October 6, 2023

Kyle Olcott
Hydropower Coordinator
Bureau of Land Resources
17 State House Station,
Augusta, Maine 04333-00017

TROUT UNLIMITED
MAINE COUNCIL

Transmitted via e-mail

RE: **Brookfield White Pine Hydro, LLC's, DEP Application # L-024307-33-G-N Rumford Falls Hydroelectric Project, for §401 State Water Quality Certification, (FERC Docket P-2333)**

Dear Mr. Olcott:

Please accept these comments for inclusion into the record for the Maine Department of Environmental Protection's ("DEP") review of the application of Brookfield White Pine Hydro, LLC's ("Applicant") to receive a water quality certification ("WQC") for its Rumford Falls hydropower project. Maine TU is a non-governmental organization (NGO) whose stated mission is: "to conserve, protect, and restore Maine's coldwater fisheries and their watersheds." Maine TU encompasses six chapters with over 2000 members. The Androscoggin River watershed is Maine's third largest watershed. Maine TU members use the Androscoggin River for recreational and aesthetic pursuits. Its members fish, boat and otherwise enjoy the watershed. Maine TU has been heavily involved with efforts to restore stream connectivity and improve water quality within the Androscoggin River Watershed since early in 2019 when it became involved with the Lower Barkers Mill (P-2808) relicensing. It is currently involved with ongoing FERC hydroelectric relicensings throughout the greater watershed from the Aziscohos Project (P-4026) at the headwaters to the Worumbo Project (P-3428) on the lower river. Maine TU and its members therefore have a direct and substantial interest in the outcome of the Rumford Falls Water Quality Certification Application.

Overview of Comments

It is Maine TU's position that operations of the Applicant's Rumford Falls Dam ("the Project") as proposed by the Applicant in its WQC application filed with DEP in August 2023 (the "Application") violate applicable Maine numeric and narrative water quality standards and cannot be approved by DEP as proposed. Accordingly, the Application must be denied. Further, the adverse individual and cumulative water quality impacts from the current operations of Rumford Falls Dam on aquatic species and poor water quality have already been witnessed, are ongoing, and the changes the Applicant has proposed will not bring the project into compliance with state water quality laws for even Class C waters, Maine's lowest water quality classification. The specific violations and adverse impacts include without limitation:

(1) The project does not meet the narrative standards for Class C waters with regard to designated uses including fishing and recreation or as habitat for fish and other aquatic life.

(2) The project has not been shown to meet DEP numeric Dissolved Oxygen ("DO") or macro invertebrate standards in the reach below Upper Dam or the reach below the Lower Powerhouse.

(3) The DO and macro-invertebrate studies that have been conducted omitted significant areas of the project contrary to DEP protocols.[1]

The Project therefore does not meet the standards established under 38 MRSA §465. This is largely due in part to Applicant's operational practices of dewatering the reach below the Upper Dam and allowing minimum flows to flow through the penstock and turbine, rather than allowing for spillway flows, and inadequate minimum flows below Middle Dam. As a direct result of this observed and documented practice, the Applicant has failed to make a reasonable effort to support all designated uses of Project resources as required under Maine law.

Assuming DO standards for Class C waters can be met, there are reasonable measures that DEP can prescribe that if implemented by the Applicant, would bring the project into compliance with Maine statutes, and we are proposing those measures within these comments.

While these comments generally align with those submitted in our Motion to Intervene[2] filed with FERC in this federal licensing matter, our emphasis here is on applicable Maine statutes. Maine TU's specific comments supporting WQC denial are as follows:.

Specific Comments Supporting WQC Denial

I. Current and proposed Project operations dewater critical aquatic species habitat areas in the Rumford Falls Project Area with serious fisheries and environmental consequences.

Minimum flows authorized by the old License terms are 1 cfs below Upper Dam[3] effectively dewatering the reach below for much of the summer. The reach below Upper Dam is unsuited for aquatic life when it is dewatered, and any organisms trapped in the stagnant pools that form below the Upper Dam during falling flows will not survive. Brookfield refers to this reach as "bypass" when it is actually the main channel of the Androscoggin River. Similarly, the riverine reach below Middle Dam has significant impacts to fisheries and aquatic habitat during periods of minimum flows.

Minimum flows authorized by the old license terms are 21 cfs below Middle Dam.[4] Brookfield proposes to: "Provide a minimum flow, primarily via notched flashboards, into the Middle Dam bypass reach of 95 cfs from May 1st to October 31st and 54 cfs from November 1st to April 30th."[5] Like the NGOs, MDIFW disagrees with Brookfield's interpretation of the information in the USR and states: "Based on our site observations and experience with evaluating aquatic habitats, *flows between 250-500 cfs appear to be appropriate* to protect and enhance the habitat for fish and other aquatic organisms, remain reasonably wadable, as well as improve aesthetics. It should be noted that flows in this range still only equate to a fraction (13-25%) of aquatic baseflow, and all excess flows would be available for hydropower

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[1] DEP Sampling Protocol for Hydropower Studies (MDEP 2019a).
[2] Maine TU Motion to Intervene and Protest, for the Rumford Falls Project dated August 4.
[3] Rumford Falls Project Final License Application, page B-1.
[4] Ibid.
[5] Maine Revised Statutes Annotated, Title 38, section 465, subsection 4: "Class C waters must be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; agriculture; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited under Title 12, section 403; navigation; and as a habitat for fish and other aquatic life. "

production. Again, we believe additional flow evaluations might help to discover the best, most-balanced value." (emphasis supplied)[6]

Maine TU is in accord with MDIFW's assessment regarding the reach below Middle Dam, and further objects to the minimum flows for both the Upper Dam and Upper Reach as proposed by Brookfield as failing to adequately consider fisheries and aquatic habitat and other environmental factors in its proposed operations. Current operations are not compliant with Maine statutes as electrical generation does not in any material way account for the other designated uses including fisheries, habitat and recreation that are required by law to be considered.[7]

II. The Environmental Impact Statement (EIS) for the seven Androscoggin River dams located upstream recommended minimum flows of 200 to 400 cfs.

The EIS issued for those dams recommended minimum flows of 200 cfs to 400 cfs.[8] The first dam included was the Shelburne project located approximately 40 miles upstream. The EIS recommended watering the bypass reaches of projects that had been dewatered similarly to the reach below Upper Dam for the Rumford Falls Project. The EIS cited benefits to salmonid habitat; similar measures should be adopted for the Rumford Falls Project. With the Rumford Project including a greater catchment, minimum flows of 250 cfs to 500 cfs are proportional and consistent with upstream practices and recommendations. Maine TU objects to the proposed minimum flows and asserts there is no justification that the Rumford Falls Project should be allowed to have a significant and detrimental effects on fisheries and aquatic habitat immediately and further downstream from the project.

