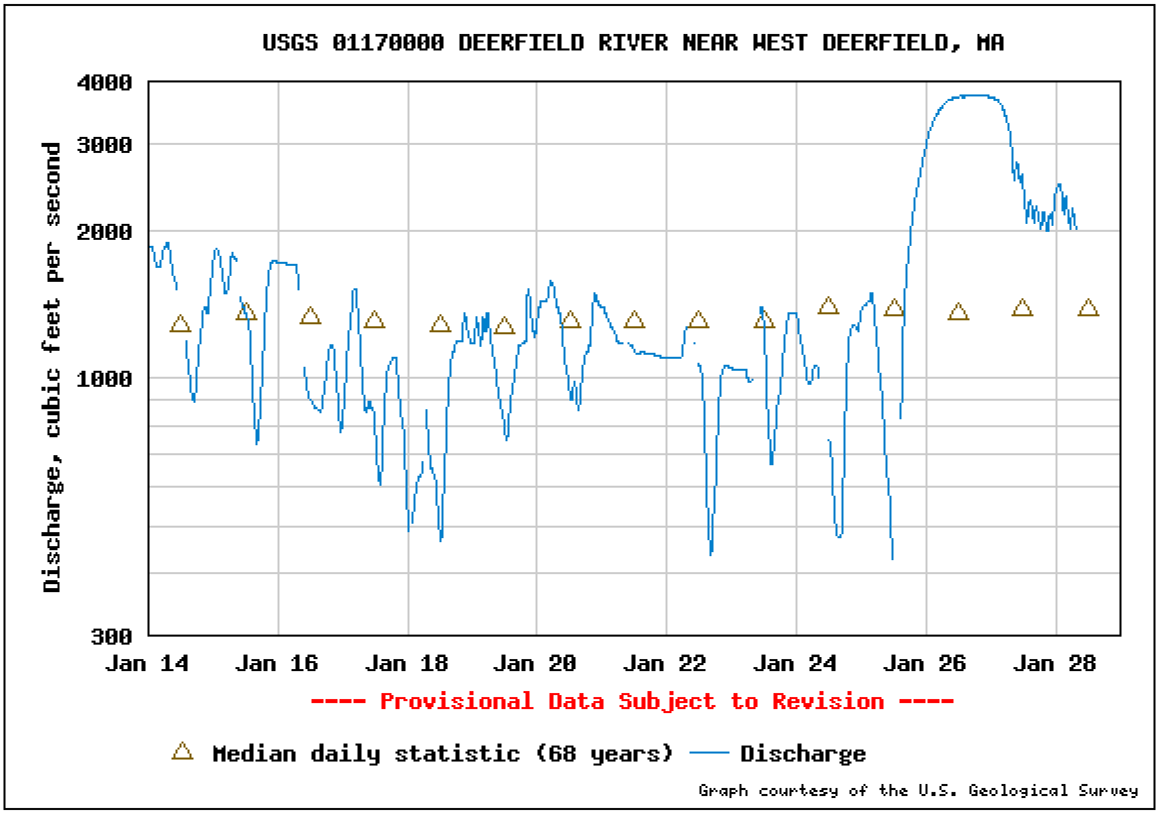
The Deerfield River System in MA includes over 100 recognized Cold Water Fishery Resource waters including many of the Deerfield's major tributaries such as the North, South, Cold, Bear, and Chickley Rivers. The Deerfield River supports a diverse fish community of both resident and migratory fish.
In Massachusetts, the entire Deerfield River corridor has been identified as "priority habitat" for rare species under the Massachusetts Endangered Species Act (MESA). Additionally, the lower Deerfield is in the historic habitat range of American shad and the current and historic range of American eel and Sea Lamprey.

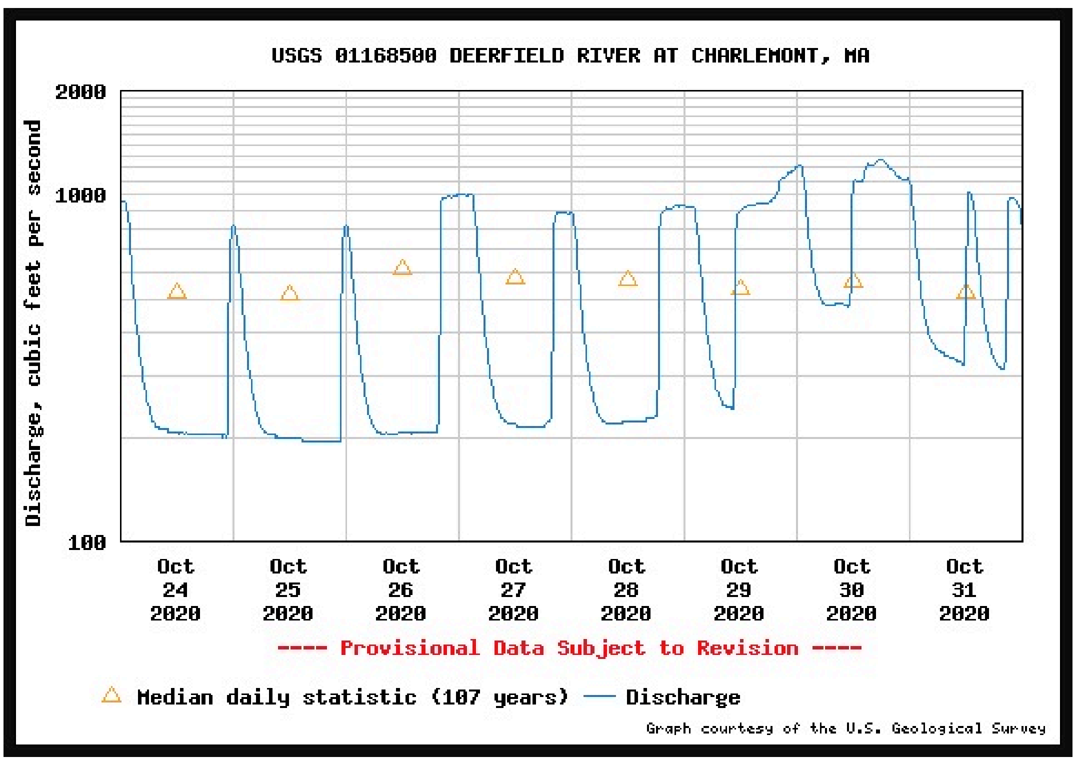
IMPACTS AND MITIGATION

<u>Flows</u>

<u>Run-of-river Operation</u>

The Deerfield River Project is not Run-of-River. It operates on a daily peaking cycle with releases that are both scheduled (for whitewater boating) and unscheduled- in response to the power market and demand. Below is the recent hydrograph from the USGS gage at Charlemont, MA. The saw-tooth pattern of daily releases is evident. This very unnatural flow pattern continues year-round.


USGS 01170000 DEERFIELD RIVER NEAR WEST DEERFIELD, MA
4000
3000
2000
1000
300
Discharge, cubic feet per second
Jan 14
Jan 16
Jan 18
Jan 20
Jan 22
Jan 24
Jan 26
Jan 28
---- Provisional Data Subject to Revision ----
Median daily statistic (68 years)
Discharge
Graph courtesy of the U.S. Geological Survey


USGS 01168500 DEERFIELD RIVER AT CHARLEMONT, MA
2000
1000
100
Discharge, cubic feet per second
Oct 24 2020
Oct 25 2020
Oct 26 2020
Oct 27 2020
Oct 28 2020
Oct 29 2020
Oct 30 2020
Oct 31 2020
---- Provisional Data Subject to Revision ----
Median daily statistic (107 years)
Discharge
Graph courtesy of the U.S. Geological Survey

Bypass Flows
The Deerfield River Project has several long bypass reaches.
The Number 5 development has two tunnels, two concrete conduits, and three canals which total 14,941 feet in length. There is also a small diversion structure on Dunbar Brook (a recognized cold water fishery resource). Water is directed from Dunbar Brook into one of the tunnels (therefore Dunbar brook is no longer connected to the Deerfield River). These structures result in **2.7 miles** of the Deerfield River being bypassed by all but the minimum flow of 73 cfs or inflow to a minimum or 57 cfs and scheduled whitewater releases (of up to 1,000 cfs) during the summer months.
The Number 4 development has a 1,514 foot long concrete and brick lined tunnel from the intake structure at the impoundment to the powerhouse forebay. This structure results in a 1.5 mile long bypass reach. The bypass reach receives the lesser of 100 cfs or inflow from Oct. 1 to May 31, and the lesser of 125 cfs or inflow from June 1 to Sep. 30.

Migratory Fish
No upstream or downstream passage or protection measures for American eel are in place (or required by the project's FERC license). American eels are present in the watershed and such measures may well be warranted.

Settlement Agreement (statement below is from the LIHI application):

> The Deerfield River Project was one of the first FERC Projects to be relicensed under a comprehensive Settlement Agreement approach executed in 1994. A five-year cooperative consultation process involving state and federal resource agencies, various non-governmental organizations (NGOs) and the licensee (at that time New England Power Company) resulted in settlement by the parties. The process of reaching this agreement included examination of the power and non-power tradeoffs and effects of a wide variety of operational scenarios. This negotiation process, after careful consideration of alternatives, resulted in a balancing of power and non-power interests associated with the Project through the Settlement Agreement. The FERC License conditions for the Project consist of the operational and environmental measures defined by the Settlement Agreement. The Settlement Agreement demonstrated the ability of diverse interests to come together in good faith to balance environmental quality, recreation, fishing, energy production, land preservation and other purposes. The agreement ensures that the Deerfield River will be managed over the License term to improve resource protection while recognizing the value of hydropower as a renewable energy resource.

The settlement agreement represents the best deal that the resource agencies were able to negotiate in the FERC arena in 1994 (i.e. major changes to project operations like going run-of-river were not on the table). The settlement agreement has resulted in better environmental conditions (specifically improved minimum flows), but current project operations do not meet the DFG's criteria for "Low Impact". Specifically, project operations allow daily peaking flows and the project includes almost 5 miles of bypassed reaches.

Studies conducted as part of the Bear Swamp/Fife Brook FERC relicensing have demonstrated significant impact to trout spawning habitat as a result of hydro peaking activities. This daily peaking is the result of the Deerfield River Project releases and is passed through the Bear Swamp/Fife Brook development. In fall 2017, the Deerfield River Watershed Chapter of Trout Unlimited (DRWTU) performed a trout spawning study along the Deerfield River and its tributaries in an effort to determine impacts of the daily peaking releases. DRWTU found evidence of Brown Trout spawning activity from Zoar Gap upriver to the Fife Brook Dam. They observed 101 redds among 4 reaches in the Deerfield above Route 2, with the highest density of redds in the uppermost reach closest to Fife Brook. The study found that dewatering frequently occurred in redds when the river flows returned to minimum after the daily peaks. Trout eggs in the Deerfield River have an increased risk of mortality from freezing and desiccation in both dewatered and reduced water velocity conditions that exist at spawning sites at minimum flow. These study results clearly show the impacts hydropeaking can have on trout spawning success and natural reproduction in this important resource area.

After the Deerfield River Project Received LIHI certification over our objection in 2012, DOER required TransCanada (then project owner) to establish a $100,000 environmental mitigation fund. Thus, demonstrating that the project and its then (and current) operations are not "Low Impact". We are not interested in continuing with mitigation and do not support the LIHI recertification.

COMMENTS

The Department does not support Great River Hydro's application for LIHI Certification of the Deerfield River Project. This project, with its large headwater storage reservoirs, long bypass reaches, and daily peaking operations has dramatically changed the nature of the Deerfield River and cannot be described as "Low Impact". However, there may be opportunities for incremental power production improvements which also result in environmental improvements under DOER's Renewable Energy Portfolio Standard Regulations.

Thank you for this opportunity to comment.

Sincerely,

Steven Mattocks
MassWildlife Aquatic Connectivity Biologist

TROUT UNLIMITED CONNECTICUT RIVER VALLEY CHAPTER

Connecticut River Valley Chapter
5607 Westminster West Road
Putney, VT 05346

dedicated to conserving, protecting, and restoring North America's coldwater fisheries

802-869-3116 **strictlytrout@vermontel.net**

To Whom It May Concern:

We do not view the Deerfield River along all of the reaches included in the LIHI Certificate #90 - Deerfield River Hydroelectric Project, Vermont and Massachusetts as being fully "Low Impact" due to the lack of upstream and/or downstream eel and fish species passage facilities at the dams along the Deerfield River creating an adverse impact on the habitat and movement of these species.

Moreover, the water temperatures immediately below some of the dams are either extremely cold throughout the year or at other facilities hot during summer high temperature times and thus are also not always conducive to the natural and desirable eel and fish species habitat.

In order to retain its "Low Impact" status Great River Hydro (GRH) should make some effort to address these impacts including consideration of using some of the fiscal benefits currently being realized by GRH with its "Low Impact" status designation that would enable increases in conservation efforts in the watershed for the benefit of fish, wildlife, and the public.

We also point out that by their nature some current GRH dam operations do offer benefits for cold-water fish species. Those cases are where the reservoir release keeps the water cool throughout the year, even during those stressful times of high, hot summer. Some of their releases create a stable flow level even during the summer and winter low flow times. Furthermore, GRH has cooperated with our TU chapter on a stream assessment project which we look forward to continuing with them.

We recommend that if Great River Hydro is to keep their "Low Impact" designation for LIHI Certificate #90 - Deerfield River Hydroelectric Project that they begin to plan during this certification period for how they might improve fish passage and reduce or remove water temperature extremes that are damaging to the fishery. We suggest that GRH increase its contribution to the Deerfield River Environmental Fund (DREF) or increase their engagement with projects initiated by the DREF so that this can provide greater opportunity to address the remaining adverse impacts in those locations in the watershed in need of conservation measures.

Sincerely

David Deen & John (Jack) Widness
President & Vice President, Trout Unlimited Connecticut River Valley Chapter 450

VERMONT FISH AND WILDLIFE DEPARTMENT

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Montpelier Vermont 05620-3702

Telephone: 802-828-1454

Distributed Electronically

January 29, 2021

Low Impact Hydropower Institute Office
1167 Massachusetts Ave
Arlington, MA 02467

Re: Deerfield Project (LIHI Certificate #90)
Comments on Low Impact Hydropower Recertification

Dear Ms. Ames,

A LIHI Certified® hydropower facility is one that is sited, designed, and operated to be compatible with environmental and social resources. Currently, Great River Hydro is seeking recertification of the Deerfield River Project as low impact. As a resource agency, the Vermont Agency of Natural Resources appreciates the opportunity to comment on the recertification of the Deerfield Project under LIHI.

According to the recertification website, "the Deerfield River Project is located on the Deerfield River, a major tributary to the Connecticut River, in Bennington and Windham Counties in Vermont, and in Berkshire and Franklin Counties in Massachusetts. It consists of eight developments: Somerset, Searsburg, Harriman, Sherman, Deerfield No. 5, Deerfield No. 4, Deerfield No. 3 and Deerfield No.2, having a total installed capacity of 86 megawatts (MW). All dam operations and generation operations are controlled remotely from the Deerfield River Control Center in Monroe Bridge Massachusetts, located near the Deerfield No. 5 Dam.

The Project area encompasses about a 65-mile reach of the river, including reservoirs. Two other developments not owned by the company are also located within this area. They are Brookfield Renewable Power's Bear Swamp Project located downstream of the Deerfield No. 5 development; and Consolidated Edison's Gardner Falls Project located downstream of the Deerfield No. 3 development."

Three of the Deerfield River Project's facilities are wholly located in Vermont: Somerset, Searsburg, and Harriman. A portion of the impoundment created by the Sherman project is also located in Vermont. All projects are licensed by the Federal Energy Regulatory Commission (FERC) under license number P-2323 which was issued in 1997 and expires in 2037. The project also is regulated under a Water Quality Certification (P.L. 92-500, Section 401) by the State of Vermont that was issued on January 30, 1995 covering the duration of the FERC license.

The Deerfield River is known as a hard-working river. Along its course to the Connecticut River, the Deerfield has a dam every seven miles on average. As a result of the Settlement Agreement in 1994, long bypass reaches that were previously dry received minimum flows. Limits on drawdowns at reservoirs to protect loons and other aquatic life were established. Recreationalists saw more boating and hiking opportunities. The eight developments that make up Great River Hydro's Deerfield Project were deemed in compliance with water quality standards, and 401 water quality certifications were issued by Vermont and Massachusetts. As a result of the Settlement Agreement, the Deerfield Project was issued a FERC license with a term of 40 years.

But, 24 years into the license term, the fact remains that the Deerfield Project is not low impact. In Vermont, the flow regime of the Deerfield River is highly modified by the Somerset, Searsburg, Harriman and Sherman projects. The Somerset Dam of the East Branch Deerfield River does not generate any power but is used to deliver inflows to the Searsburg Project downstream. Both the Searsburg and the Harriman projects have long bypass reaches, much longer than the sections of free-flowing river before the next impoundment. While these bypass reaches have minimum flow standards, they lack a natural flow regime that is essential to a functioning and healthy riverine ecosystem. In other words, they lack an ecological flow regime. In Vermont, none of the three dams have upstream or downstream fish passage. Both the Somerset and Harriman impoundments stratify, resulting in hypoxic zones in the reservoirs. According to Vermont's 2020 List of Priority Surface Water, several waterbodies impacted by the Deerfield Project have TMDLs for mercury in fish tissue (Harriman Reservoir, Sherman Reservoir, East Branch Deerfield River below Somerset Dam, Somerset Reservoir, Upper Deerfield River Below Searsburg Dam, and Searsburg Reservoir). Somerset Reservoir also has a TMDL for pH. The Lower Deerfield River below Harriman Reservoir is also listed as impaired by flow regulation.

Because of the high dam density, water quality concerns related to flow alteration, deoxygenated areas of Somerset and Harriman reservoirs contributing to elevated mercury in fish tissue, a highly modified flow regime, reservoir drawdowns impacting littoral community development, and lack of fish passage, the Vermont Agency of Natural Resources does not support the recertification of the Deerfield Project as low impact. Specific comments related to LIHI criteria are presented below.

Somerset Project

The Somerset Project, located on the East Branch of the Deerfield River, has a sole purpose of acting as a storage reservoir for the lower projects as it does not generate any hydropower. According to the 303(d) list, the East Branch Deerfield River below Somerset Dam is chronically acidified (https://dec.vermont.gov/sites/dec/files/documents/mp_PriorityWatersList_PartA_303d_2020.pdf). Extensive winter drawdowns at Somerset Reservoir also prevent the establishment of a healthy littoral community.

Zone 1: Somerset Impoundment

3.2.5 Criterion E – Watershed and Shoreline Protections- Although management of the impoundment complies with federal and state laws, extensive drawdowns prevent the establishment of littoral communities. Under the 401 Certification, the reservoir can fluctuate from a target during loon nesting season of 2128.58 ft to a low of 2107 ft, representing an annual drawdown of over 21 ft. While these drawdowns complied with the Water Quality Standards at the time of certification, the Agency does not consider them to be low impact. According to finding 219 of the 401, "The extensive drawdowns at Somerset and Harriman reservoirs are a major factor in preventing the establishment of beneficial wetland plant communities that would otherwise become established along the shoreline margins and in the shallow areas of the reservoirs."

Zone 2: Somerset Downstream Reach

3.2.1 Criterion A - Ecological Flow Regimes- The East Branch Deerfield River below Somerset Reservoir partially meets the A2 Standard of Agency Recommendation. Minimum flows in this section of the East Branch Deerfield River were established by an IFIM study conducted to support development of the 401. Minimum flows were set at 12 cfs from May 1- July 31 (or 9 cfs if inflows are < 12 cfs), 12 cfs from August 1- September 30, 30 cfs from October 1 – December 15, 48 cfs from December 16-February 28, and 30 cfs from March 1-April 30. While these minimum flows were determined to meet Vermont's Water Quality Standards over 25 years ago, the Agency does not agree that this constitutes an "Ecological Flow Regime" as defined by LIHI. An ecological flow regime as defined applies an ecosystem-based approach that supports fish and wildlife resources by considering base flows, daily, seasonal, and inter-annual variability, high-flow pulses, and short-term rates of change (Figure 2). The East Branch Deerfield below Somerset is a hydrologically altered system, primarily due to its lack of natural floods. It is not subject to daily peaking cycles or major low-flow extremes, and in many respects presents an overly static flow condition that theoretically could benefit salmonid recruitment and survival. However, it is unclear how the loss of floods and/or the presence of the dam has affected river morphology below Somerset Reservoir, and whether this exacerbates the system's naturally low productivity. Reduced peak discharges and generally stable flows produced by regulated water releases from flood control or storage reservoirs (Figure 1) inevitably impact natural stream processes including channel morphology and substrate composition. The Agency believes that such high level of flow alteration in the Deerfield watershed should not warrant certification under LIHI.

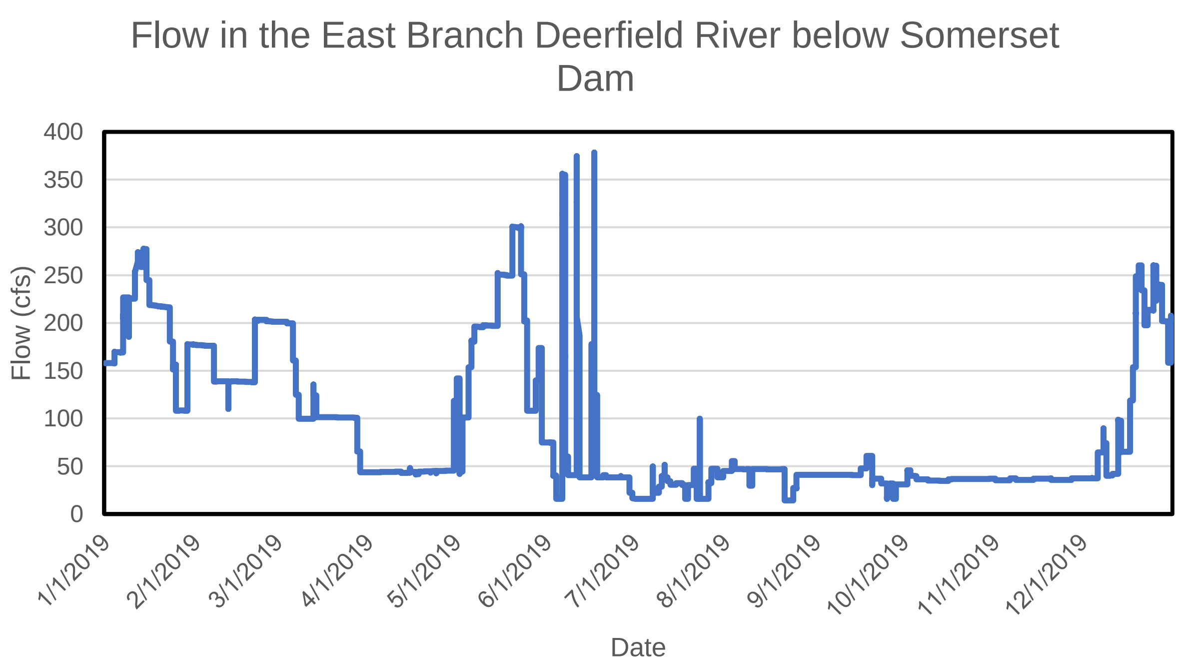

Figure 1. 2019 flows in the East Branch Deerfield River below Somerset Dam. Note the flat nature of the hydrograph, especially between July and December.