III. Data indicates that the reach below Upper Dam can provide suitable habitat for aquatic life if adequate flows are made available.

Additional water quality studies for this riverine reach were requested and not performed. In the absence of requested additional water quality studies, Exhibit 1[9] is an analysis of available photography, satellite imagery, and LIDAR for the reach below Upper Dam. The study, conducted independently, concludes: "These data demonstrate conclusively that (if watered) the reach below the Rumford Falls Project Upper Dam would support communities of aquatic life." Declining studies because the owner/operator does not want them or does not want to pay for them does not prevent an independent showing that in fact there are environmental and fisheries and aquatic habitat issues that

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[6] MDIFW Comments on Final License Application for the Rumford Falls Hydroelectric Project (FERC No. 2333) February 17, 2023, page 7.

[7] FLA, page D-4.

[8] Final Environmental Impact Statement for the Upper Androscoggin River Basin Hydroelectric Projects, New Hampshire, FERC/ESI 0070 D dated November 1993, page 4-45: "Overall, our recommendations to protect and enhance the resident salmonid populations in the Androscoggin River include: (1) operation of all seven Androscoggin River Projects in run-of-river modes, (2) maintenance of zone-of-passage minimum flow releases in the Sawmill and Shelburne bypass reaches, (3) increasing the minimum flow release for an enhanced salmonid year-round zone-of-passage in the Smith bypassed reach, (4) establishment of an interim minimum flow release for salmonid habitat in the Cascade upper bypassed reach, (5) establishing an optimum salmonid habitat flow of 400 cfs in the 7,400 ft-long Pulsifer Rips bypassed reach, (6) providing optimum salmonid habitat flows of 200 cfs and 400 cfs in the 4,500 ft-long James River Gorham, and Public Service Gorham bypassed reach for rainbow trout and brook trout fry, juvenile and adults, (7) providing a minimum flow of 200 cfs in the 800 ft-long Public Service Gorham bypassed reach for significantly enhanced juvenile brook trout and rainbow trout habitat and (8) providing downstream bypass facilities at Cascade, James River Gorham and Public Service Gorham. All of our recommended measures would contribute to protecting, significantly enhancing, and mitigating for cumulative adverse impacts that might occur to the Androscoggin River basin's resident salmonid population from the continued operations of the projects.

[9] Evaluation of Aquatic Habitat Potential for the Main Channel of the Androscoggin River Below Rumford Falls Upper Dam, Maine Council of Trout Unlimited, July 2023.

need to be considered here. Maine TU objects to this attempt to "gaslight" the negative fisheries and aquatic impacts the Project has and is proposing to have on this riverine reach. The FLA briefly references a 1991 aquatic habitat study conducted by Rumford Falls Power Co.[10] This study is over 30 years old, and does not even meet the standards of its time, for example: no photographs are included. MDIFW noted in its PAD Comments: "In addition, MDIFW has reviewed the earlier bypass study conducted in 1989 and the *methodologies employed did not quantitatively evaluate the potential benefit of various minimum flows*." (emphasis supplied)[11] While MDIFW sees it as limited, there is habitat potential in the reach, and invertebrates inhabiting the reach would add to the macro-invertebrate drift downstream adding to the fertility of the fishery below.

The Rumford Falls Power Co. study does not appear in the FLA, but was apparently used to direct the attention of the prior DEP Dams/hydropower Facilities official away from the reach below the Upper Falls during the course of the relicensing. The reaches below Upper Falls and Middle Falls both contain habitat that cannot be simply ignored; Exhibit 1 contains the best evidence available to demonstrate that the reach below Upper Dam does, and MDIFW certainly concludes that the reach below Middle dam does. These reaches must be evaluated for compliance and WQC purposes as well.

IV. The reach below Upper Dam does not meet State water quality standards and the minimum flow requirements will need to be modified.

The dewatered reaches below Upper Dam as proposed will not meet Maine numeric or narrative water quality standards when there is little to no minimum flow as proposed by Brookfield. Large dewatered reaches, clearly visible in publicly available Google Maps and other readily available sources of satellite imagery such as the Rumford Upper Falls LIDAR image provided in Exhibit 1, in many cases containing stagnant isolated pools do not appear to have sufficient water for these areas to meet the state numeric water quality standards. Contrary to DEP protocols,[12] DO and macro-invertebrate sampling was not conducted in this reach. Here the burden is on the Applicant to demonstrate that criteria have been met in the Project Area. Exhibit 2[13] provides expert testimony supporting Maine TU's assertion that the applicable water quality standards have not been met.

A. The application fails to meet the narrative standards for Water Quality Classification C.

As DEP noted in its Proposed Study Plan Comments: "Project study plans must be designed to evaluate the impact of project operations with respect to all of Maine's water quality standards, including designated uses and both narrative and numeric criteria."[14] The waters of the Rumford Falls Project are designated Class C waters.[15]

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[10] FLA, page E-57: "During the previous relicensing, and in coordination with the USFWS and MDIFW, a study was conducted to assess flows within the bypass reaches of the Project (Rumford Falls Power Co. 1991). Habitat within the bypass reaches is poor to non-existent. The upper bypass reach is steep and consists predominantly of bedrock substrate. Habitat within the lower bypass reach is also steep with cascades over bedrock and boulders." Also, at Appendix E.1-75.

[11] MDIFW Study Requests for the Rumford Falls Hydroelectric Project (FERC No. 2333) dated January 28, 2020, page 2.

[12] DEP Sampling Protocol for Hydropower Studies (MDEP 2019a): "…measurements should be made at the location of the lowest concentration and the location of the main flow. Sampling should also occur in any bypassed segment of the river created by the project."

[13] Expert Testimony of Mark Whiting dated August 3, 2023.

[14] Maine DEP letter RE: FERC No. 2333, Rumford Falls Hydroelectric Project Draft License Application Comments dated June 8, 2020.

[15] 38 MRSA §467 ¶ 12 A (2).

The narrative criteria for the Class C waters are:

> "A. Class C waters must be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; agriculture; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited under Title 12, section 403; navigation; and as a habitat for fish and other aquatic life. [PL 2003, c. 227, §4 (AMD); PL 2003, c. 227, §9 (AFF); PL 2005, c. 561, §10 (AFF).]
>
> B. Class C waters must be of sufficient quality to support all species of fish indigenous to those waters and to maintain the structure and function of the resident biological community. The dissolved oxygen content of Class C water may not be less than 5 parts per million or 60% of saturation, whichever is higher, except that in identified salmonid spawning areas where water quality is sufficient to ensure spawning, egg incubation and survival of early life stages, that water quality sufficient for these purposes must be maintained. In order to provide additional protection for the growth of indigenous fish, the following standards apply."

Presently at Upper Falls Dam, the minimum flow of 1 cfs cannot possibly meet this criteria with all flow being diverted through the powerhouse up to its full generation capacity. Under these conditions, for months out of the year, bypass flows are reduced to a trickle below Upper Dam and the reach is severely dewatered resulting in large areas of exposed rock and three nearly isolated pools. This dewatered area extends for approximately 800 feet downstream. The aesthetic and whitewater releases offered by the Applicant acknowledge that there is aesthetic value to releasing water over Upper Dam. There would be measurable value to minimum flows in this reach, and as demonstrated in Exhibit 1, there is habitat value in that reach when watered.

B. The waters below Upper Dam have not been demonstrated to meet applicable numerical DO standards or wetted width criteria.

There is no evidence of current studies that the Project meets numerical standards for DO and macroinvertebrates in the Class C waters immediately downstream of Upper Dam, or the reach below the Lower Station. However, there is ample legal authority for DEP to deny certification or impose WQC conditions based on violations of narrative standards.[16]

There has been no study data submitted that demonstrated that proposed operations for either Upper Dam or Middle Dam meet ¾ wetted width criteria as stated in DEP Protocols. The total distance from Upper dam to where all waters rejoin the Androscoggin below Lower Station is approximately 1100 yards, over half a mile. This is a major omission and grounds for application denial.

V. DEP's rejection of the request for additional water quality studies below Lower Dam was without accurate factual basis.

[16] *See S.D. Warren Company v. Board of Environmental Protection*, 2005 ME 27, 868 A.2d 210 (2005) ("S.D. Warren I"); *S.D. Warren Company v. Board of Environmental Protection*, 547 US 370 (2006) ("S.D. Warren II"). In S.D. Warren I at 442, the Court concluded that the narrative criteria at 38 M.R.S.A. § 465, which requires waters "of sufficient quality to support all indigenous fish species," was intended to be an integral part of the water quality standards for the BEP to consider. The Court also concluded, based upon the specificity of the designated uses at 38 M.R.S.A. § 465, that the Legislature's purpose for the language "suitable for the designated uses" was "that the designated uses actually be present." The court also stated that when those uses are not presently being achieved, the Legislature intended the quality of the water be enhanced so that the uses are achieved. (internal citations omitted).

DEP did not respond to the NGOs arguments that the studies under-sampled the project below the Lower Station Development.[17] This is the first project that Maine TU has encountered where there was no sampling done in or below the outflow from a powerhouse. As previously stated, the sampling conducted was not done in accordance with DEP protocols. Here, the area below Lower Dam is not the same aquatic environment as that below Middle Dam. Appropriate sampling and study designed to evaluate this unique discharge flow was simply not done. The burden is on the Applicant to demonstrate compliance with applicable standards, not on the stakeholder to show that the Applicant did not. Here the Applicant has wholly failed to meet even minimum sampling and testing requirements on this riverine section.

Maine TU objects to the lack of sampling done in or below the outflow from a powerhouse as required by protocol. The existence of a separate, state licensed discharge does not relieve the Applicant from conducting its own testing and studies of its own flow discharge particularly when the separate licensed discharge is documented and can be quantified and qualified. Maine TU submits it is arbitrary and capricious not to require sampling in this Project area as the mere existence of an additional licensed discharge does not excuse the Applicant from determining whether its flow discharge is in compliance with state water quality standards.

VI. The whitewater/scenic releases proposed by the Applicant will exacerbate the environmental harms unless commensurate measures are taken to continuously water the reach below Upper Dam.

Infrequent releases, such as those proposed for scenic or temporary recreational use are inadequate here to establish stable and sustainable fisheries and aquatic habitat. These releases will cause other problems that must be addressed through the establishment of daily, consistent minimum flows over the Upper Dam, for example, to keep aquatic organisms from becoming trapped in the three stagnant pools that form in the reach below and becoming stranded and dead. The NGOs have proposed and justified 200 cfs as an adequate flow in large part for this purpose.[18] Similarly, MDIFW does not agree with Brookfield's interpretation of its own study data and has proposed between 250 and 500 cfs for similar concerns for similar habitat below Middle Dam. Upon reviewing MDIFW's study, Maine TU agrees that flows of 250 to 500 cfs are needed for habitat in the reaches below both Middle Dam and Upper Dam.

MDIFW FLA Comments also provided significant information confirming the presence of American eels above and in the vicinity of the project.[19] Water over Upper Dam would provide a path for both downstream and upstream migration of American eels. This was not addressed by the Applicant in the License Application.

Maine TU asserts that a minimum flow of 250 to 500 cfs over the Upper Falls, presumably implemented through the use of notched flashboards, would accomplish the following: (1) re-establish a sustainable fisheries and aquatic habitat; (2) reduce aquatic species mortality by providing oxygenating, constant flows through the pools, (3) create a downstream spawning path for American eels and other indigenous aquatic organisms, (4) create an upstream path for American eels to reach the base of the dam and

[17] NGO letter NGO Request for Reconsideration of Required Water Quality Studies for the Rumford Falls Project dated September 28, 2022.

[18] NGO USR/DLA Comments, pages 2 and 3.

[19] MDIFW Comments on Final License Application for the Rumford Falls Hydroelectric Project (FERC No. 2333) February 17, 2023, pages 9 and 10.

therefore be in better position to move around or over the dam and (5) improve the views from the Rumford Falls Trail so valued by local residents.

VII. To meet the requirement for Class C waters, DEP must prescribe that minimum flows shall be directed over Upper Dam and not through the powerhouse.

MRS §480-D, section 3 states: "*In determining whether there is unreasonable harm to significant wildlife habitat, the department may consider proposed mitigation if that mitigation does not diminish in the vicinity of the proposed activity the overall value of significant wildlife habitat and species utilization of the habitat and if there is no specific biological or physical feature unique to the habitat that would be adversely affected by the proposed activity. For purposes of this subsection, "mitigation" means any action taken or not taken to avoid, minimize, rectify, reduce, eliminate or compensate for any actual or potential adverse impact on the significant wildlife habitat, including the following:*
A. Avoiding an impact altogether by not taking a certain action or parts of an action; [PL 1987, c. 809, §2 (NEW).]
B. ***Minimizing an impact by limiting the magnitude, duration or location of an activity or by controlling the timing of an activity;*** *[PL 1987, c. 809, §2 (NEW).]*
C. ***Rectifying an impact by repairing, rehabilitating or restoring the affected environment****; [PL 1987, c. 809, §2 (NEW).]*
D. ***Reducing or eliminating an impact over time through preservation and maintenance operations during the life of the project****; or [PL 1987, c. 809, §2 (NEW).]*
E. ***Compensating for an impact by replacing the affected significant wildlife habitat****. [PL 1987, c. 809, §2 (NEW).]*[20] (emphasis supplied)

The most direct way to mitigate the adverse Project effects consistent with the statutory language cited above, would be for the Applicant to divert the minimum flows of 250 cfs to 500 cfs over Upper Dam and Middle Dam using notched flashboards, and not as is presently being done with a 1 cfs minimum flow.