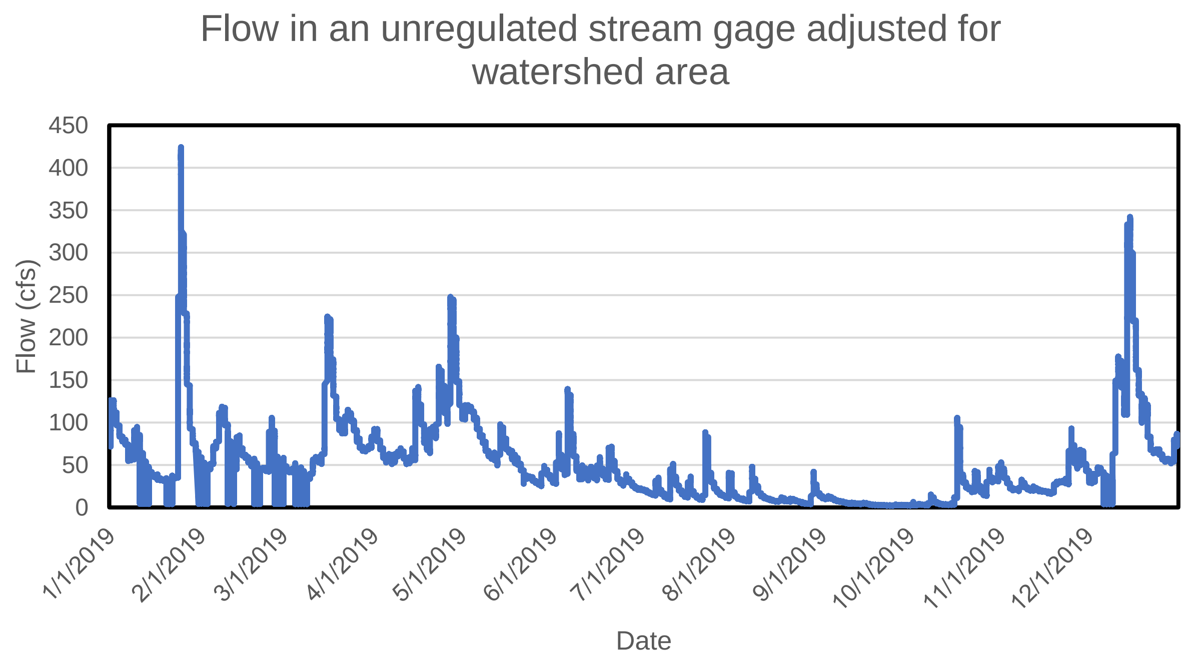

Figure 2. 2019 flows in Beaver Brook (USGS gage #010965852, watershed area= 47.8 mi^2). A correction factor of 0.6276 was applied to the data to approximate flow in the East Branch Deerfield (watershed area= 30 mi^2). Note the greater flow variability in the unregulated gage and its response to precipitation events compared to flows in the East Branch.

<u>Searsburg Project</u>

The Searsburg Project is the first mainstem river dam on the Deerfield River and is located at the confluence of the East Branch of the Deerfield River. The Searsburg Project is a peaking project with a 3.5-mile bypass reach.

Zone 3: Searsburg Impoundment

3.2.5 Criterion E – Watershed and Shoreline Protections- The 401 did not establish drawdown limits for this impoundment and the water quality certificate indicates, "the littoral zone is regularly dewatered and consequently is not conducive to production of aquatic life."

Zone 4: Searsburg Bypass Reach

3.2.1 Criterion A - Ecological Flow Regimes- The bypass reach below Searsburg dam partially meets the A2 Standard of Agency Recommendation. From June 1 to September 30, minimum flows in the 3.5-mile-long bypass are set at 35 cfs and from October 1 to May 31, minimum flow is set a 55 cfs. According to finding 163 in the water quality certificate, "much less habitat exists at 20 cfs and 40 cfs, compared to higher flows." This finding also indicates that habitat modeled in the bypass reach with WUA curves for juvenile and adult trout "increases nearly linearly with flows between 20 and 120 cfs." While these minimum flows are certainly preferable to a dewatered river, they do not constitute an ecological flow regime. Figure 3 displays the 2019 hydrograph for the bypass reach, and Figure 4 displays the hydrograph for an unregulated river with a similar drainage area (90 mi^2 vs. 89 mi^2, respectively). In the bypass reach, peak flows are higher and more frequent than in the unregulated river. For example, in the North River flows exceeded 2,000 cfs only on one occasion during spring where flows gradually increased in March and then declined in June (Figure 4). While flows in the bypass reach tended to be lower overall, they were punctuated by peak flows approximately 1.5 times higher in the unregulated river (Figure 3). In the bypass reach below Searsburg Dam, such high flows could lead to scour and displace fish.

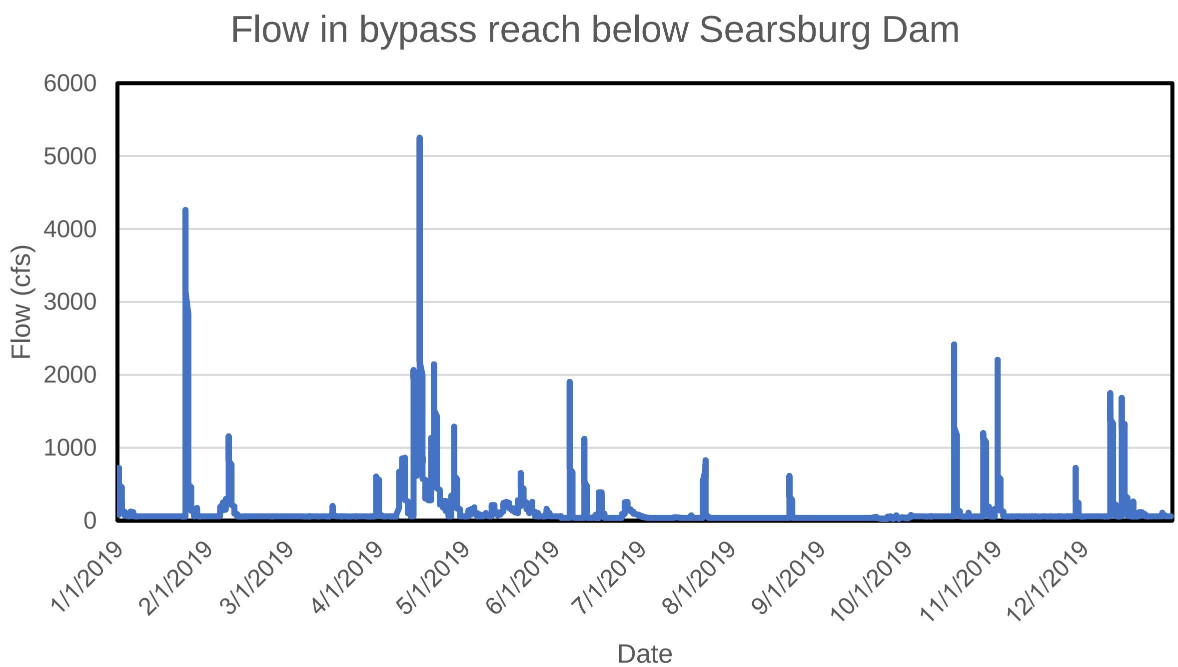

Figure 3. 2019 flows in the bypass reach of the Deerfield River below Searsburg Dam. Note the low base flows punctuated by periodically high spill flows.

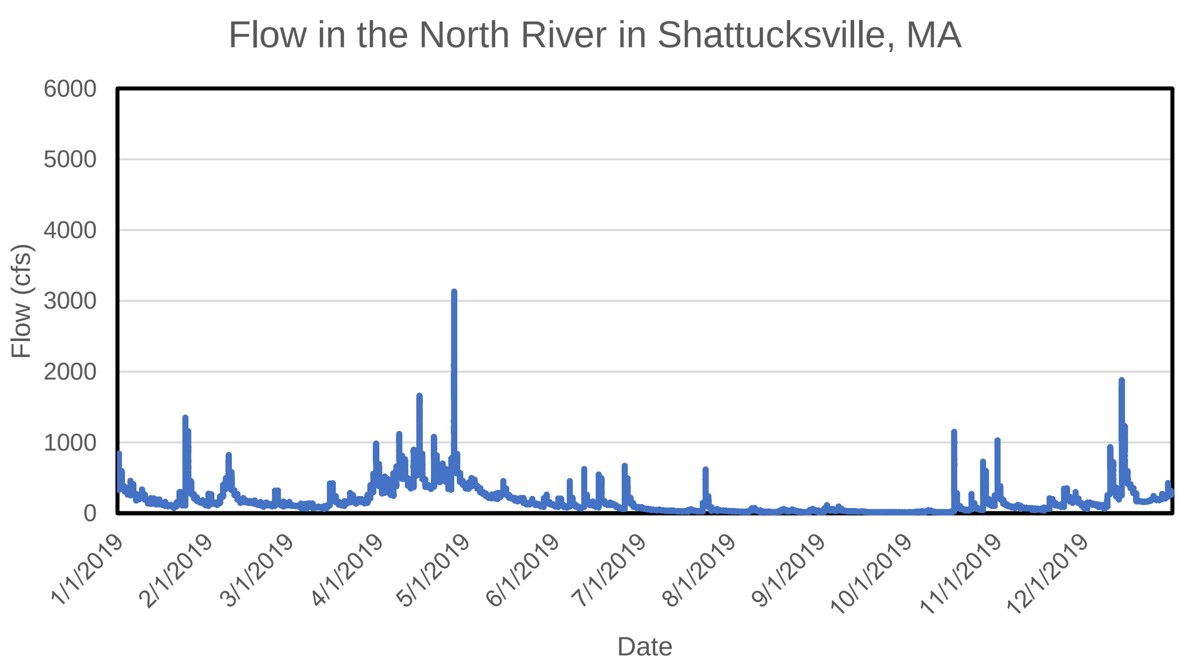

Figure 4. 2019 flows in the unregulated North River (USGS gage 01169000). Watershed area of the North River at the gage is 89 mi^2. The watershed area at Searsburg is similarly 90 mi^2.

3.2.3 Criterion C - Upstream Fish Passage

The bypass reach below Searsburg dam partially meets the standard C-1 Not Applicable/De Minimis Effect because although the dam does create a barrier to upstream passage, there are no migratory species located at the facility.

It should be noted that confining fish passage requirements to migratory fishes is an outdated approach. Aquatic connectivity has been clearly and consistently recognized as a critical ecological process and is supported by the Agency in a variety of regulatory procedures. Maintaining a connected system allows fish to seek the best available habitat for reproductive needs, food resources, thermal refuge, and cover. Aquatic connectivity also allows for the recolonization of upstream habitats after catastrophic events, such as floods or toxic discharges. Furthermore, free movement within a river system helps to maintain genetic diversity of aquatic populations.

Condition M of the Vermont 401 Water Quality Certificate dated 01/30/1995 states "*The applicant shall submit a plan for upstream fish passage at Searsburg Dam, including estimated design flows necessary for proper operation, to the Department of Fish and Wildlife for review within four months of a request. Upstream passage shall be provided March 15 -May 15 and October 1- November 15, with the period subject to adjustment based on knowledge gained about migration periods for migratory salmonids. Upstream fish passage facilities shall be installed so as to be operational within 18 months of a request by the Agency; the request will not occur any earlier than 20 years from the issuance date of this certification. The plan shall include an implementation/ construction schedule. The U.S. Fish and Wildlife Service and the Department of Fish and Wildlife shall be consulted during plan development. The plan shall include an erosion control and water management plan designed to assure compliance with water quality standards during construction. The Department of Fish and Wildlife may suspend the operation of upstream passage facilities at any time based on its fishery management needs".*

Providing upstream fish passage at Searsburg would allow riverine species such as brook and brown trout to access the headwaters of the Deerfield including tributary streams within this highly fragmented river system and should be considered.

Zone 5: Searsburg Downstream Reach

3.2.1 Criterion A - Ecological Flow Regimes- The downstream reach below the Searsburg bypass partially meets the A2 Standard of Agency Recommendation. In the 1.1- mile downstream reach of the Searsburg station, 175 cfs or inflow if less, is provided from April 20 to May 15 to provide riverine spawning habitat for smelt originating from the Harriman Reservoir. While these flows provide spawning habitat for smelt, this short river reach experiences flow fluctuations throughout the year because of daily peaking from Searsburg Station (Figure 5). While these spring flows mitigate the impact of hydropeaking on smelt spawning, they do not constitute an ecological flow regime because the frequency and magnitude of flow fluctuations in the tailrace are significantly higher than experienced in a natural flow regime (Figure 5). In the unregulated North River, for example, flows in October 2019 were at baseflow until precipitation events in the latter half of the month increased flows (Figure 7). Meanwhile in the Searsburg downstream reach, flows fluctuated daily in response to peaking operations (Figure 6). When the rains arrived in the latter half of month, flow peaks were significantly higher in the Searsburg downstream reach than in the North River which has a similar drainage area. While flows in the Searsburg downstream reach complied with the Water Quality Standards at the time of certification, the increased frequency and magnitude of peak flows represents a departure from the natural flow regime that impacts the ecological integrity of the river.

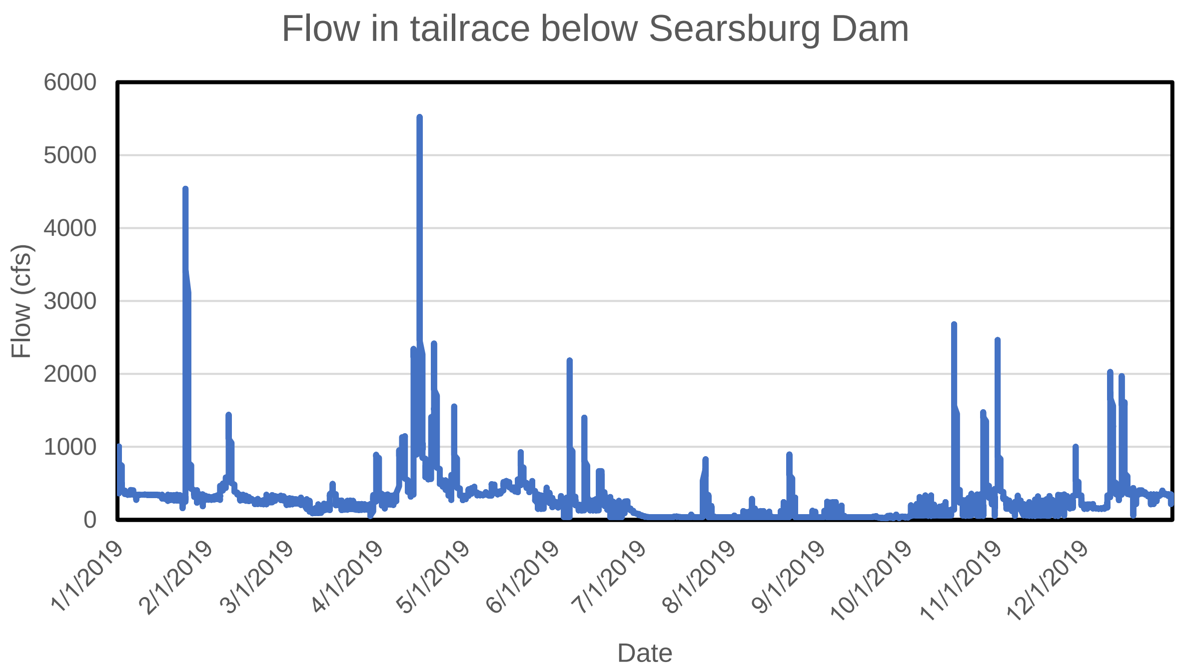

Figure 5. 2019 flows in the tailrace of the Deerfield River below Searsburg Dam. Note the higher frequency of flow fluctuations as compared to the unregulated North River (Figure 4).

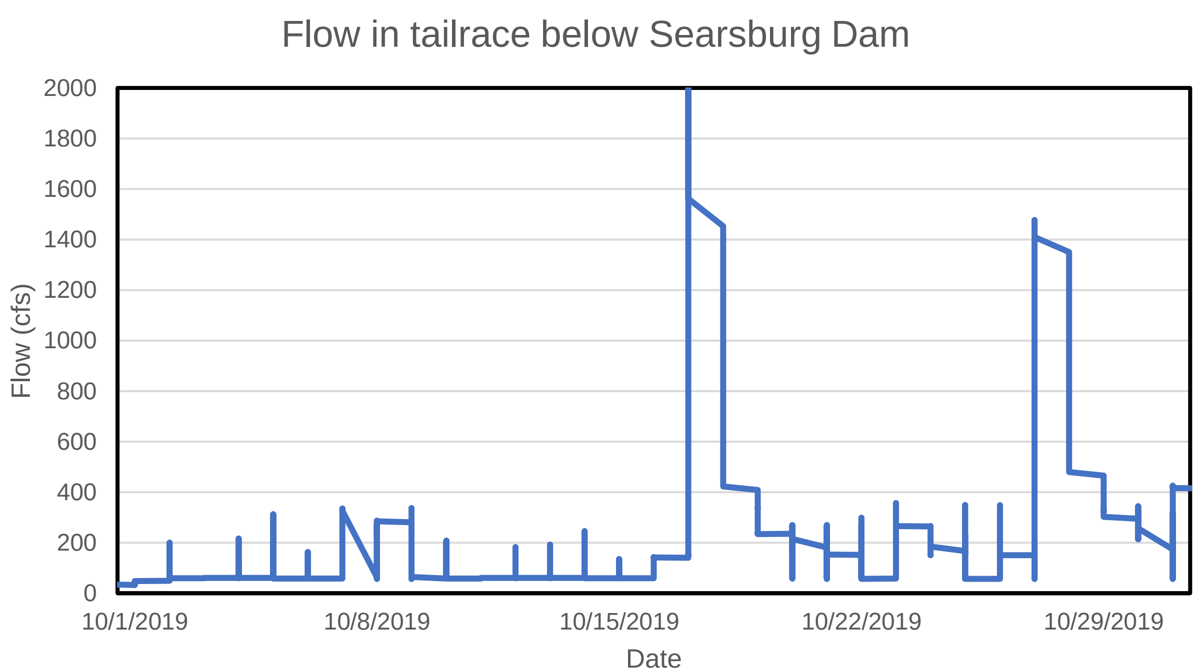

Figure 6. October 2019 flow in the tailrace of the Deerfield River below Searsburg Dam (hourly data). Note the daily flow fluctuations from baseflow provided to the bypass reach and generation flow (daily peaking) from the powerhouse.

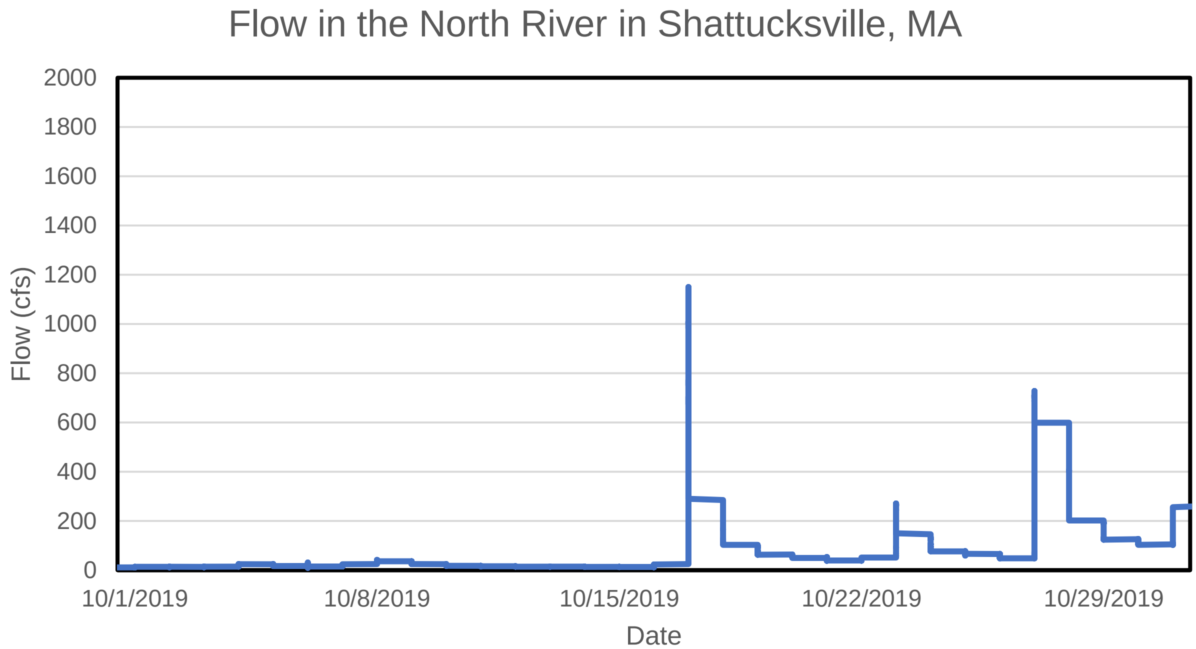

Figure 7. October 2019 flows in the unregulated North River (USGS gage 01169000). Note the low baseflows in the first part of the month followed by increasing flows in response to precipitation events in the latter half of the month.