Immediate benefits below the Upper Dam would include:

1. Stagnant pools would be eliminated.
2. Entrapment in the pools would be reduced.
3. Aquatic organisms would have a path downstream during the summer and other low-flow periods other than though a turbine.
4. Aesthetic qualities of the site would be partly restored, especially during the summer when the site receives its greatest use and attention.
5. DO levels and the presence of macro-invertebrates in the reach would increase in the presence of continuous oxygenated water flow, increasing the suitability of the habitat for aquatic organisms trapped in the pools including indigenous brook trout.
6. Both upstream and downstream passage for American eel shown to be present upstream of the project would be improved.
7. Increased flows at Upper Dam would improve oxygenation and macro-invertebrate habitat and drift improving conditions for the recreational fishery below Middle Dam.

Immediate benefits to the reach below Middle Dam would include:

1. Improvement of the fisheries habitat

[20] 38 MRSA §480-D (3), Protection and Improvement of Waters.

2. Improvement of the recreational fishery
3. Improved upstream American eel passage.

The current practice does little to reduce the impact of the project and instead perpetuates its cumulative and continuing adverse environmental impacts.

VIII. To meet the requirement that the project meet all designated uses, recreational and aesthetic uses must be further enhanced.

Maine statutes require that: "Class C waters must be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; agriculture; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited under Title 12, section 403; navigation; and as a habitat for fish and other aquatic life."[21] Besides water quality considerations previously described, the application fails to provide adequate recreational features as remediation for turning the largest waterfall in the United States east of Niagara Falls into an industrial site. Maine Bureau of Parks and Lands (BPL) comments recommend at least 10 days of aesthetic flows and 10 days of whitewater flows, saying "We continue to view the proposed aesthetic flows of 1200-1500 cfs on three summer days (June through August) *as an inadequate improvement over current flows*."(emphasis supplied)[22]. An updated list of the terms and conditions needed to be incorporated into the new license to meet all designated uses is provided as Exhibit 3.

CONCLUSION

DEP has the authority to recommend comprehensive DO and macro-invertebrate studies that could provide data as to whether the Project waters meet the criteria for a Clean Water Act Certification. Even if the Project can be shown to meet the DO and macro-invertebrate requirements for Class C waters below Upper Dam and Lower Station, Maine TU maintains that if the Rumford Falls Project is allowed to operate as has been proposed in the FLA, hydro-electric power generation will continue to be the only designated use adequately supported by the Project, and aquatic species habitat and other riverine uses will continue to cease to exist or not be practical or possible.

The following must occur for the project to meet the narrative standards for Class C waters: (1) minimum flows of 250 to 500 cfs be directed over both Upper Dam and Middle Dam; a predominance of the measures described in Exhibit 3, list of remediation measures needed to address environmental, recreational and aesthetic concerns. In the alternative, lacking these reasonable provisions, the proposed Application will not meet the relevant and applicable state standards required for certification and certification must be denied; and (2) Studies must be undertaken to determine DO and macro-invertebrates present below the Lower Station and appropriate action taken to address any discrepancies.

Exhibit 4, the scientific paper referenced in Exhibit 1, is provided for inclusion in the record to meet State evidentiary requirements should appeal of the DEP certification decision be necessary.

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[21] 38 MRSA §465-4(A), Class C Waters.

[22] BPL letter of August 25, 2023, RE: Comments and Recommendations in Response to Application Accepted for Filing, Ready for Environmental Analysis and Soliciting Comments and Recommendations, Rumford Falls Project (FERC No. 2333-094)

Exhibit 5 is the NGO Request for Reconsideration of Required Water Quality Studies for the Rumford Falls Project previously submitted to DEP.

We request that this letter with all its attachments be entered in to the record for the Department's review of the Water Quality Certification Application.

Respectfully,

Stephen G. Heinz
Maine TU Council FERC Coordinator

ATTACHMENTS:

Exhibit 1 - Evaluation of Aquatic Habitat Potential for the Main Channel of the Androscoggin River Below Rumford Falls Upper Dam

Exhibit 2 - Expert Testimony of Mark Whiting

Exhibit 3 - Revised requested License Terms and Conditions

Exhibit 4 – Benthic assemblage variation among channel units in high-gradient streams on Vancouver Island, British Columbia, Karen L. Halwas, Michael Church, and John S. Richardson, Journal of the North American Benthological Society, Volume 24, Number 3.

Exhibit 5 - NGO Request for Reconsideration of Required Water Quality Studies for the Rumford Falls Project

ELECTRONIC COPIES TO:

Scott Boak - DEP

Laura Paye - DEP

Casey Clark - MDMR

Jim Pellerin - MDIFW

Elizabeth Latti - MDIFW

John Perry - MDIFW

Jim Vogel – BPL

Scott Sells, Esq. Counsel to Maine TU

Exhibit 1

Evaluation of Aquatic Habitat Potential
for the
Main Channel of the Androscoggin River Below Rumford Falls Upper Dam

Stephen G. Heinz
Maine Council of Trout Unlimited, FERC Committee

Revised October 2023

Summary.

Analysis of available photography, satellite imagery, and LIDAR for the reach below Upper Dam of the Rumford Falls Project demonstrate that the reach is capable of supporting a viable community of aquatic life.

Background.

Rejection of the NGO request for additional water quality studies[1] by FERC[2] that would have filled the gap in the information needed for FERC to make informed decision regarding flow regimes for the Rumford Falls Project (P-2333) if and when it is relicensed. This report evaluates the potential habitat in the largely dewatered reach below Upper Dam and demonstrates that, if watered, the reach does provide suitable habitat for aquatic life.

Methodology.

Available photography, satellite imagery, and LIDAR for the reach below Upper Dam are analyzed and compared with data from data from Maine's West Branch of the Penobscot where a recent study showed that presumably less favorable habitat contained abundant and varied aquatic life. They are also compared with LIDAR of the reach below Middle Dam labeled Lower Falls.

[1] Inland Woods and Trails, the Appalachian Mountain Club, Maine Rivers, the Friends of Richardson Lake, American Whitewater and Maine Council of Trout Unlimited (NGOs) letter dated September 29, 2022, Subject: Additional NGO Comments on Rumford Falls Project Updated Study Report with Study Requests.

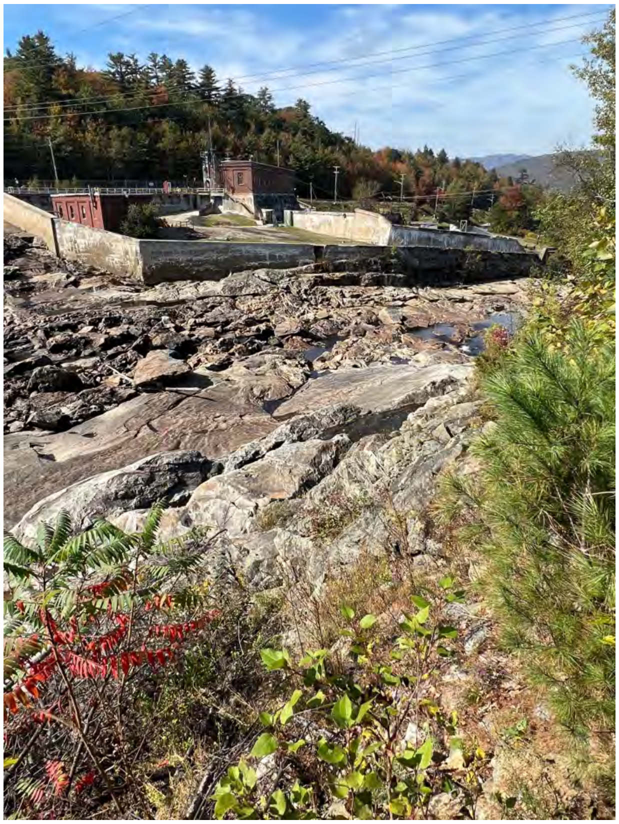
[2] FERC Issuance dated November 21, 2022, Reference: Determination on Requests for Study Modifications for the Rumford Falls Hydroelectric Project.

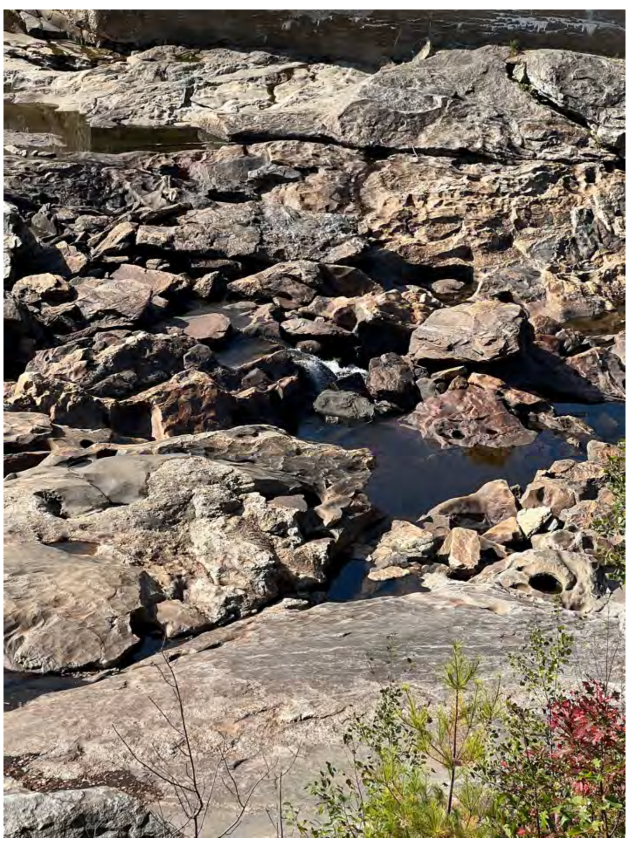
Results.

This photograph of the reach immediately below Upper Dam shows a variety of substrate sizes present creating the roughness needed for viable aquatic habitat.[3]

The following photos provide additional detail of the roughness of the substrate contained in the reach below Upper Dam. Source: John Preble, date October 5, 2023; flow from Rumford USGS gage ~2230 cfs; flashboards up – with flashboards not installed, less leakage flow would be present.

[3] Rumford Falls Trail photo accessed at https://www.mainetrailfinder.com/trails/trail/rumford-falls-trail.






This image of the reach includes LIDAR data and shows large three pools in the reach. Rumford falls mostly a series of cascades with approximately a 12% gradient overall and approximately a 2 % gradient where pools form.

Current science indicates that these gradients support communities of aquatic life. While the gradient of the entire reach is 12 percent, there are flatter sections in the upper and middle parts of the reach where three large pools are apparent. Velocities in these areas would be lower, but even the "12 percent slope does provide habitat for most stonefly species, mayflies, and both net-building and free-living caddis. Numerous species have been documented in assemblage studies of high gradient waters."[4]

These gradients are similar to gradient at the Cribworks on West Branch of the Penobscot River below Ripogenus Dam.

[4] Benthic assemblage variation among channel units in high-gradient streams on Vancouver Island, British Columbia, Karen L. Halwas, Michael Church, and John S. Richardson, Journal of the North American Benthological Society, Volume 24, Number 3.

A stranding study conducted in October of 2022 showed abundant and varied aquatic life to be present.[5] This was despite the fact that much of the substrate lacked the roughness of the reach below the Rumford Project's Upper Dam shown on page 2 of this report.

salmon parr stranded on moss after jumping out of pool

stranded crayfish

stranded stonefly nymph

live salmon parr stranded in small pool

live salmon parr stranded on ledge

[5] Stranding Study of West Branch of the Penobscot River below McKay Station, Report of Observations – October 5, 2022, Stephen G. Heinz, Maine TU Council FERC Coordinator, October 19, 2022, Attachment I.

Comparing the gradients sociated with the reaches below the upper Dam and Middle dams, they are similar. The reach below Middle Dam (labeled as “Lower Falls”) provides habitat for a stocked fishery that MDIFW has requested additional flow be provided to better support the fishery.[6] Please note difference in graphic scales.

[6] MDIFW letter dated April 19, 2023, Subject: Rumford Falls Hydroelectric Project (FERC No. 2333-094) Response to MDIFW Comments on the Final License Application, Attachment A-2, “MDIFW is concerned that the current and proposed minimum flows for the Middle Dam bypass are extremely low and unacceptable given the drainage area, physical character, length, area, biota, and fisheries potential of the bypass reach, not to mention the aesthetic concerns raised by numerous parties.


Rumford Lower Falls
Approximate Water Elevation = 425'
Approximate Water Elevation = 480'
Contour Interval = 2 feet
ESRI Orthophoto Basemap
N
0
100
200
Feet
Map created by A. Abbott, 9/20/22

Conclusion.