<u>Harriman Project</u>

The Harriman Project is operated in a peaking and seasonal storage basis. The impoundment is the second largest waterbody in Vermont and has a useable drawdown of 86 ft. Below the impoundment, there is a 4.4-mile-long bypass reach. The tailrace flows directly into the Sherman impoundment.

Zone 6: Harriman Impoundment

4.5 Criterion E – Watershed and Shoreline Protections- The Harriman impoundment partially meets the E-2 Agency Recommendation Standard. Harriman Reservoir is not only the largest body of water occurring in the Deerfield River Project, but also, when full, is the second largest water body contained in the state of Vermont. While the Settlement Agreement limited drawdowns until November 1 to 1475 ft, winter drawdowns are limited to 1440 ft. Winter drawdown of 35 ft impact littoral habitat and should not be considered low impact. Finding 281 in Vermont's water quality certificate indicates, "the winter drawdown and water level management at other times of the year will prevent the establishment of a functional littoral community. Reservoir productivity will continue to be affected."

Zone 7: Harriman Bypass Reach

3.2.1 Criterion A - Ecological Flow Regimes- The bypass reach below Harriman dam partially meets the A2 Standard of Agency Recommendation. In this 4.4-mile-long bypass reach, the minimum flow is set at 70 cfs from October 1 through June 30. From July 1 through September 30, the minimum flow is set to 57 cfs. These flows were set based on the visual habitat assessment work to provide high quality habitat conditions in the bypass reach. While these flows met water quality standards and restored flows to a previously dewatered river reach, they do not provide flow variability that is indicative of an ecological flow regime (i.e., Figures 9 and 10) or a low impact project. While flow in the New Haven River (adjusted for watershed area) fluctuated between 5 and 23,040 cfs during 2019 (Figures 9 and 10), flows in the bypass reach remained constant (Figure 8). Median flows in the New Haven River adjusted for watershed area were 347 cfs compared to 72 cfs in the bypass reach below Harriman Dam. Right below this long bypass, the tailrace is influenced by the backwater from Sherman Reservoir.

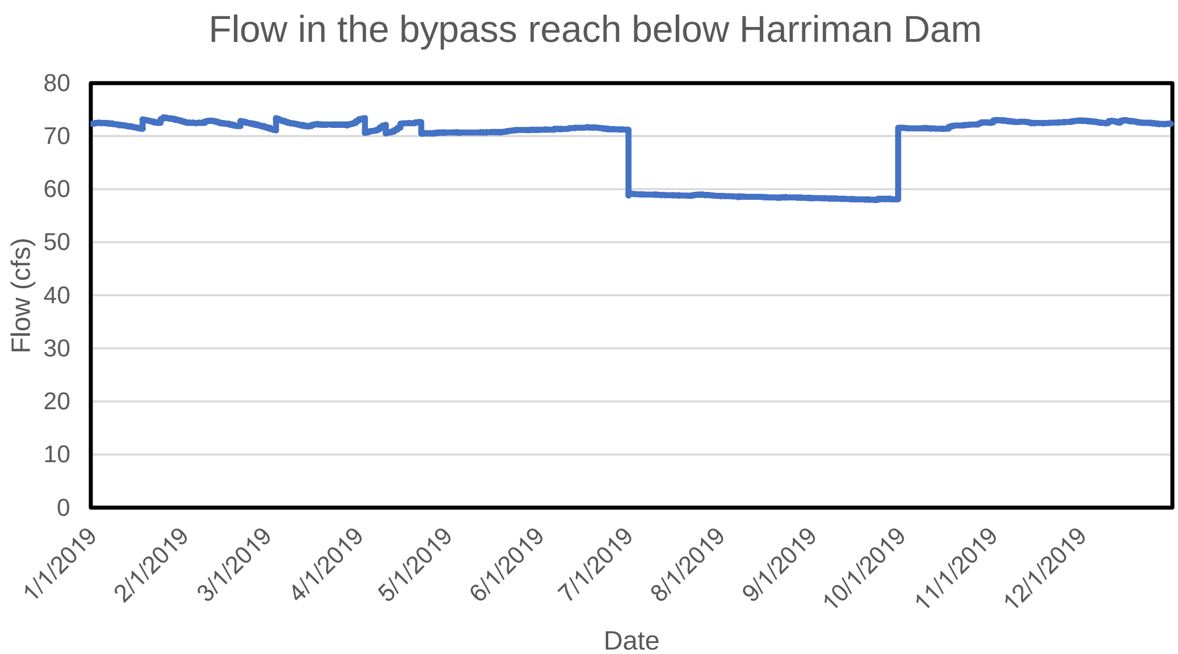

Figure 8. 2019 flows in the bypass reach of the Deerfield River below Harriman Dam. Note the stable flows lacking variability.

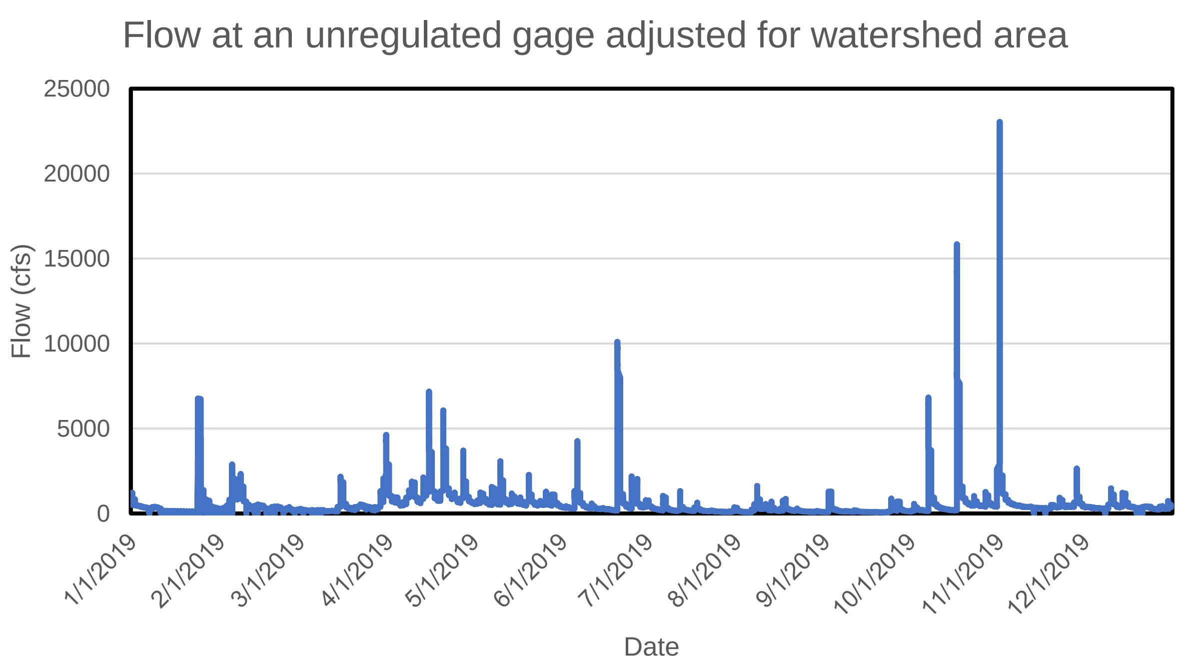

Figure 9. 2019 flows in the unregulated New Haven River (USGS gage 04282525, watershed area= 115 mi^2). A correction factor of 1.6 was applied to the data to approximate flow in the Deerfield River below Harriman Dam (watershed area= 184 mi^2). Note

the dramatically different scales and the greater flow variability in the unregulated gage compared to flows in bypass reach of the Deerfield River below Harriman Dam.

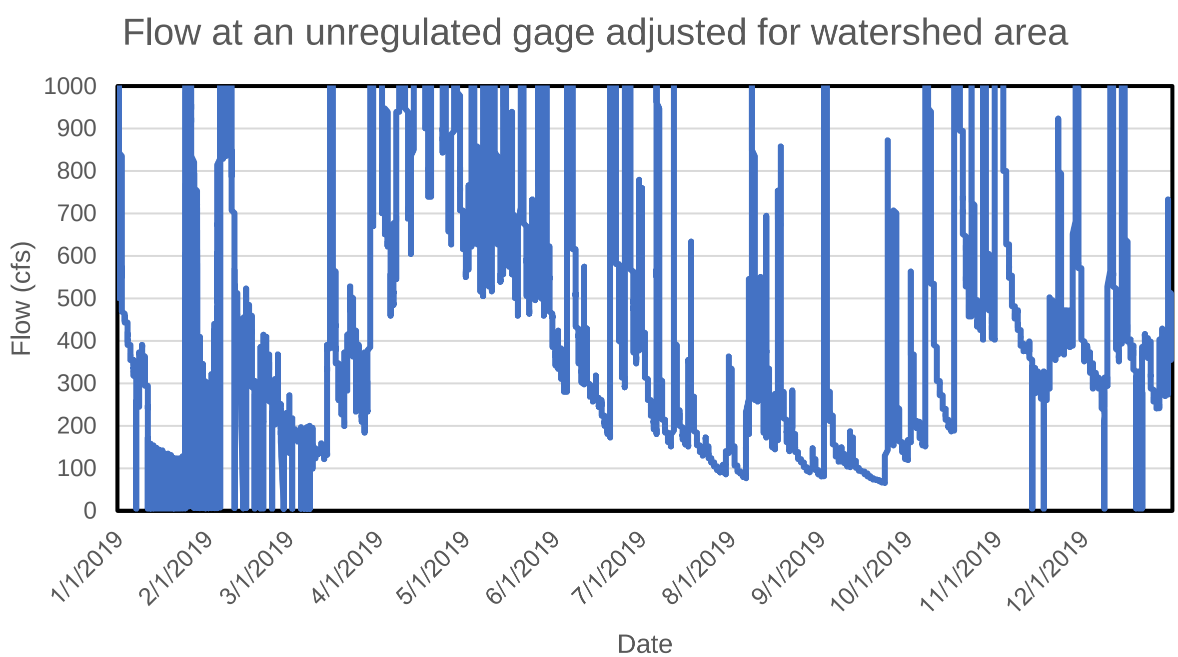

Figure 10. 2019 flows in the unregulated New Haven River (USGS gage 04282525, watershed area= 115 mi²). A correction factor of 1.6 was applied to the data to approximate flow in the Deerfield River below Harriman Dam (watershed area= 184 mi²). The scale is cropped to display highly variable flows below 1000 cfs.

Zone 8: Harriman Tailrace

3.2.1 Criterion A - Ecological Flow Regimes- The tailrace below Harriman dam partially meets the A2 Standard of Agency Recommendation. The tailrace of Harriman Dam flows directly in the Sherman impoundment. There is no free-flowing section of river between the Harriman and Sherman projects. This interferes with natural river processes and is not consistent with a low impact project.

3.2.2 Criterion B - Water Quality- Fish with tissue levels of mercury above water quality standards occur in Somerset, Harriman, Sherman and Searsburg Reservoirs, and below Somerset and Searsburg Reservoirs. While mercury does enter the system through atmospheric deposition, it can accumulate because of the presence of the reservoirs[1]. Both Somerset and Harriman reservoirs thermally stratify and have hypoxic zones in their hypolimnions. These hypoxic zones contribute to the methylation of mercury. According to finding 72 of Vermont's 401 certificate, "thermal stratification of Somerset and Harriman reservoirs during the summer create oxygen-depleted conditions in the deeper zones of the reservoirs. The intake elevations are sufficiently low that there exists a potential for withdrawal of oxygen-deficient water from the reservoirs and discharge of that water downstream into the river proper." While enough aeration occurs to comply with water quality standards for dissolved oxygen below the dams, methylation of mercury can occur in these hypoxic zones. Methylated mercury can then be mobilized downstream by these deep-water intakes.

---

[1] Evers, D. C. and P. Reaman. 1998. A comparison of mercury exposure and risk between artificial impoundments and natural lakes measured in Common Loons and their prey, 1996-97. Rept. Submitted to Central Maine Power Co., Augusta, ME.

Additional Comments

The introduction to standards under Criteria A- Ecological Flow Regimes, is that "In all locations, appropriate flow management should apply an ecosystem-based approach that supports fish and wildlife resources…" However, the LIHI standards accept that the impoundment area can be considered de minimis in all circumstances. The Agency believes this is a contradiction to the overall goal of an ecosystem approach that supports fish and wildlife.

There has been substantial research to date that indicates the harms to both habitat and aquatic biota because of impoundment drawdowns.[2] These include but are not limited to, impacts on immobile biota such as mussels[3], and decreasing macrophyte cover[4,5] , which has effects on fish spawning and macroinvertebrate densities[6]. While this LIHI 2nd edition handbook does not give the Agency an opportunity to speak to these impacts directly given "All impoundment zones can apply Criterion A-1 to pass this criterion", consideration of these impacts are necessary to understand the effect of a project on fish and wildlife resources. The Applicant does speak to instances where water level fluctuations within the impoundment zone are managed to provide ecological benefits in portions of the year (loon nesting, smelt spawning) but they do not speak to how the operations of the Project affect fish and wildlife resources for the remainder of the year.

Additionally, the Vermont Water Quality Standards have changed since 1995 Deerfield Certification specifically surrounding water level fluctuations. Current standards include hydrology criteria for not only streamflow protection (§29A-304(b)) but also water level fluctuations (§29A-304(d)).

Article 418 of the FERC license requires the Applicant "Within 180 days from the date of the issuance of this license, the Licensee shall file with the Commission, for approval, a plan to monitor the effectiveness of the existing trashracks at the Searsburg development in reducing fish impingement and entrainment at the intake… If the results of the monitoring indicate that changes in project structures or operations, including alternative flow releases, are necessary to protect fish resources, the Commission may direct the Licensee to modify project structures of operations."

The Agency reviewed both the FERC record and state records and could not confirm that a fish impingement and entrainment study took place. LIHI should evaluate whether this occurred, and if there were any changes to operations or project structures as a result.

Thank you for consideration of our comments.

---

[2] Carmignani, J.R., and A.H Roy. 2018. Ecological impacts of winter water level drawdowns on lake littoral zones: a review. Aquatic Sciences. doi:10.1007/s00027-017-0549-9
[3] Carmignani, J.R., A.H Roy, P.D. Hazelton, and H. Giard. 2019. Annual Winter water level drawdowns limit shallow-water mussel densities in small lakes. Freshwater Biology. 00:1-15.
[4] Leira, M., and M. Cantonati. 2008. Effects of water-level fluctuations on lakes: an annotated bibliography. Ecological Effects of Water-Level Fluctuations in Lakes. pp. 171-184.
[5]Aroviita, J., and H. Hämäläinez. 2008. The impact of water-level regulation on littoral macroinvertebrate assemblages in boreal lakes. Ecological Effects of Water-Level Fluctuations in Lakes. pp. 45-56.
[6] Stoffels, R. J., K.R. Clarke, and G.P. Closs. 2005. Spatial scale and benthic community organisation in the littoral zones of large oligotrophic lakes: potential for cross-scale interactions. Freshwater Biology. *50*(7), 1131-1145.

Sincerely,

Hannah Harris

CC

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Eric Davis, VTDEC
Betsy Simard, VTDEC
Margaret Murphy, VTFWD
Lael Will, VTFWD
Kathy Urffer, CRC

Connecticut River Conservancy

Clean water. Healthy habitat. Thriving communities.

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February 5, 2021

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Arlington, MA 02476

Submitted electronically to: comments@lowimpacthydro.org

Re: Comments on the Deerfield Hydroelectric Project LIHI Certification Application

Dear Ms. Ames,

The Connecticut River Watershed Council, Inc., doing business as the Connecticut River Conservancy (CRC), is a nonprofit watershed organization that was established in 1952 as a citizen group to advocate for the protection, restoration, and sustainable use of the Connecticut River and its four-state watershed. CRC has an interest in protecting environmental values that directly and indirectly support the state, regional, and local economies and quality of life of the Connecticut River and its tributaries. In that capacity, we routinely participate in hydropower proceedings under the Federal Energy Regulatory Commission (FERC) and Low Impact Hydropower Institute (LIHI) certification of the multiple hydroelectric facilities that exist in the Connecticut River watershed.

CRC assumes that the recertification of the Deerfield Hydroelectric Project is being examined under a Stage II recertification process since there has been a material change in the certification process with the implementation of the 2nd Edition Handbook since the last certificate was issued.

Multiple agencies and organizations commented on the LIHI certification application for the Deerfield Project in 2010-2012. All of them argued against Low Impact Certification at that time. Given the changes to the LIHI handbook, including one of the most substantive differences being, “a new emphasis on the scientific basis for agency recommendations and mitigation”[1] it is our expectation that the LIHI reviewer will place particular importance on the comments provided by our fish and wildlife agencies.

Based on the comments below, CRC contends that the Deerfield Project does not meet standards required to be considered for the Low Impact Hydro Certification.

Facility Information

The Deerfield River is highly manipulated by 10 dams and one pumped storage project, with Great River Hydro (GRH) being the owner of 8 of these dams of which seven generate power. Excel Table 1b provides information on the installed capacity of the Deerfield project (86MW) and the 10-year average net generation for the period 2010-2019. CRC notes that, compared to the 10-year average provided in

[1] Low Impact Hydropower Certification Handbook. 2nd Edition. Revision 2.03: December 20, 2018. Low Impact Hydropower Institute.. Page v.

the LIHI certification for the same project in 2010, that the average generation for Deerfield #4 and Deerfield #2 has been reduced by 34% and 30%, respectively. This is much lower than the other facilities, which show a slight drop that may be due to three years of drought in the last ten years. The application indicates that there have been no major infrastructure changes at these facilities. We do know that Hurricane Irene disrupted generation at some locations, but we are not sure if this is an ongoing impact or if it was temporary for a period of months or years. CRC would like some clarity on the reason for the reduction in generation at Deerfield #4 and Deerfield #2.

3.2.1 Criterion A - Ecological Flow Regimes

The LIHI Goal for ecological flow regime criterion is to ensure that, "The flow regimes in riverine reaches that are affected by the facility support habitat and other conditions suitable for healthy fish and wildlife resources."[2] GRH says in its application that they meet Standard A-1 or A-2 for their facilities in the Deerfield Project.

GRH has listed 22 zones of effect at their 9 facilities (one dam is located on a tributary to the Deerfield River at Dunbar Brook). For each of the impoundment zones, the application indicates that they meet Standard A-1. The LIHI Handbook requires that for all impoundments meeting this standard that they "explain water management (e.g., fluctuations, ramping, refill rates) and how fish and wildlife habitat within the zone is evaluated and managed…. All impoundment zones can apply Criterion A-1 to pass this criterion."[3]

The application contains some details in an Excel sheet called Table 1b, with facility information. This table includes the impoundment elevation ranges, but other than license restrictions at Somerset, there appear to be no ramping rate or refill rate or drawdown restrictions. There is no explanation of how fish and wildlife habitat within each of the impoundments are evaluated or managed. Stakeholders have raised concerns about very warm and very cold water temperatures above and below some of the dams affecting temperature sensitive species, but there has been no effective response to address concerns.

GRH says that their downstream reaches all meet Standard A-2. To meet standard A-2, the applicant must either explain the scientific or technical basis for the agency recommendation, including methods and data used; explain how the recommendation relates to agency management goals and objectives for fish and wildlife; and explain how this provides fish and wildlife protection, mitigation and enhancement.[4]

There is no explanation of the methods and data used for any of the goals and objectives. A technical basis was not given for the minimum flows at each facility, although there is a general mention of an IFIM study. The Settlement Agreement or FERC order on the license does not provide this justification. The peaking flows at each facility are not explained at all in the application. The issue of converting any facilities to run of river was not "on the table" during the negotiation for the Deerfield River Settlement Agreement, but that does not mean there is no impact or concern about the impacts of peaking to the entire river system. We especially do not see how Zone No. 14, Dunbar Brook downstream reach, could

[2] Low Impact Hydropower Certification Handbook. 2nd Edition. Revision 2.03: December 20, 2018. Low Impact Hydropower Institute. Page 6.
[3] Ibid. Page 56.
[4] Ibid. Page 56.

possibly meet standard A-2, since there is no minimum flow provided below that impoundment and the stream channel is completely dry unless the dam is full enough to spill.

Comment letters on LIHI Re-certification for the Deerfield Project submitted by the Massachusetts Division of Fisheries and Wildlife dated January 26, 2021 and the Vermont Fish and Wildlife Department on January 29, 2021 argue against re-certification based on flows. CRC agrees with both comment letters. We will also add that Yellen and Bout (2015)[5] looked at the effect of groundwater interactions with hydropeaking patterns on the Deerfield River in Massachusetts, and one of the conclusions of their study was: "The combination of hydropeaking and resultant water table mounding adjacent to dam-controlled rivers may mean that even in humid areas, licensed minimum flow requirements may be insufficient to meet desired goals if substantial losses occur within the reach of concern."

It is CRC's continued belief that a river broken up by 10 dams (8 under GRH's ownership) that all operate under some form of peaking, whether it is seasonal storage, weekly storage, or daily peaking, can not be considered "low impact."

3.2.2 Criterion B - Water Quality

The stated goal for the water quality criterion is that, "Water quality is protected in waterbodies directly affected by the facility, including downstream reaches, bypassed reaches, and impoundments above dams and diversions."[6]

GRH's application says that they satisfy this criterion under Standard B-2. In order to satisfy this standard they must show that, "The facility is in compliance with all water quality conditions contained in a recent Water Quality Certification or science-based resource agency recommendation providing reasonable assurance that water quality standards will be met for all waterbodies that are directly affected by the facility."[7] Additionally, the Standards indicate, "In all cases, if any waterbody directly affected by the facility has been defined as being water quality limited (for example, included on a state list of impaired waters that do not fully support designated uses), *the applicant must demonstrate* [emphasis added] that the facility has not contributed to the substandard water quality in that waterbody."[8]

The Lower Deerfield River below Harriman Reservoir is listed on the Vermont 303(d) list for Low temperature hypolimnetic water release from the reservoir.[9] Additionally, the East Branch Deerfield River, Below Somerset Dam is on the Vermont 303(d) list for low temperature dam releases.[10] GRH fails to demonstrate in their application that the facilities do not contribute to the substandard water quality as identified in these 303(d) listings.

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[5] Yellen and Bout (2015). Hydropeaking induces losses from a river reach: observations at multiple spatial scales. HYDROLOGICAL PROCESSES.

[6] Low Impact Hydropower Certification Handbook. 2nd Edition. Revision 2.03: December 20, 2018. Low Impact Hydropower Institute. Page 7.

[7] Ibid. Page 8.

[8] Ibid. Page 7.

[9] State of Vermont 2020 List of Priority Surface Waters. Part F. Surface Waters Altered by Flow Regulation. Page 8.

[10] State of Vermont 2020 303(d) List of Impaired Waters. PART A. Impaired Surface Waters in Need of TMDL. Vermont Department of Environmental Conservation. Watershed Management Division. Page 9.

As the application states, several GRH impoundments on the Deerfield system are listed as impaired for mercury in fish tissue. Though the mercury itself comes primarily from atmospheric sources outside of New England, the impoundments do contribute to the problem. Rising and falling water levels in impoundments have been shown to promote the conversion of inorganic mercury compounds to methylated mercury, which is absorbed up the food chain. This phenomenon is well known enough that there has even been research to strategize ways to lower methylmercury concentrations from hydroelectric reservoirs and lakes.[11]

Additionally, the continued use of plastic to line the flash boards at Dam No. 3 (and possibly elsewhere) are a concern, although the river below this dam is not considered impaired because of this, and CRC does not know if the issue came up when the 401 Water Quality Certificate was issued by MassDEP. When the river runs high, the flash boards are designed to fail and the plastic along with the boards are washed downstream. This seems to be wasteful and a potentially harmful addition of plastics into the Deerfield and Connecticut Rivers, as well as the Long Island Sound and Atlantic Ocean downstream.

3.2.8 Criterion H - Recreational Resources

The goal of this criterion is that, "The facility accommodates recreation activities on lands and waters controlled by the facility and provides recreational access to its associated lands and waters without fee or charge."[12]

One of the strengths of the Deerfield River project license and Settlement Agreement is the number and variety of recreational offerings along the entire system. GRH claims to satisfy this criterion under Standard H-2. In order to meet this criterion the facility must, "demonstrate[s] compliance with resource agency recommendations for recreational access or accommodation (including recreational flow releases), or any enforceable recreation plan in place for the facility."[13]

GRH says that recreation facilities are in place and maintained as described in the Final Completion Status Report for Deerfield River Project dated March 31, 2010. The 2010 status report provides updates as to the installation and maintenance of all facilities described in the 1993 Deerfield Project Recreation Plan. GRH also cites a 2018 FERC Environmental Compliance Inspection and report. GRH's predecessor owners, TransCanada and U.S. Gen, did install new and upgrade existing facilities. CRC believes that, in order to meet the criterion, citing a report from 10 years ago and a FERC inspection report that seems to indicate that FERC did not even visit all the recreation facilities, is not sufficient for "demonstrating compliance." GRH should have a list or table of all the recreation facilities associated with each of the hydro facilities that make up P-2323 and then have either a checklist or a series of photos (or preferably both) showing that each of the facilities is, in fact, still there, the signage is still in place, and the facilities are well maintained. [CRC adds as a note to LIHI, that the lack of information demonstrating compliance here makes us less confident in LIHI's proposed recertification process we commented on recently. If a full re-certification effort like this one does not provide complete information about recreation facility

[11] Mailman, Stepnuk, Cicek, Bodaly (2006). Strategies to lower methyl mercury concentrations in hydroelectric reservoirs and lakes: A review. Science of the Total Environment. Sep 1;368(1):224-35. Available online at https://pubmed.ncbi.nlm.nih.gov/16343602/.

[12] Low Impact Hydropower Certification Handbook. 2nd Edition. Revision 2.03: December 20, 2018. Low Impact Hydropower Institute. Page 12.

[13] Ibid. Page 13.

status, how will the proposed yearly notice possibly provide enough information that the public can respond to?]

CRC is glad to see that GRH finally has a public website that lists their facilities (https://www.greatriverhydro.com/facilities/). But, the information available on recreation amenities on this site is very minimal. For example, for Deerfield No. 4 Station, under “Available Recreation Facilities,” the web page states associated recreations sites are, “A picnic grounds and a fisherman’s access with gravel boat ramp are located along the river.” Where are these facilities located? How can you find them? As for the boat ramp associated with the Deerfield #4 impoundment, diagrams and photos from the 2010 Status Report indicate that this boat ramp shares a driveway with a private home, with signage located at the ramp area rather than located on Route 2 -- it’s not clear to the public that the boat ramp is open to the public unless you make the choice to drive down what looks like a private area. If signage on Route 2 is not desirable, then information on the website would help clarify.

Additionally, the website indicates that, “No overnight camping is allowed. Vehicles left after closing will be towed at the owners expense.” When is closing? Is there any way to accommodate cars left at any of the sites who are staying in the area multiple days for hiking, camping, or otherwise? What ever happened to the 5 primitive camping sites contemplated for Somerset in the 1993 Deerfield River Recreation Plan?

GRH indicates that “an annual schedule is published by April 1” of each year of whitewater releases, but it is not clear, based on the application, where that schedule is published. This schedule should be added to the GRH website outlining the release date and time and estimated time that the releases will reach each access area.

In terms of allowing recreational access to its lands, there are a couple of locations in which GRH has recently restricted access to the river on its lands. One is the land along the river near the station to Deerfield No. 3. Fencing was put up in response to people allowing dogs to swim in the forebay (an obvious safety problem), but instead of placing fencing just around the forebay or the roadway around the forebay, they restricted access to the entire area, blocking all informal routes to the river. Unfortunately, this roughly coincided with new ownership of the adjacent Lamson & Goodnow buildings and that owner (who, according to tax maps, owns a portion of the forebay area) also blocked access to the river. This means there is no access to a beautiful section of the Deerfield River below the Number 3 dam within easy walking distance to Shelburne Falls village residents on the Buckland side, until you get to the Gardner Falls station recreation trail, which is owned by a different hydropower company and already has LIHI certification. [As of this writing, we understand and appreciate that GRH is willing to discuss access issues in this area or other areas of Buckland]. Additionally, GRH owns lands along the Deerfield River in the town of Deerfield near the Stillwater Bridge, where there were plans for a dam that was never built. Recently, guard rails were put up at that location, reducing the available parking at that location by more than half. As far as we know, this was not done in coordination with the town. In the 2010 status report on the recreation facilities, the area was listed saying there were no planned changes to that parking and access area.

These two actions may not be in keeping with the goals of the Outdoor Recreation Management Policy articulated in the 1993 Recreation Management Plan: “Providing access to the water and to all areas within the ownership, where it is safe to do so.”

Conclusions

It is CRC's position that a multi-dam system like this, and one that includes at least one seasonal storage reservoir, **does not meet standards required to be considered for Low Impact Hydro Certification**.

If the LIHI staff and board disagree, CRC would encourage the following recommendations and conditions for re-certification.

Ecological Flow Regimes

- GRH should work with MA state fisheries staff to determine if a minimum flow at Dunbar Brook below the dam is desired and then willingly release that flow even if not required in a license.
- Increase GRH's contribution to the Deerfield River Environmental Fund (DREF) to mitigate for impacts to the system, potentially providing enough funding to take out unneeded dams or fix problematic culverts in the Deerfield River watershed.

Water Quality

- GRH should make some accommodation to monitor and adjust for extreme temperatures above and below the facilities.
- GRH should evaluate if there are ways to operate their reservoirs that would reduce mercury methylation.

Recreation

- GRH should provide more information on the status of all recreation amenities provided in this license as part of the application.
- GRH should provide maps of all lands under its ownership and provide information regarding public accessibility on each parcel or groups of parcels.
- GRH should continue to participate in community and regional meetings related to river access along the Deerfield River.
- GRH should improve the information available on its website so that people can learn about and access the vast amount of recreational offerings provided under this license.
- GRH should provide more information on flows from each facility than is currently provided in the outdated Waterline forecast. Users should be able to find out not just the current flow but flows from the previous 8 hours and a forecast of the next 8 hours. In addition, it should be easy to find the whitewater release schedule.

CRC is very grateful for the opportunity to comment. CRC is strongly supportive of the Low Impact Hydropower Institute's certification program and feels strongly that certified facilities should go above and beyond what is required to satisfy the FERC licensing process in order to earn this certification. Those efforts will inspire continued innovation in the hydropower sector.

Sincerely,

Andrea F. Donlon

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River Steward, MA

Kathy Urffer

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ATTACHMENTS

Yellen and Bout (2015)

Cc:
Derek Standish, MassDEP
Brian Harrington, MassDEP
Steven Mattocks, MA DFG
Jeff Crocker, VT DEC
Eric Davis, VT DEC
Betsy Simard, VT DEC
Hannah Harris,VT Fish & Wildlife
Melissa Grader, USFWS
Ken Sprankle, USFWS
Katie Kennedy, TNC
Jim Perry, Deerfield River Watershed Association
Bob Nasdor, American Rivers
Michael Vito, Trout Unlimited Deerfield River Chapter
David Deen, Trout Unlimited Connecticut River Valley Chapter

HYDROLOGICAL PROCESSES
Hydrol. Process. (2015)
Published online in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/hyp.10438

Hydropeaking induces losses from a river reach: observations at multiple spatial scales

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Abstract:

In humid regions, where gaining river conditions generally prevail, daily hydroelectric dam releases alter downstream surface water–groundwater interactions by reversing the head gradient between river and adjacent groundwater. Previously, it has been noted that artificial stage changes due to dam releases enhance hyporheic exchange. Here we investigate the regulated Deerfield River in northwestern Massachusetts at multiple scales to evaluate how changing downstream geologic conditions along the river mediate this artificial hyporheic pumping.

Water budget analysis indicates that roughly 10% of bank-stored water is permanently lost from the 19.5-km river reach, likely as a result of transpiration by bank vegetation. An adjacent reference stream with similar dimensions and geomorphology, but without hydropeaking, shows predictable gaining conditions. Field observations from streambed piezometers and thermistors show that water losses are not uniform throughout the study reach. Riparian aquifer transmissivity in river sub-reaches largely determines the magnitude of surface water–groundwater exchange as well as net water loss from the river. These newly documented losses from hydropeaking river systems should inform decisions by river managers and hydroelectric operators of additional tradeoffs of oscillatory dam-release river management. Copyright © 2015 John Wiley & Sons, Ltd.

KEY WORDS hyporheic; hydropeaking; dam release; surface water-groundwater; Deerfield River; streambed temperature

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INTRODUCTION

For several decades, river and wetland ecologists have documented and publicized the impacts of dams on fish and other biota (e.g. Raymond, 1979; Ward and Stanford, 1983; Poff *et al.*, 1997). In addition to impacting flow regime and geomorphic processes (e.g. Ligon *et al.*, 1995; Magilligan *et al.,* 2003), hydrologists have recently recognized the potential for abrupt, anthropogenic stage changes downstream from hydroelectric dams to dramatically alter surface water–groundwater (SWGW) interactions (Arntzen *et al.*, 2006; Boutt and Fleming, 2009; Sawyer *et al.*, 2009). Whereas most river reaches consistently gain or lose water, particularly within a given season, dam-controlled rivers often switch from gaining to losing on the time scale of daily energy demand cycles. Hydropeaking—discrete dam releases during periods of peak electricity demand—raises and lowers river stage abruptly. Downstream from hydropeaking dams, abrupt stage changes reverse the vertical head gradient (VHG) between surface water and underlying groundwater, thus causing these reaches to continually alternate between gaining and losing states.

In the last twenty five years, several investigators have documented crucial stream processes at work within the hyporheic zone (Boulton *et. al*, 2010), the region below a stream where stream and ground water mix (Brunke and Gonser, 1997). These processes include mediation of cycling of nitrogen (Jones *et al*., 1995), phosphorous (Mullholland *et al*., 1997), and carbon (Findlay *et al*., 1993) within streams. Recent recognition of the importance of hyporheic zone processes to river ecosystems coupled with the near ubiquity of flow alteration in the developed world (Graf, 1999) makes it essential that we understand how hydropeaking may be altering SWGW interactions and the sensitive ecotone that inhabits streambeds. Here, we explore how changing downstream geologic conditions shape the magnitude and direction of changes in the hyporheic zone associated with hydropeaking. Furthermore, we propose that in certain conditions, hydropeaking can cause a typically gaining river reach to permanently lose water.

A handful of studies have used streambed probes, often at a single study site, to make discrete measurements to document alterations to SWGW interactions as a result of hydropeaking. Arntzen *et al*. (2006) noted a hysteretic pattern of VHG reversals in riverbed materials in the

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Hanford Reach of the Columbia River downstream of a dam with ~2-m stage changes. Most notably, variation in the magnitude of the VHG at different sites was largely a product of different bed material conductivity. Sawyer *et al.* (2009) extensively documented the altered SWGW exchange dynamics at a study site downstream from Austin, Texas, USA on the Colorado River. The authors used piezometric data, geochemical observations, and heat tracer data to illustrate how hydropeaking causes a dramatic increase in the extent of the hyporheic zone (HZ) at the study site. At the same site, Gerecht *et al.* (2011) noted the potential for hyporheic pumping to impact streambed temperature and provide thermal buffering at low stage when the river quickly reclaimed water from the overpressured streambed. Hanrahan (2008) monitored VHG at sites of known importance for salmon spawning in a mostly bedrock-bound reach of the Snake River. From observations of minimal VHG despite large, abrupt stage changes, he concluded that dam-induced hyporheic exchange was minimal due to limited unconsolidated bank material in the canyon setting of the study site. All of these studies evaluated the phenomenon of hydropeaking-induced SWGW exchange as a function of very local site properties. Here, we build on their work by investigating this phenomenon at larger spatial scales, incorporating water budget analysis and the potential impact of reach geomorphology on hyporheic pumping.

On the Deerfield River in western Massachusetts, we set out to better understand the effect of reach-scale geologic characteristics, such as changing valley aquifer morphology and stratigraphy, on the magnitude and direction of dam-induced hyporheic exchange. Indication that the study reach loses water, despite its location within the humid northeastern United States, led us to focus on the role of dam-control in potentially causing rivers to lose water. Whereas previous studies have focused on a single site or small collection of sites, we use a combination of discrete scale field measurements as well as reach-scale water budget analysis to obtain a more systemic picture of the effects of abrupt stage changes on SWGW interactions. Furthermore, we focus on the role of riparian aquifer characteristics, including hydraulic properties and variation in areal extent, in controlling the nature of dam-induced SWGW intermixing.

SITE DESCRIPTION

The Deerfield River (DFR) watershed covers 1722 km^2 across portions of southern Vermont and northwestern Massachusetts, USA before entering the Connecticut River in Greenfield, Massachusetts (Figure 1A). Our study reach stretches from the Fife Brook Dam in Rowe, MA 19.5 km downstream to USGS gaging station 01168500 in Charlemont, MA. In the span of the study reach, tributaries and streams entering the DFR increase the river's contributing area 40.4% from 666 km^2 at the upstream end of the reach to 935 km^2 downstream. In this reach, four major subwatersheds (area > 30 km^2 each) enter the DFR, accounting for roughly 80% of the increase in contributing area.

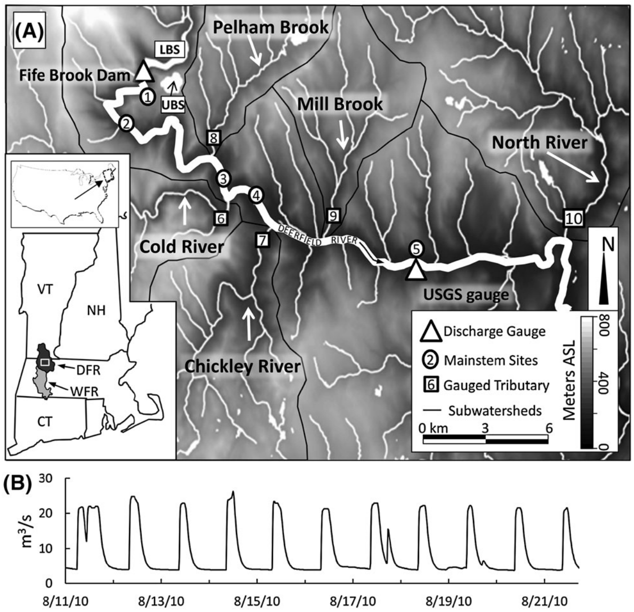


Figure 1. (A) Site map of the study area. The entire DFR watershed is shown in inset at bottom left spanning parts of Vermont and Massachusetts. The WFR watershed is just south of DFR. In the shaded elevation map, the mainstem of the DFR (thick white line) runs southeastward with the study reach defined by the two discharge sites (triangles). The Lower Bear Swamp (LBS) impoundment and Upper Bear Swamp (UBS) pump-storage reservoir appear in the northwest corner of the blown up area. Four large tributaries within the study reach, as well as North River are labeled. (B) Typical summer discharge fluctuations on the Deerfield River during a 10-day dry period

The largely rural watershed (>90% forested) displays typical Northeastern United States climate throughout most of its area. Average annual precipitation reported by gauges within the watershed ranges from 110 to 130 cm depending on elevation. Precipitation is distributed evenly among the seasons. Seasonal variations in evapotranspiration play a dominant role in controlling average monthly runoff, with a disproportionate amount of runoff occurring during spring due to snow melt and high soil moisture conditions.

A steep longitudinal river gradient (slope = 0.075 in dammed reach) and humid climate make the DFR ideal for hydroelectric power generation. Harriman and Somerset reservoirs (off north edge of Figure 1A) in the Vermont part of the watershed provide most of the storage for six downstream run-of-river generating facilities by storing on average 54% of mean annual discharge. These large upstream reservoirs are drawn down in late winter (see Supplementary Figure 1), providing storage for flood control during the spring freshet and power generation as the stored spring floods are incrementally released during summer peaks in energy demand (P. Moriarty, personal communication, November 30, 2010). Storage of the spring flood suppresses the annual hydrograph, largely preventing discharge events greater than 400 m^3/s within the study reach.

The summer hydrograph within the study reach is dominated by the signature of Fife Brook Dam, a small impoundment (low flow residence time $<$ 3 days) constructed in 1974 that allows for hydropeaking and provides water for pump storage generation. On an average summer day, discharge from the dam increases from 3.5 m^3/s to 25 m^3/s for roughly 8 midday hours, raising river stage anywhere from 0.4 to 0.7 m depending on channel morphology (Figure 1B.).

The study reach is located in the Berkshire Hills physiographic province (Friesz, 1996), characterized by narrow river valleys surrounded by steep bedrock hill slopes. Lower gradient valley bottoms generally contain 0–20 m stratified drift and modern alluvium. However, in some locations Pleistocene glaciation over-deepened a few bedrock valleys, which now accommodate up to 50 m of this unconsolidated material in places. We refer to this valley fill material that is hydraulically connected to a local drain as the riparian aquifer. The majority (70%) of riparian groundwater basin recharge is derived from adjacent metamorphic crystalline bedrock uplands via runoff, fracture flow and shallow subsurface flow (Friesz, 1996). Other recharge occurs via direct precipitation inputs to water bodies and tributary valley bottoms.

Along the study reach, riparian aquifer hydraulic conductivities change dramatically. The upper 5.5 km of the reach is largely bedrock-bound, with the exception of a ~7-m depth to bedrock observed at site 2. Mabee *et al.* (2007) detailed the extent and nature of the valley fill aquifer spanning the lower 14 km of the study reach. Strata there are typical of glacial morphosequence valleys (Koteff and Pessl, 1981): fining upwards glaciofluvial deposits throughout the site with glaciolacustrine sediment overlying the most downstream parts of the reach in Charlemont, MA (Figure 2). Reworking of coarse proglacial delta sediments has mantled the modern valley bottom with high conductivity (30–100 m/d) modern alluvium. As glacial lakes drained and the valley adjusted to lowered base level, the mainstem of the river has incised through this surface alluvium in most locations and the streambed directly overlies glaciofluvial sediments. Streambeds on the DFR and major tributaries are generally made up of cobbles and boulders that are only mobilized during high-discharge events. At pinch points

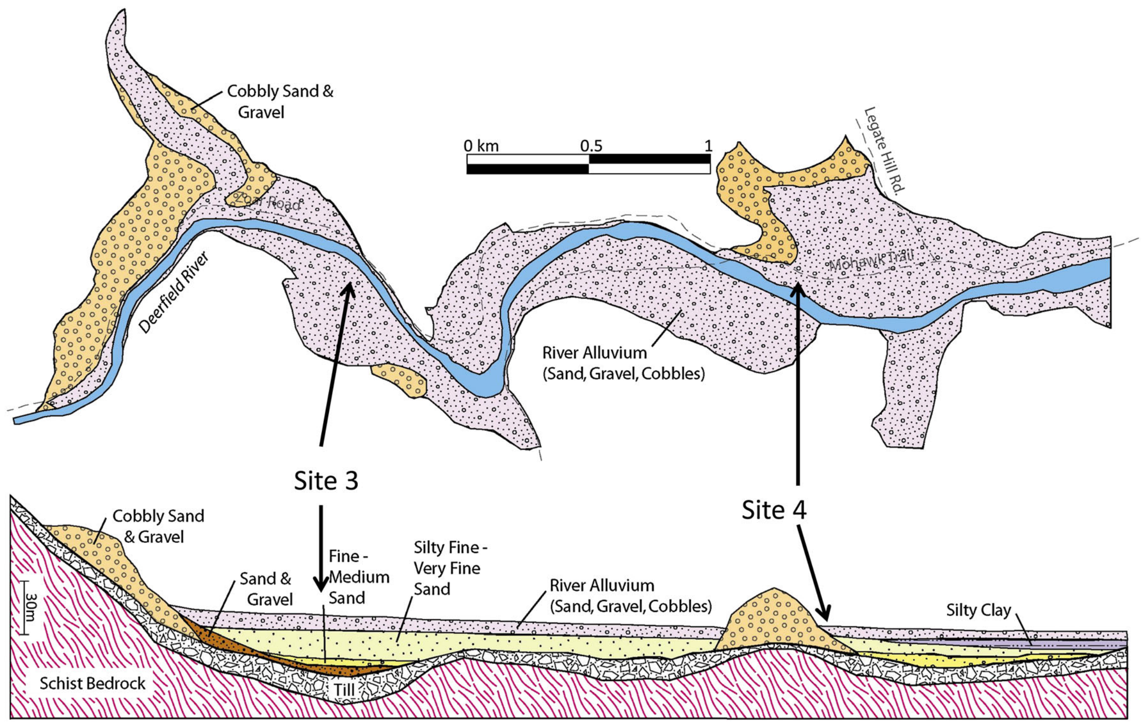


Figure 2. Map view (top) and cross section down the valley axis (bottom) of surficial geology of the lower two thirds of the study reach showing the glaciofluvial and glaciolacustrine deposits that fill the over-deepened bedrock valley (modified from Boutt 2010). The locations of sites 3 and 4 are indicated by black arrows on both the map and cross-section views. Sites 1 and 2 are upstream of this schematic. Site 5 and the downstream discharge gauge are just off the right side of this diagram

in the upper half of the study reach (such as site 1), where resistant bedrock outcrops along the banks, residue on extracted in-stream piezometers made up of a clay-rich matrix with angular grains embedded indicated that the river likely runs directly over lodgement till in these areas. At the most down-stream sections of the reach, the riverbed lies directly atop fine grained, low-permeability glaciolacustrine material.