Fisheries habitat suitability is largely a function of substrate roughness and gradient. The reach below Upper Dam shows significant roughness with much of the gradient in the 2 to 4% range capable of supporting aquatic communities. Habitat below Ripogenus Dam with similar gradients that shows less roughness was recently demonstrated to show a thriving aquatic community that included fish and macro-invertebrates. The substrates and gradient for the reach below Upper Dam are similar to those below Middle Dam where MDIFW maintains a trout fishery. These data demonstrate conclusively that (if watered) the reach below the Rumford Falls Project Upper Dam would support communities of aquatic life.

Exhibit 2

IN THE MATTER OF

Brookfield White-Pine Hydro LLC)
Project No. P-2333-091)
Application for Major New License)
Rumford Falls Hydroelectric Project)

EXHIBIT 3

AFFIDAVIT OF MARK WHITING, PhD

I, Mark Whiting, hereby declare the following statements are true and accurate to the best of my knowledge, information and belief:

1. My name is Mark Whiting. I am a Senior scientist with 50 years of experience in biology, ecology, conservation, and fisheries restoration. I was formerly employed by Maine DEP and as part of my employment worked in the Division of Licensing and Enforcement (for approximately 8 years) and as a biologist in DEP's Salmon Program (for approximately 16 years). I am a Member of the Board for the Downeast Chapter of Trout Unlimited. I am also Chair of the Board for the Hancock County Soil & Water Conservation District. As such, I am an elected official for Hancock County. My Curriculum Vitae is attached to this affidavit.

2. I have reviewed the Rumford Falls Project and other documents in the public record and my professional opinion regarding the License Application is as follows:

3. The Applicant has failed to conduct the studies or tests required to show that the License Application's proposed minimum water flows are sufficient to sustain fisheries and aquatic habitat. This is large part due to the fact that (1) the proposed minimum flows do not provide enough oxygenated water over a sustained daily period of time; and (2) the Applicant has thus far failed to demonstrate that it will meet the state of Maine's water quality standards, specifically in the State classified Class C waters below the dams.

4. The Androscoggin River at Rumford below the upper dam consists of two critical reaches, the Falls (the almost dry and bypassed riverbed) and the Bypass (which has almost all of the upstream river water contained in a man-made channel). Both reaches are subject to the above described conditions that impact fisheries and aquatic habitat.

5. To sustain fisheries and aquatic habitat, the Androscoggin River at Rumford needs minimum flow requirements like those upstream at Gorham, New Hampshire. The river in Rumford is downstream of - and has a larger watershed than Gorham, and so the Falls should have at a very minimum the same requirements as the upstream site. At Gorham, the minimum flows in the bypassed river channel are 400 cfs from May – Jun, and 200 cfs the rest of the year[1]. This flow regime supports fish migration and spawning, recreational fishing, maintains the integrity of aquatic communities, and protects other public uses for Maine's third largest river.

6. The Applicant did not investigate the numerical water quality criteria (dissolved oxygen (DO), temperature, and bacteria) below the upper dam that will be required as part of the state of Maine's Water Quality Certification (WQC) process. It is my understanding that the water quality standards, requirements or conditions imposed under the WQC will be later incorporated into the FERC License; therefore the Applicant should conduct the tests and studies to show that these standards are being met. Because of a lack of consistent oxygenation, I do not believe that areas that are dewatered during low flows or minimum flows allowed under the current or proposed license will meet state water quality standards or sustain any meaningful fishery or aquatic habitat. To show that the river reaches in the Project area meets state standards, both the river and the Bypass must be tested and documented. I believe the natural river channel in its entirety throughout the Project area will clearly support fisheries and aquatic communities if a consistent minimum flow of at least 200 cfs is established. The applicant also needs to do water quality, fish studies, and macroinvertebrate studies to confirm that it is in the public interest to maintain or improve the water quality consistent with hydropower operations.

7. Rapid increases and decreases in river flow, such as those proposed for whitewater recreation, are major stressors for fisheries and other aquatic life. Studies have shown that rapid changes in water level will strand fish in isolated pools, expose invertebrates and plants to desiccation, reduce spawning success, and decrease biodiversity and abundance[2]. A ramping study should be used to find a way to manage the changes to minimize these impacts which can also be mitigated remedied with a consistent, oxygenated minimum flow.

8. At the Middle Dam, the Applicant proposes increases in minimum flows from around 21 cfs to 95 cfs. This would be inadequate to establish fisheries and aquatic species habitats which here will require at least a daily minimum flow of at least 200 cfs. Greater flows will help the Applicant meet state water quality DO and biological criteria. Higher minimum flows will support aquatic life, increase DO, and stabilize habitat so that plants and animals can grow, and the river will look like a natural river[2]. In contrast, dewatered or stagnant water areas are not likely to meet state water quality criteria which may preclude a FERC license from issuing. Similarly, the environmental considerations in FERC licensing process, particularly the development of an Environmental Assessment (EA) will be affected by Project areas that are untested, unstudied and present numerous environmental challenges particularly with respect to the detrimental effects low to minimally existent low flows and periodic high discharge flows have on fisheries and aquatic habitat.

9. The Applicant appears to assert that sampling the Bypass and trailrace are not needed because they are not representative of the river conditions. State DEP sampling protocols require the sampling of bypasses and the tailrace, and that is where most of the water is. The Applicant is required to show that the river (including bypass and tailrace) meet state water quality criteria[3]. FERC protocols also required and assessment of the project's flow discharge, distinct from other discharges into the same water body as is common in many water sheds where dams, mills and municipal dischargers are co-located on the same riverine section. Here the Town of Rumford discharges in the river pursuant to an NPDES discharge permit and, in contrast to the Rumford Dam's flow discharge, the nature and quantity of its discharge are well documented and easily distinguished from dam flow discharge.

10. The remedies for fisheries and aquatic species habitat degradation here are fairly straightforward. The original stream channel needs more daily minimum water flows and those

increased minimum flows need to be part of the license. A ramping study needs to be done to help minimize fish stranding. The water quality studies need to be done to ensure that the Project is not impairing water quality and will meet state water quality standards.

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[1] FERC Final Environmental Impact Statement, Upper Androscoggin Basin Hydroelectric Projects, New Hampshire: FERC/EIS 0070 – D, summary page xviii.

[2] Widen, et al. 2021, Let it flow: Modeling ecological benefits and hydropower impacts of banning zero-flow events in a large, regulated river system. Science of the Total Environment 783 (2021) 147101

[3] Maine DEP, Methods for Biological Sampling and Analysis of Maine's Rivers and Streams, page 5.