Directly to the south of the DFR watershed, a series of gauges on the geomorphically similar Westfield River (WFR) allows for reliable comparison of SWGW processes in a reference watershed that lacks hydropeaking. The reach between upstream and downstream discharge gauges measures approximately 28 km, the upper 13 km of which are relatively bound by bedrock. The lower 15 km of this reference reach flows through a broad alluvial valley similar to that of the lower Deerfield study reach. Flood control dams on two of the three WFR branches dampen annual peak flows, but generally do not modify seasonal median discharge as observed in the DFR.

METHODS

Water budget observations

We constructed a simple water budget to evaluate reach-scale SWGW interactions by accounting for major inputs to and outputs from the river system, excluding groundwater. Any difference in absolute value between system inputs and outputs therefore indicates gains from or losses to the riparian aquifer. There is no major groundwater or surface water withdrawal within this rural, mountainous watershed.

Upstream discharge from Fife Brook hydroelectric dam plus contributions of four major tributaries comprised water budget inputs. The four gauged tributaries cumulatively make up 80% of downstream increase in contributing area, thereby providing a minimum bound for surface water inputs. Evaporation plus downstream discharge measured at the Charlemont, Massachusetts USGS gauge (01168500) comprised outputs from the system. We estimated an evaporation time series using an energy balance approach according to Valiantzas (2006), which approximates the Penman Equation (Penman, 1948), but makes use of more commonly observed meteorological data. This method is a physically based energy balance approach that sums estimates of incoming short wave radiation, outgoing long wave radiation, and turbulent energy exchanges. Estimated linear evaporation rates were multiplied by the approximate surface area of the river reach to obtain a time series of volumetric losses from the river due to direct evaporation from the river surface. Thus, the water budget equation used was

$$GW = (Q_{dn} + E)\text{-}\left(Q_{up} + Q_{trib}\right) \quad (1)$$

where Q_{up} is discharge just downstream of the Fife Brook dam, Q_{trib} is the combined discharge of the four largest tributaries in the reach, Q_{dn} is discharge at the downstream end of the reach, and E is direct evaporation from the surface of the DFR. The difference between inputs and outputs—GW—represents changes in storage of the groundwater system. The two terms on the right side of Equation (1) are reversed from general convention in order that negative GW values indicate times when the river was losing water to the groundwater system. Positive values conversely indicate gaining conditions.

Continuous rain-free periods of nine days were identified during the summers of 2005 and 2010 for which we had reliable data to account for water budget inputs (Table I). Most of the data presented were collected during the summer of 2010. However, we also calculated the water budget during the summer of 2005, both because it was the only other summer for which Q_{up} data were available and to allow for comparison with other years to evaluate if patterns were consistent across multiple summers. In addition to summer analysis periods, two suitable periods for analysis were identified during spring and fall dormant conditions (shaded in Table I).

To account for flood wave travel time, each component of the water budget was lagged forward to correspond

Table I. Average values of water budget components for rain-free 9-day periods with associated error estimates for each integration. Dormant season reference time periods are shaded grey. GW indicates the net result of water budget calculations showing losses across all summer observation periods

	GW (m^3/s)	Qdn (m^3/s)	Qup (m^3/s)	Qtrib (m^3/s)	Avg E (m^3/s)
July 1–9, 2010	−0.99 ± 0.061	13.27 ± 0.002	13.75	0.64 ± 0.147	0.117 ± 0.001
Aug 8–16, 2010	−1.33 ± 0.134	12.10 ± 0.017	12.94	0.57 ± 0.103	0.075 ± 0.015
Sep 4–12, 2010	−0.93 ± 0.138	6.39 ± 0.007	6.75	0.65 ± 0.113	0.085 ± 0.017
Jul 22–30, 2005	−1.95 ± 0.414	8.51 ± 0.027	8.62	1.94 ± 0.384	0.094 ± 0.018
Aug 5–13, 2005	−1.52 ± 0.257	8.38 ± 0.470	8.85	1.13 ± 0.225	0.083 ± 0.017
Mar 20–28, 2005	3.79 ± 2.76	18.00 ± 2.28	11.38	3.59 ± 0.72	0.023 ± 0.001
Nov 7–13, 2009	−0.08 ± 5.48	24.1 ± 4.81	20.84	3.33 ± 0.67	0.012 ± 0.002

with earlier Q_{up} time stamps. Q_{dn} was lagged earlier by 4.5 h, which corresponded to the average time it took a 25 m^3/s pulse to travel the reach. E and Q_{trib} were each lagged 2.25 h to provide average parameter values during a given flood wave.

In order to evaluate the extent that different variables drive the system, individual dam-release events were delineated. Each event's beginning and end were denoted by departure from and subsequent return to minimum baseflow releases from Fife Brook Dam (Supplementary Figure 2A). Water budget time series components were integrated over given release events and summed to evaluate the extent of SWGW exchange for individual dam hydrographs. In this way, data points could be resolved from the various time series described in Equation (1). By calculating loss during each dam release, these data can be compared to potential causal mechanisms for river losses.

We tested the sensitivity of water budget results to varying lag times of Q_{dn} behind Q_{up}. Lag times were adjusted in half our increments from 3 h to 5.5 h. For each lag trial, the GW term was computed for several individual dam hydrographs and for 2010 9-day summation periods. Lags between 3 and 5-h tests show little change in net loss at daily or 9-day time scales, with an average change in the value of GW of 0.89% for all time periods tested (Supplementary Figure 2B). Because, observed lag times for flood propagation between gauges were consistent across analytical periods, and always between 4.25 and 4.75 h, we kept lags constant across analytical periods.

In order to perform calculations on 2005 data, a Q_{trib} record was reconstructed based on a linear regression between observed Q_{trib} values and those from the neighbouring North River, which has a USGS discharge gauge. Simulated 2010 Q_{trib} baseflow values at each time step differed from the observed time series by an average of 3%. The small total discharge of the four tributaries relative to that of the DFR study reach causes this error to be less than 1% of the GW term for 2005 analytical periods.

A simpler water budget was constructed for the adjacent Westfield River (WFR) that accounts for only upstream and downstream discharge. Tributary inputs were not available for this system. Upstream discharge data were compiled by adding values from a gauge on each of the WFR's three main branches (USGS gauges 0118100, 01180500, and 01179500). Downstream discharge is taken from a USGS gauge (01183500) located 28 km downstream of the confluence of the three branches.

Error propagation

Using conservative values of each water budget component in order to minimize estimated losses from the river, we tested whether perceived losing conditions could be due simply to observational error. To do this, we considered maximum possible outputs from the system and minimum adjusted inputs. Q_{dn} was adjusted higher by a constant percentage corresponding to the average of the absolute value of error reported from USGS field measurements at the site. This reported error is the percent difference between observed discharge and that inferred from the stage. Where the specific field measurements following evaluation periods used to make error adjustments, Q_{dn} would have been revised smaller, and thereby driven losses more negative, defeating the stated goal of this loss minimization exercise. Instead we averaged the absolute value of all field measurements ($n = 68$) dating back to 1948 on days when discharge was less than 30 m^3/s. There was no relationship between discharge and measurement error. To adjust the Q_{dn} record, each observation in the time series was adjusted upwards by 0.13%, which corresponded to the average error in the historic records.

To conservatively evaluate error in Q_{trib}, we subtracted 20% from each observation, consistent with minimizing losses from the river. Q_t only considers discharge from four tributaries and does not account for surface water inputs from 20% of the reach catchment made up of smaller streams. Therefore, Q_t adjusted with this error is almost certainly lower than actual tributary inputs, thereby avoiding possibility of overestimating losses from the river. Observations from the E time series were also each revised upwards by 20%, bringing average E consistently above regional daily evaporation estimates reported in the region. Q_{up} was measured by utility companies and verified via independent observations of dam tailwater stage coupled with a rating curve and electrical power production. Due to the rigor applied and the multiple measurement methods, we have not adjusted Q_{up} in error analysis.

Streambed observations

Five study sites within the 19.5-km study reach were instrumented to collect discrete measurements of VHG and streambed temperatures. We selected field sites to capture a range of riparian aquifer geometries, from bedrock bound channel at site 1, to extensive stratified drift at sites 3 and 4, and intermediary conditions at sites 2 and 5. At sites 1 and 2, we performed seismic refraction surveys and pinned the bedrock reflector to the bottom of a schematic glacial U-shaped valley. At sites 3 and 4, extensive borehole and geophysical investigations detailed in Mabee *et al.* (2007) were used to constrain aquifer geometry.

Streambed head and river stage were used to calculate vertical hydraulic gradient (VHG) as the ratio of the difference in head between the river and the underlying groundwater over the distance between the river bottom and the top of the piezometer screen following Arntzen *et al.* (2006):

$$VHG = \frac{h_{HZ} - h_R}{z_R - z_S} \quad (2)$$

where h_{HZ} and h_R are head in the hyporheic zone and river, respectively; z_R and z_S are elevation above an arbitrary datum of the river bottom and the top of the well screen, respectively. Thus, when the numerator is positive, head in the streambed exceeds that in the river and we assume that the river gains water from the aquifer.

At each site, VHG and vertical temperature distribution were monitored. Limited equipment precluded simultaneous monitoring at all sites. Between two and five days of observations were recorded at each site during periods of non-precipitation and routine hydropeaking (e.g. Figure 1A). Each monitoring deployment captured at least two dam-induced floods, ensuring that we captured changes in the direction of the hydraulic gradient. Streambed VHG and temperature observations were collected from 4-cm outside-diameter solid steel pipes following the recommendations of Cardenas (2010) fitted to a drive point. We screened piezometers by drilling six 1-cm perforations 10 cm above the drive point. Piezometers were deployed at ~10-cm river depth during low stage by driving with a slide sledge until the top of the screen was 50 cm below the streambed, after which the piezometer was developed by flushing the screen with approximately 10 l of water. Pressure transducer data loggers (Solinst LevelLoger 3001, 1.4-mm resolution) were placed in these piezometers and in the river to record river stage and hyporheic zone head at 5-min intervals. Temperature loggers (iButton model DS1921Z, 0.125 °C resolution) were placed in similarly constructed piezometers affixed to a metal rod to measure temperature in the river and the streambed at 10 cm and 30 cm below the river bottom. Rubber baffles inside the piezometer every 10 cm limited convective heat transport within the well. The VTD probe at site 3 malfunctioned. As a substitute, we make use of temperature data from the VHG pressure transducer pair, which record temperature in addition to absolute pressure. The HZ pressure transducer was at a depth of 50 cm, 20 cm below the lowest thermistors at other sites.

In addition to monitoring VHG, we conducted slug tests to estimate bed hydraulic conductivity prior to removal of each streambed piezometer. Wells were redeveloped by pouring roughly 10 l of river water into the pipe and allowing time for the head to return to static level. A 50-cm section of pipe fitted with a false bottom and filled with river water was used to instantaneously raise the head in the well. A pressure transducer recorded the head recovery at 1-s intervals. The recovery was modeled using Bouwer–Rice method (Bouwer and Rice, 1976), which is appropriate for underdamped systems where the well screen is completely within the saturated zone. Three slug tests were performed for each piezometer. Due to problems with short circuiting around the outside of the well bore immediately after piezometer emplacement, we could only perform slug tests on our wells that had been deployed for several days and subsequently redeveloped. Thus, only one well could be tested at each of the five study sites.

Riparian aquifer wells

We make use of data collected previously as part of a study of groundwater resources within the region (Friesz, 1996). Two wells were installed at distances of 3 m and 40 m from the river at site 4 (see Figure 1A for location), where the river flows through a broad alluvial aquifer. Both wells were screened in coarse alluvium. River stage oscillations propagate through the conductive alluvial sediments there and are evident in both well hydrographs. We use the horizontal distance between these wells and the difference in head during summer of 1994 to calculate a time series of hydraulic gradient within the riparian aquifer. This gradient time series, coupled with Friesz's (1996) estimate of hydraulic conductivity of 100 m/d was used to calculate a Darcy-based horizontal flux adjacent to the river.

RESULTS

Water budget calculations

Water budgeting indicates that the DFR study reach consistently lost water to the adjacent aquifer over 24-h periods during summer months. Several nine day summations of the GW term in Equation (1) across two water years all show water losses (negative GW terms) from the river to the riparian aquifer (Table I). Total loss from the river during summer periods averaged 14% of upstream discharge. Summer upstream discharge (Q_{up}) exceeded downstream discharge (Q_{dn}) for all five rain-free periods examined. During spring, consistent gaining conditions prevailed despite a similar hydropeaking regime (Figure 3B). Integration across these 9 days in spring indicated average reach gains of 3.79 m^3/s. One suitable autumn analysis period was identified as well during which GW was close to zero. However, tributary discharge during this period was not directly measured and was likely well above levels at which our regression with the North River applies. Observation of persistent losing periods during summer periods suggests that some mechanism acting in concert with abrupt stage changes drives water permanently away from the river.

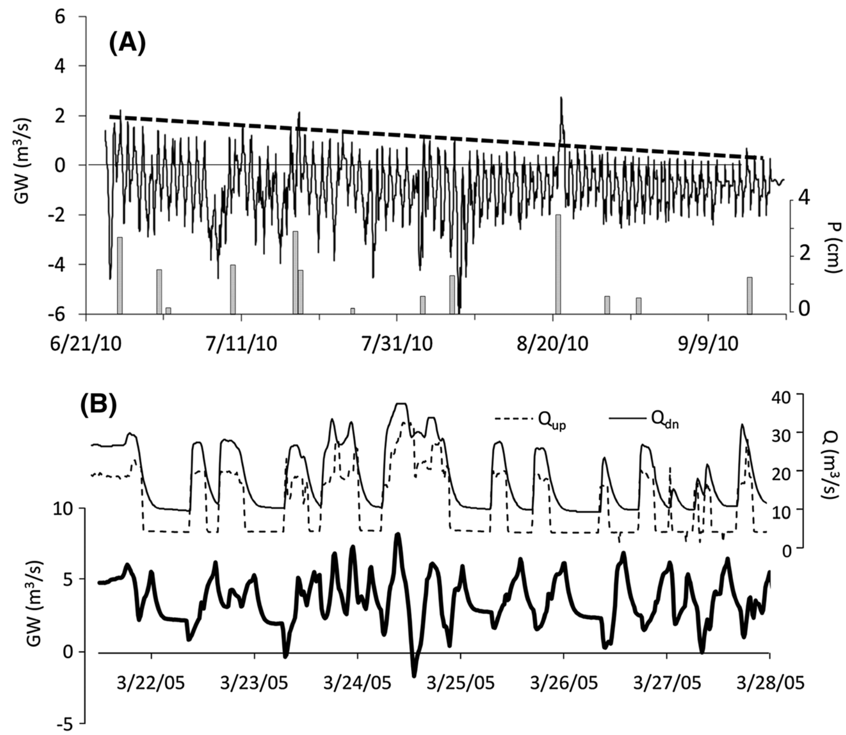


Figure 3. A 12-h moving average of the GW term from Equation (1) (A) shows a decline in the magnitude of temporary positive (gaining) excursions. Dashed dark line highlights this trend. Daily precipitation measured in Ashfield, MA depicted by grey bars. (B) Upstream and downstream discharge during spring 2005 hydropeaking with resultant GW term depicted with heavy black line. Q_{up} is lagged 4.5 h. Q_{up} for 2010 cannot be shown due to a confidentiality agreement signed with the data provider

Conservative error propagation, designed to minimize loss estimates, resulted in smaller losses from the river. However, Q_{up} still exceeded Q_{dn} for all evaluation periods. The downward revision of losses ranged from 0.06 to 0.41 m^3/s, for an average of 14% reduction in net losses (Supplementary Figure 3). Therefore, we can state without qualification that the river loses water consistently during summer.

A time series of the GW term of Equation (1) shows a clear negative trend in the magnitude of temporary gaining periods throughout summer of 2010 (Figure 3A). Short gaining periods occurred at the beginning of the low stage phase of each dam-induced hydrograph. As discussed earlier and noted by Gerecht *et al.* (2011), a dam-induced decrease in stage causes a local temporary head gradient reversal back towards the river. Sharp positive excursions from the seasonal decrease in the GW term are explained by precipitation events and accompanying runoff that was not accounted for in our four gauged tributaries. Lack of observations during high stage events on tributaries makes the magnitudes of these displayed hydrograph spikes uncertain due to error in tributary rating curves for high stage values.

Streambed observations

Streambed observations provide a more detailed perspective on the dynamics of SWGW interaction at sites with varying geologic context. Due to profound heterogeneities in streambed hydraulic conductivities at the pool and riffle scale (Conant, 2004) and sparse observations due to limited equipment, these data should be viewed primarily as confirmation of water budget observations made at the reach scale. Nevertheless, streambed temperature patterns generally confirmed losing conditions, especially during dam releases, with notable exceptions due to pool and riffle scale changes in valley morphology.

Site 1

Located just below the Fife Brook dam, this site is characterized by a bedrock bound channel with very limited transmissivity in the limited to non-existent riparian aquifer (Figure 4D). As a consequence of the minimal porous media and accompanying storage, changes in river stage quickly permeated the entirety of the narrow strip of bank alluvium. Thus, minimal gradient could be maintained between river head and that in the HZ (Figure 4A). The stage–VHG relationship was nearly horizontal indicating that regardless of changes in stage, VHG remained nearly absent.

Vertical temperature distribution at site 1 generally confirmed limited stage change-induced hyporheic pumping, consistent with the findings of Hanrahan (2008). Namely, the deepest temperature logger, at

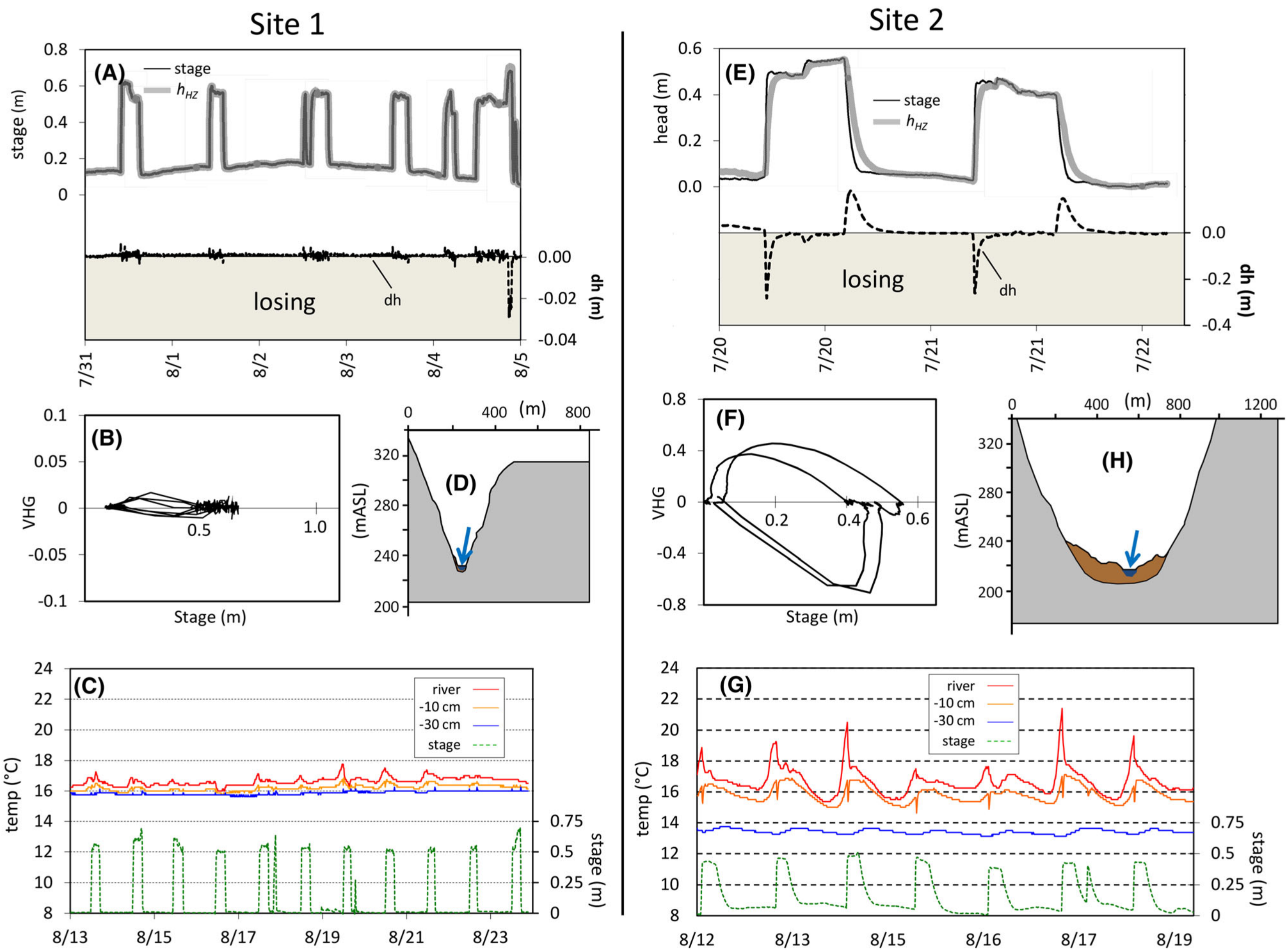


Figure 4. Streambed observations from site 1 (A–D) and site 2 (E–H). A and E show river stage, head 50 cm below the river bed (HZ Head), and the difference between these two measurements (dh); note that dh is plotted at different scales for sites 1 and 2. B and F show vertical hydraulic gradient (VHG) as a function of stage. C and G plot temperature in the river, as well as 10 cm and 30 cm into its bed. River stage depicted with green dashed line. D and H show schematic valley cross sections. Bedrock is shaded grey, valley fill is brown, and the river location is identified by a blue arrow

30 cm below the streambed, recorded almost no change in temperature regardless of changes in stage. Fife Brook Dam, Lower Bear Swamp Reservoir's bottom release dam, discharges cold water resulting in relatively steady river temperature and minimal diurnal temperature swings. HZ temperature 10 cm below the riverbed weakly echoed surface temperature signals. However, 30 cm into the HZ, temperature varied minimally above the resolution of the logging instrument. The continuous low temperature of the HZ here illustrates that insignificant volumes of slightly higher temperature river water are advected below the riverbed.

Site 2

At site 2, the river runs over a moderately wide (~200 m) valley bottom with up to 7-m-thick unconsolidated sediments (Figure 4H). It was expected that intermediate valley fill dimensions would provide for moderate SWGW exchange. With only seismic profiling and shallow auguring, we cannot be sure what comprises the roughly 7 m of sediments here. The VHG record suggests that the bank and HZ media impeded porous flow to a greater degree than sites 3 and 4. The low K here is evidenced by large dh values following abrupt stage changes (Figure 4E). The wide circle of the stage–VHG relationship suggests that gaining or losing conditions are highly hysteretic (Figure 4F), with the direction of flow highly dependent on previous stage. The near symmetry of the record about the *x*-axis indicates that the river here was neither strongly gaining nor losing over longer time periods.

The surface water diurnal temperature signal here appeared more like that of an unregulated river, with rising values during the morning hours due to heating that occurred in the 4 km downstream from Fife Brook Dam (Figure 4G). However, the daily arrival of the cold dam flood hydrograph from upstream ended morning increases in surface water temperature. Temperature 10 cm below the river bottom closely mirrored that at the surface, but never exceeded it. As observed in streambed temperature records in Hatch *et al.* (2006) and other studies, the diurnal temperature signal at depth here lagged behind that at the surface due to the time for heat to reach that depth. At the deepest level, 30 cm, the diurnal signal is barely visible. The low temperature at this level approximates that of regional groundwater, suggesting that water from the river does not strongly influence temperature at depth.

Immediately following abrupt stage increases, we observed that the 10-cm temperature logger recorded a short-lived drop in temperature just as the river head increased (Figure 4G). We would otherwise expect surface water to be driven down and raise the HZ temperature. Boutt (2010) noted that loading of the riparian aquifer by added mass from the sudden arrival of a dam release flood wave could cause a jump in head in layers below confining units. If this process operates at site 2, one would expect a brief upward hydraulic gradient, pushing deeper, colder water towards the surface. Poroelastic loading driving colder water up explains this brief drop in temperature at depth when we would otherwise expect warming there. Furthermore, it indicates that a confining layer likely exists here close to the surface, consistent with the short duration of maintained VHG.

Sites 3 and 4

Sites 3 and 4 have similar valley geometries, similar hydrogeologic settings, and appear to respond similarly to abrupt stage increases (Figure 5). At both sites, wide and deep glaciofluvial deposits fill upwards of 40 m of over-deepened bedrock depression. Postglacial deposition of silty-fine to very fine sand underlies the streambed and grades finer downstream towards site 4. Coarse, high conductivity (up to 30 m/day) alluvium covers these deposits and forms the river banks in this reach. At both sites, referenced stage elevation exceeded HZ head at almost all times (Figure 7A, E) resulting in a negative VHG (Figure 5B, F). Immediately following flood-wave arrival, the difference in head was especially pronounced, when higher stage strongly drove water out of the river and into the riparian aquifer.

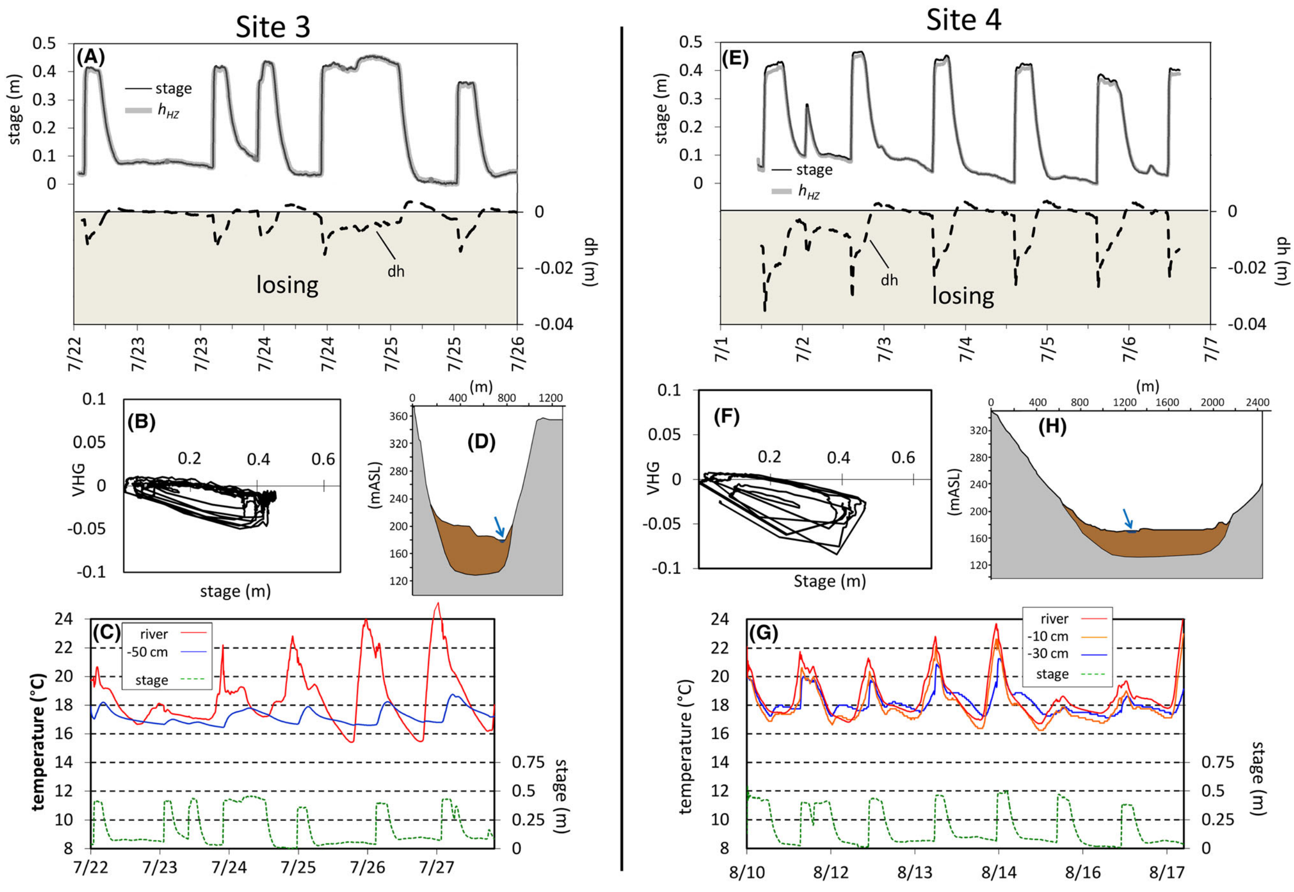


Figure 5. Streambed observations from site 3 (A–D) and site 4 (E–H). A and E show river stage, head 50 cm below the river bed (HZ Head), and the difference between these two measurements (dh). B and F show vertical hydraulic gradient (VHG) as a function of stage. C and G plot temperature in the river, as well as 10 cm and 30 cm into its bed. River stage is shown in green dashed line. D and H show schematic valley cross sections. Bedrock is shaded grey, valley fill is brown, and the river location is identified by a blue arrow

Both sites 3 and 4 display hysteretic VHG–stage curves (Figures 5B and 7F) that remain almost entirely below the *x*-axis. Daily dam releases, together with the influence of prior HZ head conditions on the direction of the VHG, caused this cyclic pattern in the VHG–stage relationship. For example, just before an abrupt stage increase, the hydraulic gradient between surface and HZ water was at its minimum. When the flood wave arrived, river head (h_R) jumped dramatically above HZ head (h_{HZ}), making the VHG strongly negative. The slow rise in h_{HZ} in response to downward seepage from the river reduced VHG, as indicated by the curve approaching the *x*-axis. When stage fell abruptly, h_{HZ} remained briefly elevated, causing the relationship to plot slightly above the *x*-axis and the river to gain back some of the lost water before the next flood wave arrived and forced more water into the subsurface.

At sites 3 and 4, most data points on the VHG–stage relationship (Figures 5B and 7F) fall below the *x*-axis, indicating that the river likely lost water at both locations. In general, the magnitude of VHG at site 4 was greater than that at site 3, perhaps reflecting the downstream decrease in grainsize which would cause a similar decrease in hydraulic conductivity and serve to better maintain a gradient during high stage events.

Streambed temperature records at sites 3 and 4 (Figures 5D and 7H) both show closely coupled stream and HZ temperatures. The added depth of the site 3 piezometer, which is shown in place of the faulty VTD probe data, caused expected additional dampening and lagging of the diurnal temperature signature.

Slug testing

Hydraulic conductivity (K) estimates for all sites are relatively high (>20 m/d) with values generally being higher at the two downstream sites (Table II). Results from site 3 vary considerably, possibly due to a poor connection between the piezometer and streambed media, allowing for a rapid attenuation of the initial head perturbation via short circuiting around the outside of the well bore. Due to the point-scale nature of these slug test-based K estimates, results are presented with the caveat that they do not capture the spatial heterogeneity at each site. Rather, they provide some context for observed changes in hyporheic head within each piezometer.

Riparian aquifer wells

Streambank head observations from Friesz (1996) corroborate strongly losing conditions at this location. In the well located 3 m away from the river and screened within the high horizontal hydraulic conductivity alluvium at site 4, head was consistently higher than that observed in the well 40 m away from the river. Observations taken over 14 days in early July indicate an average difference in head of 0.11 m corresponding to an average head gradient of 0.0028 away from the river (Figure 6). Our Darcy-based approach, when applied to both banks of the 19.5-km river reach, results in an average loss of 3.6 m^3/s, or roughly three times water budget losses reported in Table I.

Table II. Slug test results from DFR sites 1–4 reported in m/d. Results from site 3 vary considerably due to a poor connection between the piezometer and streambed media, allowing for a rapid attenuation of the initial head perturbation

Site	1	2	3	4
Trial 1 (m/d)	14.1	35.0	353.5	142.6
Trial 2 (m/d)	23.7	36.6	126.4	138.2
Trial 3 (m/d)	23.6	33.7	288.3	108.9
Average (m/d)	20.5	35.1	256.1	130.5

Additional observations

Due to problems with piezometer screen clogging and infrequent hydropeaking during piezometer deployment, data from site 5 are less valuable than sites 1 – 4. Streambed temperature and VHG data from that site generally indicated gaining conditions, which is consistent with limited depth to bedrock and pinching out of the alluvial basin material at the site driving groundwater to the surface from basin-scale flowpaths.

DISCUSSION

Our water budget approach to understanding the effects of hydropeaking on SWGW interactions suggests that the DFR study reach loses water as a result of hydroelectric management practices. Given the combination

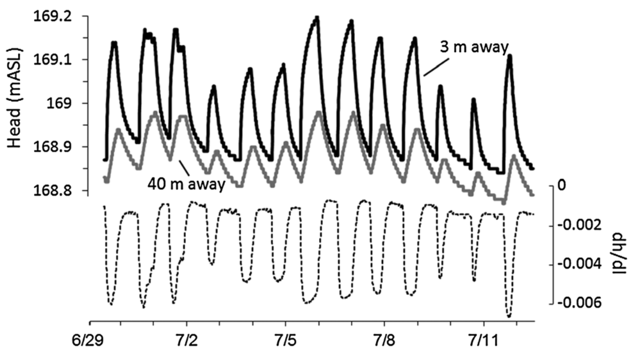


Figure 6. Head observations at site 4 in wells screened in riverbank alluvium at distances of 3 m from the river (black line) and at 40 m from the river (grey line). Head gradient (dh/dl) time series is plotted below head observations with dashed line. Data taken from Friesz (1996)

of New England's temperate climate and the reach's expansive till-mantled upland watershed draining towards the valley fill aquifer, one would expect the water table to slope towards the river and drive water there. Comparison with the adjacent and geomorphically similar, but minimally regulated Westfield River (WFR) watershed, illustrates the impact of upstream storage on summer flows in the DFR. The DFR's July and August 2010 discharge exceeds the WFR's by 67%, despite having a 27% smaller watershed study area.

Juxtaposition of a relatively smaller watershed and larger discharge shows the extent to which the DFR's average summer stage is elevated by releases from upstream reservoir storage, thereby affecting the gradient across the SWGW exchange zone. Whereas DFR water budget accounting shows consistently decreasing downstream flow, WFR discharge increased by an average of 72% in a 28-km reach between the confluence of its three main tributaries and its downstream gauge during July and August 2010 (Figure 7A). Although this increase was due in part to tributaries entering the WFR, its watershed area only increases by 61%, smaller than the increase in discharge. In this humid region, it is reasonable to deduce that the proportional increase is due in part to groundwater inputs. The same analysis on the DFR study reach shows that over the course of the summer, there is only a 1% increase in downstream discharge, despite the contributing area increasing by 40% down the 19.5-km study reach. Upstream storage roughly doubles DFR area normalized discharge during summer relative to that of the WFR (Figure 7B).

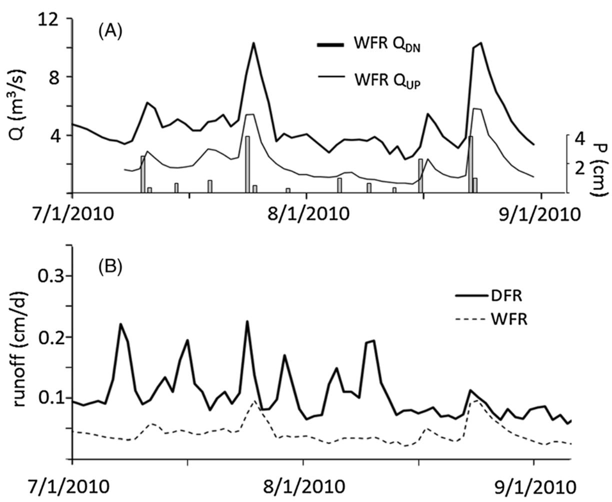


Figure 7. (A) Upstream and downstream daily average discharge for the Westfield River, not accounting for tributary inputs within the interim river reach. Note that discharge increases in the downstream direction at all times. Daily precipitation in Huntington, MA depicted by grey bars. (B) Average daily runoff from Deerfield (DFR) and Westfield (WFR) Rivers. The DFR record always exceeds the WFR record during summer despite smaller watershed area

An argument could be made that downstream change in the DFR's geomorphic confinement may in itself cause losses to the groundwater system. However, the WFR study reach lies within a similar geomorphic context and contains similar changes in confinement. More specifically, within its study reach, the DFR upper 10 km averages 80 m of riparian aquifer width, broadening to an average of 430 m in the reach's lower half. Similarly, the WFR expands from an average riparian aquifer width of 90 m in its upper 13 km to 570 m in its lower half (Supplementary Figure 4). Furthermore, the downstream end of the DFR study reach is defined by a pinching out of the riparian aquifer as bedrock comes to the surface in the vicinity of the downstream gauge (Q_{dn}). Water lost to the riparian aquifer as a result of reduced river confinement should therefore return within the study reach.

Two possible mechanisms may explain permanent losses from the river: (1) stage increases drive water into groundwater storage at time scales exceeding seasonal cycles; (2) transpiration by riparian vegetation removes water from the aquifer allowing for repeated losses. The first mechanism seems unfeasible given that empty pore spaces would quickly be filled given the volume of water being lost from the river. Correlation between the amount of loss for individual flood events and several independent variables was tested. The variables tested were: (A) the magnitude of the stage change for an individual event; (B) the duration of the elevated stage event; and (C) evaporative flux from the river as a proxy for potential evapotranspiration (PET) by riparian vegetation.

It was initially hypothesized that a higher hydraulic gradient away from the river caused by a larger dam release would drive more water into the riparian aquifer and therefore correlate well with reach-scale loss. However, no correlation was observed between changes in discharge from before to during a dam release and the amount of loss for that release. This is likely due to the small variation in the stage difference during hydropeaking. For example, at site 3, the change in stage in response to a dam release ranged from a minimum of 36 cm to a maximum change of 42 cm.

The duration of high discharge events varied a great deal from as short as 7 h to as long as 24 h. It was hypothesized that a longer period of time during which high stage caused a hydraulic gradient away from the river would drive more water out of the river. Two events extending well into the following calendar day were considered outliers and discarded. Duration of dam release *versus* reach-scale loss was plotted for the remaining events for 2010 rain-free periods. A cluster of data points around 7.5 h with no visible trend indicated that flood duration did not adequately explain the variation in the amount of loss for a given event (Figure 8A).

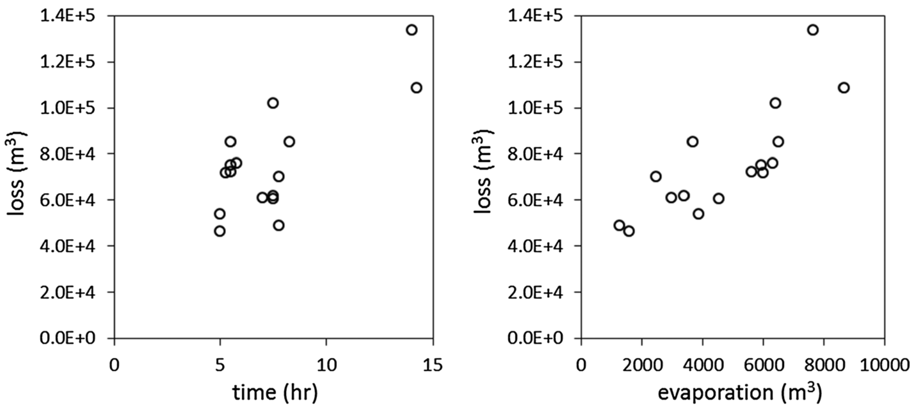


Figure 8. (A) Duration of dam release and (B) volumetric evaporation from the river surface both plotted against total water loss (GW term in Equation (1)) for individual dam release events in 2010

Last, ET from riparian vegetation was invoked to explain persistent losses throughout the summer. Because vegetative transpiration data were not available, direct evaporation from the DFR study reach surface was used as a proxy for ET forcing. Generally shallow water tables in the riparian zone, bolstered by daily bank storage events, make it likely that riparian vegetation exists in an energy, rather than moisture-limited growing regime. Therefore, evaporation from an open water surface calculated using an available energy balance method such as Penman (1948) provides an approximation for ET forcing from riparian forests. Although evaporation rate did not correlate well with total reach-scale loss, total estimated volumetric evaporation from the study reach displayed a strong relationship (Pearson $r^2 = 0.65$, $p = 0.016$) with reach loss (Figure 8B).

Total volumetric evaporation calculated as the product of linear evaporation rate, area of the study reach, and duration of the flood proved to be a better causal variable for two reasons: (1) total evaporation factored in the effects of evaporative forcing as well as the duration of the event—a longer event would permit more evaporation to occur—and (2) removal of water from the riparian aquifer was necessary to explain persistent and increasing losses throughout the summer. Thus, volumetric evaporation was really an incorporator of natural evaporative variables and human-controlled flood duration.

Previous temperate climate studies have documented the effects of riparian vegetation ET on both low-order streams (Gribovszki *et al*., 2008) and large alluvial plain systems (Krause and Bronstert, 2007). The significant role of ET suggested by this study on a large, hydropeaking river's in-stream flows, however, is undocumented. Comparison with the Westfield River suggests that hydropeaking is likely responsible for the losses from the DFR and correlation with evaporative forcing. Daily bank-full events on the DFR raise the water table adjacent to the river (Figure 9D). This in turn drives the capillary fringe higher allowing more vegetation to access water that otherwise would have returned to comprise part of the river's low stage discharge.

Over the course of each anthropogenic flood, the pressure wave propagates into the bank causing pore spaces immediately above the capillary fringe fill due to matric suction. Suction is sustained all summer by the cumulative effect of ET, which generally maintains an upward gradient towards the root zone. Therefore, via hydropeaking, water availability in the riparian zone adjacent to these artificially high stage events can shift ET from a moisture-limited towards an energy-limited phenomenon. Each day's bank vegetation transpiration serves to maintain or intensify this gradient, sucking water away from the river. ET from preceding days may play a role in the amount of loss for a given flood event due to its role removing water from the oscillating capillary fringe zone.