APPENDIX TO AFFIDAVIT OF MARK WHITING

Curriculum Vitae

Mark C. Whiting (retired biologist)
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EDUCATION

Oregon State University, Corvallis, OR
Ph.D. in Marine Ecology **1983**

Brigham Young University, Provo, UT
M.S. Botany with Chemistry Minor **1977**

Brigham Young University, Provo, UT
B.S. Zoology and Ecology **1975**

OTHER EDUCATIONAL EXPERIENCES

- Postdoctoral Research Associate, diatom and algae specialist, acid rain research in New England and California Sierra Nevada, U of Maine, Indiana U, and UC Santa Barbara **1983-1991**
- Summer intern, ecology of marine algae, Chesapeake Bay Center for Environmental Studies, Smithsonian Field Station **1977**

EMPLOYMENT HISTORY

Maine Dept. of Environmental Protection, Bangor **1998-2016**
Biologist with the Division of Environmental Assessment
Developed and managed a volunteer-based water quality monitoring program in the Maine salmon rivers to provide necessary background information to assist in salmon restoration, also co-managed DEP's volunteer river monitoring program (VRMP) for Maine, began liming salmon rivers to mitigate for acid rain in 2010

Maine Dept. of Environmental Protection, Bangor **1992-1998**
Environmental Specialist with the Bureau of Land and Water Quality, Division of Licensing and Enforcement

University of Maine at Machias **1991**
Assistant Professor, taught undergraduate chemistry labs

Eastern Maine Technical College, Marine Trades Center, Eastport **1990-1991**
Adjunct faculty, taught undergraduate classes in oceanography and marine biology

Maine Maritime Academy, Castine
Instructor, teaching undergraduate classes in oceanography and general college chemistry **1989-1990**

US National Park Service, Everglades National Park

Biologist, tagging sea turtles to assess population size, health and nesting success **1973**

Selected Publications: (monitoring, ecology and conservation)

Whiting, MC, JD Brotherson & SR Rushforth, 1978. Environmental interactions in summer algal communities in Utah Lake. Great Basin Naturalist 38: 32-41

Whiting, MC & CD McIntire, 1985. An investigation of the distributional patterns in the diatom flora of Netarts Bay, Oregon, by correspondence analysis. J Phycology 21 (4): 21-31

Whiting, MC & H Schrader, 19985. Late Miocene to Early Pliocene Marine Diatom and Silicoflagellate Floras from the Oregon Coast and Continental Shelf. Micropaleontology 31 (3): 249-270

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Whiting, MC & E Linsey, 2006. Water Quality Summary for Kenduskeag Stream and Upper Watershed Tributaries. Maine DEP report DEPLW-0762 pp. 1-21

Whiting, MC & W Otto, 2008. Spatial and Temporal Patterns in Water Chemistry of the Narraguagus River: A Summary of Available Data from the Maine DEP Salmon Rivers Program. Maine DEP report DEPLW-0940 pp. 1-32

Whiting, MC, 2009. Penjajawoc Stream a Summary of Water Quality Data from the 2008 Field Season. Maine DEP report pp. 1-31

Whiting, MC, 2010. Katahdin Iron Works and its Effect on the Water Quality of the West Branch of the Pleasant River. Maine DEP report DEPLW-1172 pp. 1-23

Whiting, MC, 2015. Water quality survey of Maine salmon rivers: the 2015 field season, Downeast, the Union & the Aroostook Rivers. Mane DEP report, pp. 1-18

Whiting, MC, 2017. The Union River Turbidity Study in Relation to Graham Lake Level Management. A report to the Downeast Salmon Federation for relicensing of the Union R dams, FERC Hydroelectric project #2727

Whiting, MC, 2019. Maine Brook Trout and Water Quality. A report to the National Park Service, Acadia National Park

Whiting, MC & J Porada, 2020. Spat Boxes and Nursery Nets as Strategies for Enhancing Clam Harvest and Post-Harvest Recovery on Mudflats. Hancock County Soil & Water Conservation District report pp. 1-9

Signed at Ellsworth, Maine, this 3rd day of August 2023.

Mark Whiting

STATE OF MAINE

August 3, 2023

Personally appeared the above-named Mark Whiting, and made oath that the statements made by him in the above Affidavit are true and accurate and made on his personal knowledge, unless stated upon information and belief, in which case he believes them to be true.

Notary Public My Commission Expires:

Michelle Campbell
Notary Public, State of Maine
My Commission Expires January 26, 2030

Exhibit 3

Modified Terms and Conditions Request

Minimum whitewater flows of 1500 cfs over the lower falls from 10:00 a.m. to 5:00 p.m. Friday through Sunday during the months of July, August and September

Minimum aesthetic flows of 1000 cfs over both the upper falls and lower falls from 10:00 a.m. to 8:00 p.m. Friday through Sunday during the months of July, August and September

Additional aesthetic flows of at least 1000 cfs during the Rumford Pumpkinfest Event held annually in mid-October and during up to two additional events not to exceed three days if/when determined by the Town of Rumford

Minimum flows of 250 to 500 cfs from both Upper Dam and Lower Dam at all times to prevent dewatering, reduce strandings, and maximize the aquatic habitat

Appropriate additional studies to determine the environmental effects of these changes to project operations

An improved trail from the vicinity of the Rumford Public Library to the water to provide access for white water activities in the lower falls (when watered) and to the pools providing fishing opportunities within the falls during favorable flow conditions

Restoration of the traditional 'fisherman's trail' to access the tail of the lower falls during favorable flow conditions. Located in an area originally acquired by the Town for parkland, the area is currently used by the Town of Rumford for accommodation of the snow it plows from town roads.

Relocation of the Logan Brook Access to the impoundment above Upper Falls

Retention and improvement of the carry-in launch and parking below the U.S. Route 2 in Mexico to continue access to the trout fishing opportunities downstream at the confluence of the Swift River and the Androscoggin River as well as upstream in the Swift River

Retention and improvement of the new Rumford Falls Trail segment replacing the segment that Brookfield had closed. This will provide a very satisfactory replacement for the old trail below that had been used by area residents to view the upper falls (when watered).