Focusing in from reach-scale data to discrete piezometers and streambed thermistors indicates that valley width plays a large role in determining the magnitude of SWGW exchange and therefore potential water loss due to hydropeaking. Streambed temperature data from wider valley bottom sections (sites 3 and 4) illustrate enhanced hyporheic pumping where extensive porous media extend laterally great distances away from the river providing bank storage during short-lived hydroelectric floods.

Riparian head observations that indicated 2–3 times greater losses than those observed by water budget methods are consistent with this influence of reach morphology on the magnitude of losses. Because we have applied this exercise to the site with the most transmissive (wide and high K) valley aquifer, this number by no means approximates processes as they operate in the field. Rather it serves to highlight that (a) this river is indeed strongly losing and (b) that losses are concentrated in wide valley bottoms where hyporheic pumping extends far from the river, thus explaining the discrepancy with water budget calculations.

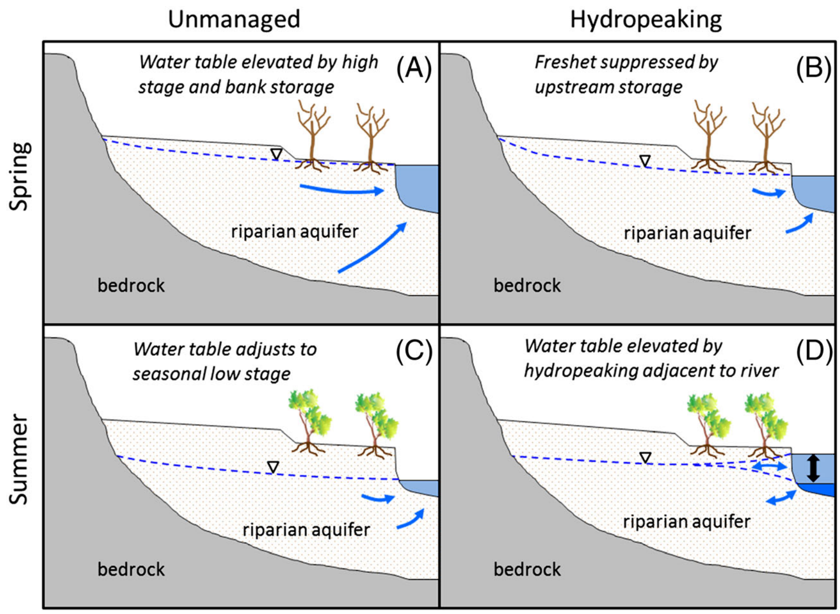


Figure 9. Schematic cross-sectional illustrations of how seasonal changes affect unmanaged *versus* hydropeaking river reaches. The water table is depicted by dashed blue line. The river is at right in each image. Blue arrows depict magnitude and direction of groundwater flow. Note that hydropeaking can make river water available to transpiring trees on lower terraces, whereas those along unmanaged streams are hydraulically disconnected from the saturated zone during summer

A time series of the GW term of Equation (1) (Figure 3A) shows the cumulative effect of ET over the course of the summer. As the riparian aquifer is drawn progressively down by the seasonal effect of ET, the magnitude of brief, low-stage gaining periods decreases. By the end of summer, the river loses water almost continuously, even during low-stage events. Three factors cause a hydraulic gradient away from the river and make it nearly impossible for the river to gain even after dam release events. First, upstream storage allows for daily bank-full events, which cause a mounding of the water table similar to snowmelt-fed streams in arid regions. Second, the cumulative effect of vegetative transpiration progressively removes water from the vadose zone, thereby increasing matric suction and removing water from the saturated zone and depressing the water table. Last, and unique to dam-controlled rivers, storage and suppression of the spring hydrograph in upstream reservoirs artificially subdue expected increases in riparian aquifer head during the spring (Figure 9B). Analysis of 2000–2005 upstream reservoir storage volume time series indicates an average capture of 7.7e10 m^3 from March to May, which would equate to an increase in average spring discharge of 12.23 m^3/s if allowed to flow downstream during the spring. Krause and Bronstert (2007) showed that in higher order streams, surface water–groundwater dynamics play a larger role in changes in riparian aquifer head than direct precipitation inputs. Whereas most valleys experience a significant freshet during which high river stage induces bank storage and raises the riparian water table, the DFR begins summer already at a deficit because the freshet is dampened by upstream storage (Figure 9B).

If hydropeaking indeed can induce a typically gaining river reach to lose water permanently, dam operators face a whole new set of considerations when drafting dam-release procedures. From an ecological standpoint, these results may be heartening, at least early in the growing season. Short-term bank-storage from previous releases may bolster minimum flows via the return flow of bank storage from previous dam releases. While increasing the total volume of low flows, this riparian zone return water also provides thermal buffering due to its relatively lower temperature. However, during late summer, when coldwater fisheries are most vulnerable, broader seasonal drawdown of the riparian aquifer would negate this benefit due to reversal of the hydraulic gradient away from the river at nearly all times in the flood cycle. The combination of hydropeaking and resultant water table mounding adjacent to dam controlled rivers may mean that even in humid areas, licensed minimum flow requirements may be insufficient to meet desired goals if substantial losses occur within the reach of concern.

Recognition of hydropeaking-induced losses should also inform hydropower optimization techniques. Rivers used for hydropower production often flow through a series of run-of-river generating facilities downstream of major storage impoundments. Currently, energy producers account for water mass conservatively and plan schedules to make use of each unit of water at subsequent downstream dams (De Ladurantaye *et al*., 2007). In deregulated energy markets, optimization techniques tend to favour larger releases on days with greater demand and therefore higher energy prices (Shawwash, Siu and Russell, 2000). However, in light of the finding that during the growing season up to 10% of this water may disappear from the system for every 20 km it travels, it might be prudent to mitigate hydropeaking in certain contexts to thereby reduce water losses.

In river systems where multiple dams in series transform energy from the same water into electricity at successive downstream facilities, recognition of induced losses from hydropeaking may significantly alter best practices. Changes to optimization methods will depend on downstream geomorphic conditions, regional flood threat, head-drop at various facilities, and other factors. Constrained river systems with bedrock channels will likely see little loss if the interpretation about riparian vegetation above holds true. Nevertheless, hydroelectric operators in most watersheds face an unforeseen tradeoff to making large releases on hot days with high evaporative demand.

CONCLUSION

Water budget analysis shows incontrovertibly that the DFR study reach loses water, whereas a non-hydropeaking geomorphically similar reference stream (Westfield River) does not. While this comparison with a neighbouring river is sound, and a qualitative mechanistic description of hydropeaking-induced losses is highly plausible, it remains to be seen if river management for hydropower causes losses on other systems. Observations of vertical hydraulic gradient and streambed temperatures generally support water budget findings and show that induced water losses are greater in reaches with broad alluvial aquifers in contact with the river. Cross correlations with reach losses suggest that the duration of high stage events and the amount of evaporative forcing explain in part the cause of river losses. Limited far-field piezometric data within the riparian aquifer and a lack of direct observation of evapotranspiration make it hard to constrain the amount of loss due to SWGW interactions and riparian vegetation dynamics. However, a multiple scale approach using both reach scale water budget accounting and point measurements of SWGW interactions offers a unique perspective on how hydropeaking can cause a typically gaining river reach to lose water.

ACKNOWLEDGEMENTS

We gratefully acknowledge support from the National Institutes for Water Resources via the Massachusetts Water Resources Research Center. Taylor Lucey assisted with field data collection. Steven Sauter of Ashfield, MA generously provided weather data for evaporation estimates. Peer review by Audrey Sawyer and two anonymous reviewers greatly improved this manuscript.

REFERENCES

Arntzen EV, Geist DR, Dresel PE. 2006. Effects of fluctuating river flow on groundwater/surface water mixing in the hyporheic zone of a regulated, large cobble bed river. *River Research and Applications* **22**(8): 937–946. DOI: 10.1002/rra.947

Boulton AJ, Datry T, Kasahara T, Mutz M, Stanford JA. 2010. Ecology and management of the hyporheic zone: stream–groundwater interactions of running waters and their floodplains. *Journal of the North American Benthological Society* **29**(1): 26–40. DOI: 10.1899/08-017.1

Boutt DF. 2010. Poroelastic loading of an aquifer due to upstream dam releases. *Ground Water* **48**(4): 580–592. DOI: 10.1111/j.1745-6584.2009.00663.x

Boutt DF, Fleming BJ. 2009. Implications of anthropogenic river stage fluctuations on mass transport in a valley fill aquifer. *Water Resources Research* **45**. DOI: 10.1029/2007WR006526.

Bouwer H, Rice RC. 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. *Water Resources Research* **12**(3): 423–428. DOI: 10.1029/WR012i003p00423

Brunke M, Gonser T. 1997. The ecological significance of exchange processes between rivers and groundwater. *Freshwater Biology* **37**(1): 1–33.

Cardenas, MB. 2010. Thermal skin effect of pipes in streambeds and its implications on groundwater flux estimation using diurnal temperature signals. *Water Resources Research* **46**(3). DOI: 10.1029/2009WR008528

Conant, B. 2004. Delineating and quantifying ground water discharge zones using streambed temperatures. *Ground Water* **42**(2): 243–257.

De Ladurantaye D, Gendreau M, Potvin JY. 2007. Optimizing profits from hydroelectricity production. *Computers & Operations Research* **36**(2): 499–529. DOI:10.1016/j.cor.2007.10.012

Findlay S, Strayer D, Goumbala C, Gould K. 1993. Metabolism of streamwater dissolved organic carbon in the shallow hyporheic zone. *Limnology and Oceanography* **38**(7): 1493–1499. DOI: 10.4319/lo.1993.38.7.1493

Friesz PJ. 1996. Geohydrology of Stratified drift and streamflow in the Deerfield River Basin, Northwestern Massachusetts. Water-resources investigations report 96-4115. US Department of the Interior, US Geological Survey.

Gerecht KE, Cardenas MB, Guswa AJ, Sawyer AH, Nowinski JD, Swanson TE. 2011. Dynamics of hyporheic flow and heat transport across a bed-to-bank continuum in a large regulated river. *Water Resources Research* **47**(3): DOI: 10.1029/2010WR009794

Graf WL. 1999. Dam nation: a geographic census of American dams and their large-scale hydrologic impacts. *Water Resources Research* **35**(4): 1305–1311.

Gribovszki Z, Kalicz P, Szilágyi J, Kucsara M. 2008. Riparian zone evapotranspiration estimation from diurnal groundwater level fluctuations. *Journal of Hydrology* **349**(1): 6–17. DOI: 10.1016/j.jhydrol.2007.10.049

Hanrahan TP. 2008. Effects of river discharge on hyporheic exchange flows in salmon spawning areas of a large gravel-bed river. *Hydrological Processes* **22**(1): 127–141. DOI: 10.1002/hyp.6605

Hatch C0E, Fisher AT, Revenaugh JS, Constantz J, Ruehl C. 2006. Quantifying surface water–groundwater interactions using time series analysis of streambed thermal records: method development. *Water Resources Research* **42**(10). DOI: 10.1029/2005WR004787

Jones JB, Fisher SG, Grimm NB. 1995. Nitrification in the hyporheic zone of a desert stream ecosystem. *Journal of the North American Benthological Society* **14**: 249–258. DOI: 10.2307/1467777

Koteff C, Pessl Jr F. 1981. Systematic ice retreat in New England. US Geological Survey Professional Paper 1179.

Krause S, Bronstert A. 2007. The impact of groundwater–surface water interactions on the water balance of a mesoscale lowland river catchment in northeastern Germany. *Hydrological Processes* **21**(2): 169–184. DOI: 10.1016/j.jhydrol.2007.09.028

Ligon FK, Dietrich WE, Trush WJ. 1995. Downstream ecological effects of dams. *BioScience* **45**(3): 183–192. DOI: 10.2307/1312557

Mabee S, Fleming B, Boutt D. 2007. Hydrogeologic assessment of the West Charlemont aquifer, project completion report. *Charlemont: Massachusetts,USA*.

Magilligan FJ, Nislow KH, Graber BE. 2003. Scale-independent assessment of discharge reduction and riparian disconnectivity following flow regulation by dams. *Geology* **31**(7): 569–572. DOI: 10.1130/0091-7613(2003)031<0569:SAODRA>2.0.CO;2

Mulholland PJ, Marzolf ER, Webster JR, Hart DR, Hendricks SP. 1997. Evidence that hyporheic zones increase heterotrophic metabolism and phosphorus uptake in forest streams. *Limnology and Oceanography* **42**(3): 443–451. DOI: 10.4319/lo.1997.42.3.0443

Penman HL. 1948. Natural evaporation from open water, bare soil and grass. *Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences* **193**(1032): 120–145. DOI: 10.1098/rspa.1948.0037

Poff NL, Allan JD, Bain MB, Karr JR, Prestegaard KL, Richter BD, Sparks RE. Stromberg JC. 1997. The natural flow regime. *BioScience* **47**(11): 769–784. DOI: 10.2307/1313099

Raymond HL. 1979. Effects of dams and impoundments on migrations of juvenile chinook salmon and steelhead from the snake river, 1966 to 1975. *Transactions of the American Fisheries Society* **108**(6): 505–529.

Sawyer A, Bayani Cardenas M, Bomar A, Mackey M. 2009. Impact of dam operations on hyporheic exchange in the riparian zone of a regulated river. *Hydrological Processes* **23**(15): 2129–2137. DOI: 10.1002/hyp.7324

Shawwash ZK, Siu TK, Russell SD. 2000. The BC hydro short term hydro scheduling optimization model. *IEEE Transactions on Power Systems* **15**(3): 1125–1131.

Valiantzas JD. 2006. Simplified versions for the penman evaporation equation using routine weather data. *Journal of Hydrology* **331**(3–4): 690–702. DOI: 10.1016/j.jhydrol.2006.06.012

Ward JV, Stanford JA. 1983. The serial discontinuity concept of lotic ecosystems. *Dynamics of Lotic Ecosystems* **10**: 29–42.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher's web-site.

From: "John Ragonese" <jragonese@greatriverhydro.com>
To: "PBMwork@maine.rr.com" <PBMwork@maine.rr.com>
Cc: "mfischer@lowimpacthydro.org" <mfischer@lowimpacthydro.org>, "Jennifer Griffin" <jgriffin@greatriverhydro.com>
Bcc:
Priority: Normal
Date: Tuesday January 19 2021 12:09:16PM
RE: A few questions on Deerfield

Hi Pat:

Hope you are well and Happy to have survived 2020 in many different ways.

Below are my response to your questions (sans #3 and 4; as we have addressed those previously). If Jen sees any errors in my response, she can let us both know!

John

Upstream and Downstream Fish Passage

1. **Please provide a brief summary of what (if any) upstream passage facilities were installed at Deerfield No.2, and what if any monitoring activities required by the license have been implemented up until your received the approval that Articles 409, 410, 411 and 413 were suspended. If any facilities were constructed, what is their status now?**

   Requirements for upstream passage at No. 2 Dam were tied to Atlantic Salmon restoration and fry stocking efforts by MADFW upstream in the basin. Those efforts were discontinued and MADFW supported the suspension of upstream passage requirement issued by the FERC. Prior to the suspension, the requirement was tied to a trigger of returning adult salmon to the base of No. 2 dam AND a formal request by the USFWS or CRASC. Monitoring occurred from 2004 through 2013, after which the monitoring requirement was suspended with the concurrence from MADFW and USFWS. No upstream passage facilities have been requested or constructed.

2. **Please provide a brief discussion of any measures used for downstream passage that have been used at Deerfield 2, 3 and 4 developments, and whether or not such passage measures are still being used. Also, identify what if any monitoring activities were conducted in the past.**

   A number of downstream passage facilities and methods were installed, tested, monitored and modified for the primary purpose of passing smolts previously stocked as fry in the basin upstream of No. 3 and 4 dams. All formal and seasonal requirements to provide DS passage have since been suspended. In terms of the most recent methods that provided the highest survival and passage:

   At No. 4 dam, smolts were either passed via spill into the bypass or through the intake, forebay and units. Smolts were guided in the forebay by nets suspended from overhead. Net are no longer installed but the means for providing remains as it is through station discharge due to the high survival though the slow horizontal units that are identical to No. 3 and No. 2 staion.

   At No. 3 dam, smolts were passed primarily into the bypass though a gate and guided by an angled bar rack. Fish that enter the forebay and pass via units have a high survival but were thought to have been delayed potentially by the longer forebay.

   At No. 2 Dam, also a fish gate and sluiceway were constructed, it was never effective in attracting significant numbers of downstream migrating smolts. Alternatives were to use submerged gates or units (Minimum flow is provided through unit discharge). Unit survival was high and in the end was the most effective means of passing smolts. That means continues obviously.

Cultural and Historic Resource Protection

1. **is it accurate to say that while many features at the Project are considered <u>eligible</u> for National Register Listing, that none have been formally listed to date?**

   Correct. But being eligible is basically the same thing as being on the Register from a requirement and compliance standpoint we just choose not to apply for listing.

2. **Is there an expected timeframe for the removal of the storage building at Deerfield No. 2?**

   Early 2021.

From: PBMwork@maine.rr.com <PBMwork@maine.rr.com>
Sent: Tuesday, January 19, 2021 11:14 AM
To: John Ragonese <jragonese@greatriverhydro.com>; 'mfischer@lowimpacthydro.org' <mfischer@lowimpacthydro.org>
Subject: FW: A few questions on Deerfield

[EXTERNAL EMAIL] DO NOT CLICK links or attachments unless you recognize the sender and know the content is safe.

Hi John

I just remembered you had also provided a separate response to my stage 1 report (which I just looked at) that already gave your take on the items I identified in my fish passage question # 3. It also said that your acknowledge the Searsburg WQC conditions were not affected by the suspension of the fish passage related license articles. And you also reported that no requests for such passage/protection concerns at Searsburg have been requested to date.

Therefore, you can ignore my questions #3 and 4 for now...unless Maryalice has a different perspective. I'll be reaching out to her separately to check.

Pat

From: PBMwork@maine.rr.com
To: "jragonese@greatriverhydro.com", "mfischer@lowimpacthydro.org"
Cc:
Sent: Monday January 18 2021 11:27:09AM
Subject: A few questions on Deerfield

Hi John

First, I have to complement you on the terrific final application you submitted for Deerfield. Its one of the best I have reviewed...and I have reviewed a lot!

However, in my typical fashion of wanting to include any details that a member of the LIHI Technical Committee, Maryalice or Shannon may have during its review, I am hoping you can provide me the following information. Most of the requested information is to allow for a historical understanding of Project features and to document compliance with resource agency requirements (e.g. fish passage) until they were no longer required.

Upstream and Downstream Fish Passage

1) Please provide a brief summary of what (if any) upstream passage facilities were installed at Deerfield No.2, and what if any monitoring activities required by the license have been implemented up until your received the approval that Articles 409, 410, 411 and 413 were suspended. If any facilities were constructed, what is their status now?

2) Please provide a brief discussion of any measures used for downstream passage that have been used at Deerfield 2, 3 and 4 developments, and whether or not such passage measures are still being used. Also, identify what if any monitoring activities were conducted in the past.

I realize both agencies are saying you are incompliance with their original WQCs, but the following additional detail would be helpful:

3) The application does not indicate that the MA WQC was modified to remove or suspend the conditions addressing upstream and downstream fish passage facilities, needed improvements or monitoring, that were incorporated into License articles. Is there any documentation, even emails, that show communication with the agencies on the status of conditions? This summary should address both up and downstream passage.

4) The VT WQC, Conditions K, L and M address upstream and downstream fish passage installation and impingement/entrainment protection, all at Searsburg. While no license Article includes requirements for Searsburg, the license says all conditions of the WQC are incorporated except MA WQC Condition I and VT WQC Condition O. So arguably these remain in effect. Can you fill me in on the status of compliance with each of these?

Cultural and Historic Resource Protection

1) is it accurate to say that while many features at the Project are considered eligible for National Register Listing, that none have been formally listed to date?

2) Is there an expected timeframe for the removal of the storage building at Deerfield No. 2?

I look forward to your update. Thank you.

Pat

From: "John Ragonese" <jragonese@greatriverhydro.com>
To: "PBMwork@maine.rr.com" <PBMwork@maine.rr.com>
Cc: "Jennifer Griffin" <jgriffin@greatriverhydro.com>
Bcc:
Priority: Normal
Date: Thursday January 21 2021 1:41:02PM
RE: One more question

Pat,

I believe we have gone through this before with you or (a prior reviewer?) Please make a note 😊…

No assessment was made or is required as it was tied to providing downstream passage for Harriman salmon management. That program or management goal has largely been abandoned. Attached is the final Searsburg Trash Rack plan after adopting comments from USFWS and VTFW.

In a nutshell as stated in 3.2 of this document, "***Both USFWS and V ANR agree that deferring the planning and implementation of any monitoring makes good sense and should clearly wait until VDFW determines management objectives and determines the need for downstream fish passage requirements.***"

Also in the Plan under 2.1 (6), "***Existing trashrack configuration and approach velocity data for Searsburg dam suggests that significant protection is currently available to the native non-migratory fishery above the dam. Current bar spacing is 1.25 inches; average approach velocity is 1.2 ft./sec.; and maximum flow is 345 cfs. These are relatively low values.***"

FWS does not recommend any measures to protect fish from entrainment where velocities are less than or equal to 2 fps

John

From: PBMwork@maine.rr.com <PBMwork@maine.rr.com>
Sent: Wednesday, January 20, 2021 1:32 PM
To: John Ragonese <jragonese@greatriverhydro.com>
Subject: One more question

Hi John

I apologize for missing this in my earlier email of questions (and even my stage 1 report). Can you tell me if the assessment of the effectiveness of the Searsburg trashracks required by License Article 418 and related Condition L of the VT WQC resulted in the need to change the trashracks and if so, approximately when were the modifications made?

Thanks

Pat

Responses to reviewer requests for clarifications or questions to GRH regarding Deerfield River LIHI Recertification Comment Letters

1) Please provide information you have that addresses the comments that the deoxygenated waters of Harriman and Somerset reservoirs are contributing to increased mercury levels in fish in these reservoirs. **GRH does not have any information and believes this is pure speculation not based on specific knowledge or site specific data or proven relationships. Organic methylation of mercury has been, in some studies, tied to impoundment fluctuation, but this also has not been found to be the primary causal element in mature or older reservoirs – particularly in long-standing reservoirs in a temperate climate. The phenomenon is more closely tied to more recently developed reservoirs where vegetative materials were simply flooded. As VT largest body of water at the elevation Somerset and additionally Harriman at a slightly lower in elevation, they and the surrounding drainage area, captures atmospheric deposition mercury as well as NOx and Sox. Input into the reservoir comes through direct rainfall as well as drainage area runoff. At Somerset old growth Red Spruce stands have all largely died out showing distinct evidence of acid rain deposition (needle yellowing) similar to other high elevation spruce further indicating effects of aerial deposition of harmful elements and compounds.**

   Have any comparison studies been done between fish from these reservoirs and other similar New England impoundments or lakes that do not stratify? Was this something studied during re-licensing? **No specific studies or direct comparison has been made and nothing remotely similar to this question has been raised previously or studied. At Moore reservoir (FMF), Mercury in fish tissue has been monitored for many years. Highest concentrations have been occurred in fish occupying areas at the upstream end of the reservoir, which does not stratify, and based on opinions presented by Biological Research Institute staff likely reflect the mercury loading into the reservoir stems from inflow from upstream basin runoff (White Mtns).**

   Are the reservoir discharge points above or below the typical hypoxic zone? **The primary discharge structures are deep and therefore likely below the epilimnion if a thermocline is present during warmer summer months. Water quality sampling of oxygenated discharge and at point downstream of outlets and Harriman powerhouse indicates sufficient dissolved oxygen to meet WQ Standards.**

2) Please provide information you have that addresses the comments that littoral vegetation and shoreline wetland communities in the larger reservoirs are being impacted by reservoir fluctuations. **Yes, its apparent that seasonal winter drawdowns is in part associated with the lack of significant riparian wetlands plant communities. What is not apparent in the comment is:**

   > **There are few if any such shallow riparian shorelines at Harriman due to the steepness and rocky nature of the shorelines. Wetlands were evaluated at Somerset and a number of adjacent large wetlands are unaffected by reservoir drawdowns. They exist year-round yet lie immediately adjacent to the main body of water in addition to the areas that were**

identified as large beaver meadows and ponds in the adjacent woodlands maintained in their natural state.

Seasonal winter drawdowns provide much needed water to sustain downstream flows such as below Somerset, Searsburg, Harriman and the lower Deerfield. Flow in the reach below Fife Brook dam, noted by TU and MADFW in their comments as needing a higher winter flow to support trout spawning than required at the project, is largely augmented by water released from Harriman Reservoir storage, aligned with the timing of the winter drawdown of Harriman Reservoir in preparation of the annual spring runoff and recharge. Similarly, the guaranteed minimum flow below Deerfield Number 2 dam is sustained through reservoir storage. There have been times when we have had to approach the VANR to allow even a few inches of water out of Harriman during a stable or rising period to maintain downstream flow, only to have the agency balk at such a request.

General evidence of the need for reservoir storage and release is rooted in the Deerfield River Project itself. The Project was initially configured as three lower Deerfield River run-of-river stations (D4, D3, D2) plus Somerset Reservoir. In order to sustain flows at these small projects, reservoir storage was necessary. It was not until 15-20 years later, that Harriman, Sherman, Searsburg and D5 were constructed.

Conversely, the winter drawdown and store and release function of these major impoundments serve the public and downstream portions by providing flood control benefits. Besides reducing peak flows in the lower Deerfield River during T.S Irene Harriman as historically absorbed flash flooding emergencies. In 1987, the 11-mile reservoir rose a total of 44 feet within a 1-2 day period in the spring.

Was this something studied during re-licensing?
Yes, with respect to identifying wetlands and wetland potential in and adjacent the reservoir Is there any information available that suggests the lack of such vegetated zones has impacted fisheries in the reservoirs? The VT 401 WQC addresses reservoir fluctuation and the Secretary determined that the continued reservoir fluctuation meets the Standards (see also 401 Comments Responsiveness Summary pages 2-3)

Any comparative data from other similar New England systems?
GRH does not have any such data.

3) Please provide information you have that addresses the comments about the current flow regimes in the bypasses with regard to supporting fisheries resources in them. The Handbook (pg 66) specifically requires: “Explain how the recommendation (i.e. agency approved min flows) provides fish and wildlife protection, mitigation and enhancement (including in-stream flows, ramping and peaking rate conditions, and seasonal and episodic instream flow variations).

Such data should include a summary of the past IFIM modeling studies and in-field assessments completed (by bypass identified in the comments) that was used to set the existing minimum flow regimes.

GRH believes the recently provided VT and MA 401 WQC's provide ample proof that significant field work and stream habitat assessments as well as development of aquatic based flow were performed and that agency review, consultation and considerations were utilized in the development of the flow regimes. For more specific descriptions of the considerations, refer to these documents although the detail present in the MA 401 WQC is limited in comparison to the VT WQC.

4) Please discuss why some were modeled and others done via field assessment. If possible, please provide a copy of these past reports.
GRH believes that adequate references and descriptions in the VT 401 WQC provides the basis for utilizing IFIM, qualitative field assessments of habitat variables at varying flows and the estimation of localized Deerfield River aquatic base flows provides ample evidence that a thorough and in depth consideration of various scientific methods was used in the development of instream flow requirements. See VT 401 WQC Finding 142 for example.
142. In the flow regulated reaches of the project, site-specific evaluations of the functional relationship between flow and fisheries habitat have been completed and considered in the determination of necessary minimum flows for the purposes of this certification. The studies are discussed below. One study methodology is the Instream Flow Incremental Methodology (IFIM), which quantifies physical habitat available, for certain fish species and life stages, at alternative flows based on habitat variables of depth, velocity, substrate, and cover. The IFIM modeling produces graphs of weighted usable area (WUA) as a function of flow. WUA is a composite measure of the quality and quantity of habitat available at alternative flows.

5) Please provide a discussion of how the current impoundment management systems are supporting fish and wildlife resources.
Impoundment fishery management has historically relied upon state stocking programs, however under the License, stable (or rising) management requirements are stipulated for the benefit of littoral spawning (Harriman and Somerset), access to spawning habitat for smelt (supporting the goal to produce a natural, self-sustaining population in Harriman Reservoir) in below Searsburg Station and Loon nesting protection at Somerset Reservoir.

6) Please provide flow data (if you have it) that compares releases from Deerfield #5 and below Fife Brook to understand the concern expressed by MDF&W about trout spawning studies showing de-watering of redds after peaking have returned to normal levels. I am wondering if flows below Fife Brook are associated more with Deerfield peaking or release via Fife Brook from Bear Swamp.
GRH cannot speculate what or how BSPCo chooses to operate its project. We can provide the following as factual information about how the projects relate to each other and ensure adequate flow is maintained for current license requirements.

- **Fife has a required minimum flow of 125 cfs that is guaranteed from storage – it does not specify from where.**
- **D5's minimum flow is 50 cfsh lower and therefore although Fife is also required to pass our D5 discharge through the Fife Brook and lower reservoir it does not do so instantaneously otherwise it would run out of water making up the 50 cfsh deficit.**
- **Additional makeup water (delivered to the upper reservoir or maintained in lower reservoir in order to keep the PS system in balance and at full capability (capacity) is required from time to time (due to evaporation or otherwise unknown to GRH). As a result, we do not know when this is but occasionally, they request it or check in with us to be sure they can.**
- **What GRH requires is that the discharge below Fife Brook provides us with water to meet our minimum flows including the 200 cfs at D2. We have a sense of what is coming in naturally below Fife Brook and so make sure that our D5 discharge will accommodate our D2 requirement.**

Harriman discharge (which passes through Deerfield No. 5 into the Fife Brook development) largely accommodates the flow requested by stakeholder and agencies for the winter trout spawning below Fife (300-350 cfs). As GRH draws Harriman down during the winter in preparation of the spring refill, this discharge largely maintains adequate flows downstream in the 300-350 range during most of not typically all of Nov-March. MADFW and MADEP has data that shows this and therefore the premise, comment and accusation is unsubstantiated.

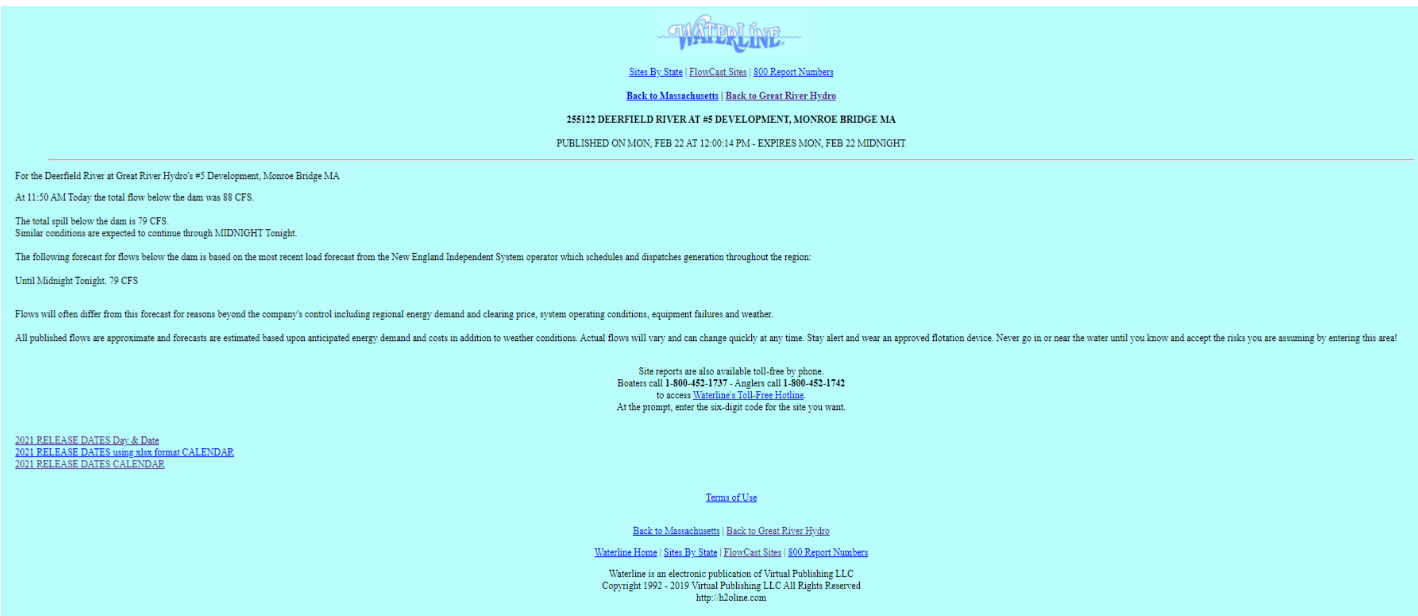
7) Please identify if there are any alternative release points that would allow you to release water from different levels in the Somerset, Searsburg and Harriman reservoirs that might help with the cold water release concerns.
There are no alternative release points to provide water into the reaches immediately below each dam. Again, while there is cold water immediately below the dams, significantly greater downstream portions of Deerfield River below these dams depend upon and thrive on this source and supply of cold and oxygenated water.

8) Please confirm that
    a) FERC inspected all recreational sites in 2018.
    Yes they were. FERC reports do not take photos and such of each and every area. From the FERC report: ***"(2) Recreation, Land Use, and Aesthetics Resources: Article 423 required the licensee to file a supplement recreation information document to the project's Comprehensive Recreation Plan. During the inspection, a vehicle/walking tour was conducted to inspect the Deerfield Project fishing, boating access, and other recreation areas. During that tour, the condition of all the required recreational facilities was noted to be well maintained with accessible facilities. Appropriate signage was found at the public access areas."***

    b) Where the annual flow schedule is "published" to? How does the public get it?

GRH provides anticipated schedule for the next day that is generally posted by afternoon after the ISO-NE releases the anticipated generation schedule. GRH also provides realtime (within last 10 minutes) flow or discharge information in addition to the anticipated schedule. The information is available by phone or through its FlowCast web hosted by H2Oline.com

With respect to the whitewater release flow schedule below Deerfield Number 5 Dam, the release schedule is developed several months prior to the first release date and distributed to all interested boating and fish groups that disseminate it or publish it as they see fit. GRH publishes it on the same Waterline site for D5 used for providing scheduled and real-time flow information at all its facilities. GRH has never had anyone express concern over use of this site (other than the CRC comment) in presenting the whitewater release schedule and also showing when boatable flows are present on a natural or managed unscheduled basis.
Example:


WATERLINE

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255122 DEERFIELD RIVER AT #5 DEVELOPMENT, MONROE BRIDGE MA

PUBLISHED ON MON, FEB 22 AT 12:00:14 PM - EXPIRES MON, FEB 22 MIDNIGHT

For the Deerfield River at Great River Hydro's #5 Development, Monroe Bridge MA

At 11:50 AM Today the total flow below the dam was 88 CFS.

The total spill below the dam is 79 CFS.
Similar conditions are expected to continue through MIDNIGHT Tonight.

The following forecast for flows below the dam is based on the most recent load forecast from the New England Independent System operator which schedules and dispatches generation throughout the region:

Until Midnight Tonight. 79 CFS

Flows will often differ from this forecast for reasons beyond the company's control including regional energy demand and clearing price, system operating conditions, equipment failures and weather.

All published flows are approximate and forecasts are estimated based upon anticipated energy demand and costs in addition to weather conditions. Actual flows will vary and can change quickly at any time. Stay alert and wear an approved flotation device. Never go in or near the water until you know and accept the risks you are assuming by entering this area!

Site reports are also available toll-free by phone.
Boaters call **1-800-452-1737** - Anglers call **1-800-452-1742**
to access Waterline's Toll-Free Hotline.
At the prompt, enter the six-digit code for the site you want.

2021 RELEASE DATES Day & Date
2021 RELEASE DATES using xlsx format CALENDAR
2021 RELEASE DATES CALENDAR

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c) Are the 5 primitive campsites still at Somerset?
There are no formal campsites at Somerset – there are informal sites but due to the potential disturbances to the larger numbers of nesting pairs of loons that nest largely on the same islands that were designated for this enhancement. At the request of VTDFW and with the support of the loon restoration program managers (now Vermont Center for Ecostudies), plans for camping on Somerset were abandoned.

9) Also, please summarize the consultation that CRC says GRH is doing to address public access issues. [Near D3 forebay and at Stillwater Bridge river access]

At D3 the area we had to fence off was the maintenance roadway along the top of the dike surrounding the D3 forebay. This structure is not the river buy a steep sided, canal with flow and potentially hazardous if someone were to fall into or deliberately go into the water. Other

similar features at other projects are all fenced. Historically there has not been a problem but more recently we observed people letting their dogs swim in the forebay and at one time a person had to enter the water to retrieve their animal. Due to steepness of the forebay and the velocities in the forebay could potentially push a person or animal into the intake racks we were forced to fence off the area but continue to evaluate other fencing layout options. Whether the fencing includes the roadway adjacent to the forebay or just the forebay alone, neither block off access to the river. We have always maintained a fence around our maintenance facilities and access road to the D3 station. This is not intended to or preventing river access, it prevents use of the forebay and maintenance roadway and facilities. It's intended to provide needed safety. Access to the reach below D3 is not provide other than the portage at the dam. We cannot comment on other previous relied upon access to the bypassed reach between the dam and the powerhouse through private property such as the referenced Lamson-Goodnow site. As inferred in the CRC comment, the Shelburne side of the Deerfield River is not restricted by the hydro project and potentially provides opportunity for public access. The reach below the power station lies within the Gardner's Falls project and would be the responsibility of that licensee.

CRC's comment regarding 50% reduction in parking, installing guardrails, no communication with Town at the Stillwater bridge river access location and lack of mention in the 2010 FERC Environmental Public Use Inspection are addressed below.

- **The river access at the Stillwater Bridge is not a formal Deerfield Recreation area and is in part owned by the Commonwealth of MA and therefore not inspected by FERC.**
- **Guardrails were installed at this location many years (15-20 by my recollection) ago to reduce unauthorized dumping over the banks toward the river.**
- **Recently at the request of the Deerfield police and with Town official knowledge, GRH was asked to install a cable that limited areas that were being used improperly or illegally. GRH obliged. GRH does not believe this caused a reduction in the intended and designated parking area, simply cut off unauthorized access including driving vehicles into the Deerfield River, parking in the shallow shoals exposed under low flow conditions.**

10) We especially do not see how Zone No. 14, Dunbar Brook downstream reach, could possibly meet standard A-2, since there is no minimum flow provided below that impoundment and the stream channel is completely dry unless the dam is full enough to spill.

The short portion of the Dunbar Brook below the Dunbar Brook structure was never an issue of concern or considered by agency and NGO stakeholders as requiring a protected flow. The reasons for such are as follows:

- **The short reach below the structure has little habitat diversity as it is largely composed of large boulders and material. The length of stream bed between the structure and the River Road culvert is 440 feet in length. The length below the culvert to the Deerfield River confluence is similarly in 450 feet long, steep and rocky.**

- **The River Road culvert, between the confluence and the structure is 225 feet in length perched above the stream bed on the downstream end.**
- **Flow in Dunbar Brook due its steepness is typically very low and when they are not, are they are very high following a rain event, thus washing much of the finer materials. Maintaining a conservation flow in this reach will not likely support or provide significant habitat or provide tributary access from the bypassed reach.**
- **The passive water control structure is not a typical dam-impoundment structure that stores and releases water as its purpose. Its primary function is to allow high brook flows to bypass the canal and shed water from the canal if the canal elevation is too high due to sidehill inflow. Water levels above the structure in the small pool matches elevations in the No.1 canal and impoundment above the D5 dam. The water behind the structure is not managed or is significant in terms of storage. The structure's purpose was primarily to enable high Dunbar Brook flows to safely pass through the canal/tunnel system at D5 and prevent overfilling the canal/tunnel system and potentially breach the canal wall. It has the capability to pass not only high Dunbar Brook flow but serves as a safety valve or fuse plug should too much water end up in the canal/tunnel system from sidehill discharge directly into the canals in addition to what is coming in at the dam. When flows are low in the Dunbar Brook, they simply are absorbed into to canal system and as a result no flow is present below the structure.**

Threatened and Endangered Species Protection

Criterion	*Standard*	*Instructions*
F	PLUS	Bonus Activities: • Describe any enforceable agreement that the facility has with resource agencies to operate the facility in support of rare and endemic species. • Describe any enforceable agreement that the facility has with resource agencies to take proactive measures in the vicinity of the facility to substantially minimize impacts on species that are at risk of becoming listed species. • Describe any enforceable agreement that the facility has with resource agencies to be a significant participant in a species recovery effort.

Great River Hydro provides the following additional information in pursuit of the Plus Standard for Threatened and Endangered Species Protection for the following Zones of Effect:

ZoE 1 – Somerset impoundment
ZoE 10 – Sherman tailrace
ZoE 11 – D5 bypassed reach
ZoE 15 – D4 impoundment
ZoE 21 – D2 impoundment

As discussed in the November 2020 application, the common loon (*Gavia immer*) was endangered in Vermont when the Deerfield River Project was licensed in 1997 and operating constraints (discussed in Section 4.1) were established at Somerset Reservoir, where one mating pair was known to nest. Though the loon was removed from the endangered list in 2005, the Company continues to manage the reservoir for loon nesting. Additionally, at the requests of VANR and VDFW Great River Hydro requested FERC lower the licensed target elevation of Somerset Reservoir during the loon nesting period to accommodate more recent nests (see page 2, bullet 3 of the November 2020 application). The single mating pair of loons nesting on Somerset Reservoir in 1997 has grown to 2-4 breeding pairs nesting each year, producing 45 loons since 1978 (personal communication Eric Hanson, Vermont Center for Ecostudies).

In Massachusetts, the Division of Fisheries and Wildlife (Division) delineates priority habitat for all state-listed species, including threatened, endangered, and species of special concern. Priority habitats are used by the Division for screening projects and activities that may result in the take of state-listed species and to provide guidance to owners regarding a project or activity through consultation with the Division.

In addition to the three threatened species identified in Great River Hydro's November 2020 application, Priority Habitat for four species of special concern is managed under Great River

Hydro's Compliance Plan. The four species are mountain alder (Alnus viridis ssp. crispa), a vascular plant; ocellated darner (Boyeria grafiana), a dragonfly; longnose sucker, (Catostomus catostomus) a fish; and the twelve-spotted tiger beetle (Cicindela duodecimguttata). Within the Project area, Priority Habitat mapped for these four species of special concern totals 42.5 acres, and for the three threatened species 14.7 acres. The species of concern are found in zones of effect 10, 11, 15 and 21. The threatened species are found in three of these four zones.

The Compliance Plan specifies and describes O&M tasks undertaken by Great River Hydro within the Deerfield River project area, maps project areas and the activities that occur within each project area, discusses avoidance and minimization of impacts, and identifies control measures in place to mitigate potential impacts. Staff and contractors are trained and supervised, and BMPs are implemented. For example, regular vehicle and equipment inspections are conducted to aid in the safe and effective operation of machinery. Areas of impact are minimized, approved methods are employed, and updated tools and techniques are used. Erosion and siltation control measures are used as needed to protect regulated resources. Timing restrictions or seasonal work windows may be developed if there are any species-related requirements. Any future adaptive management measures implemented to protect a resource would comply with state and federal regulations.

Should Great River Hydro choose not to participate in this program, or be found in non-compliance with the program, each of its activities would be subject to individual review by the State. Participation in, and compliance with the program allows Great River Hydro to conduct routine maintenance within its Project boundary without seeking additional permission from the State. Activities proposed to be conducted in Priority Habitat that are not specified in the Compliance Plan would be brought to the State for appropriate permitting.

Appendix D

Deerfield Project Recreational Facilities
Shown on the Final Completion Status Report

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Topsham ME U.S.A.
04086
Tel. 207.729.1199
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www.stantec.com

Stantec

0 12,000'
Feet

Client/Project 195600161
TransCanada Recreational Enhancements
Deerfield River Hydroelectric Project
FERC No. 2323

Figure No.
1

Title
Recreation and Enhancement Sites
Location Map

December 8, 2009; Revised April 4, 2010

195600161–f001–Location.dwg