Retention and improvement of the other recreational facilities currently under study as recommended by the Recreation Facilities Focus Group

Exhibit 4

J. N. Am. Benthol. Soc., 2005, 24(3):478–494

Benthic assemblage variation among channel units in high-gradient streams on Vancouver Island, British Columbia

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Department of Geography, The University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z2

John S. Richardson[3]

Department of Forest Sciences, The University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z4

Abstract. We characterized channel unit types in 13 steep, headwater streams in British Columbia, Canada, based on physical variables, to determine the influence of channel unit type on benthic macroinvertebrate assemblages. Macroinvertebrate abundance was highest in riffles, followed by rapids, pools, boulder cascades, chutes, and bedrock cascades. Heptageniidae, Nemouridae, Chironomidae, Leptophlebiidae, Enchytraeidae, Chloroperlidae, Lepidostomatidae, and Tricladida were most abundant in either riffles or rapids. Baetidae and Simuliidae preferred bedrock cascades and chutes, and predominance of these families resulted in a distinct assemblage structure within these 2 channel unit types compared with other types. Benthic assemblages within riffles, rapids, pools, and boulder cascades were not distinctive from each other. Significant interstream variation was apparent in abundance of all taxonomic groups studied. In general, invertebrates were more abundant in streams with perennial flow regimes compared to those with intermittent or ephemeral flow. Assemblage structure within ephemeral streams was distinct because of the preponderance of Enchytraeidae. Defining physical characteristics of stream channel units using benthic macroinvertebrate assemblages is a useful means of discriminating habitat conditions within small, high-gradient streams.

Key words: benthic macroinvertebrates, benthic habitats, flow regime, first-order channels, headwater channels, substrate, water velocity.

A channel unit is a morphologically distinct portion of stream channel, commonly one to a few channel widths in length (Church 1992). Mountain streams exhibit various forms of channel units (Grant et al. 1990, Hawkins et al. 1993). For example, cascades, rapids, and chutes are common unit types in streams with high gradients, whereas pools and riffles are characteristic unit types in channels with low to moderate gradients. Compared with larger and better-studied downstream environments, small headwater streams often are under-appreciated and even ignored (Meyer and Wallace 2001), and so their channel units are poorly characterized. Recently, however, Halwas and Church (2002) showed that dominant substrate and bed slope together provide a reasonable characterization and stratification of channel unit types in high-gradient streams of the western slopes of the Vancouver Island Mountains.

It is well known that benthic organism distribution is determined largely by substrate and current velocity (Minshall and Minshall 1977, Huryn and Wallace 1987, Angradi 1996). Because streambed slope and velocity are directly related, bed slope indirectly influences benthic distributions. Stream-dwelling organisms have evolved morphological and behavioral traits to contend with high variation in substrate characteristics and velocity (Hynes 1970, Minshall 1984). For example, the predominant taxa in steep, rocky, fast-water environments possess morphological and behavioral adaptations for attachment (e.g., hooks and silk), clinging (e.g., long, curved tarsal claws, dorsoventral flattening of the body, streamlining and ballasts), or current avoidance (e.g., site selection, burrowing) (Hynes 1970, Merritt and Cummins 1996). In contrast, organisms in depositional environments may be adapted for burrowing in fine sediments, and relatively poorly adapted to clinging or inhabiting interstitial spaces (Bar-

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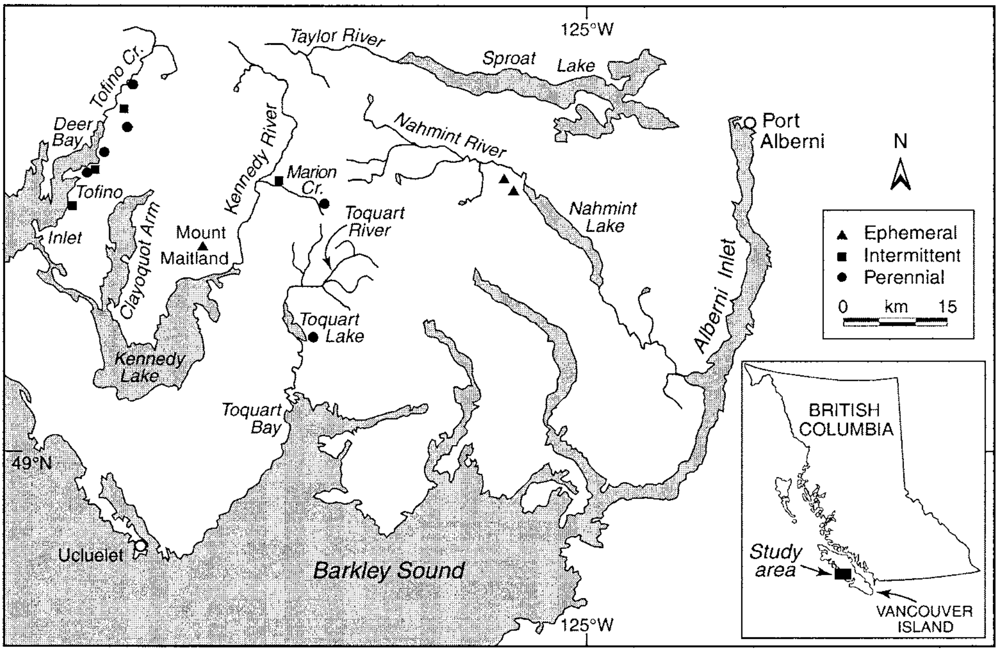

FIG. 1. Study area and locations of study reaches in the Clayoquot Sound region, on the western slope of the Vancouver Island Mountains, British Columbia. (Study streams: ephemeral $n = 3$, intermittent $n = 4$, and perennial $n = 6$). (Reprinted from Halwas and Church 2002, with permission from Global Rights Department, Elsevier Scientific Publishing, P.O. Box 800, Oxford, UK 0X5 1DX.)

muta 1989, Hauer and Resh 1996). In this context, predominant substrate and bed slope together may provide a means to distinguish channel unit types in high-gradient streams, and thus at least partially explain benthic distributions (Southwood 1977, Hawkins et al. 1993). We investigated the premise that channel unit types differentially influence benthic macroinvertebrate assemblages, and thereby represent distinct sets of habitat characteristics.

We characterized the physical attributes and associated benthic macroinvertebrates of 6 channel unit types in 13 headwater streams on Vancouver Island, British Columbia. We selected study channels that were considerably steeper (up to 80%) than most previously described. We quantified variation in macroinvertebrate abundance and assemblage structure among the 6 channel unit types, and considered this variation in terms of the physical environment. We sampled many streams over multiple dates, and thus also considered the influence of confounding factors such as interstream and temporal differences on variation in invertebrate assemblages. Our primary goal was to identify particular habitat features of channel unit types through the concurrent analysis of physical conditions and macroinvertebrate occurrence.

Methods

Study site

The study streams were in the Clayoquot Sound region and surrounding areas on the western slopes of the Vancouver Island Mountains (Fig. 1). The geology was dominated by coarse crystalline and metamorphic intrusive rocks overlain by glacial till. Mountain peaks ranged from 500 to 1300 m (Ryder 1978). Valley sides commonly were >60% slope, highly dissected, and extremely rugged. Coniferous forests dominated the landscape. Annual precipitation, predominantly occurring as winter rainfall, ranged from >1800 mm at inland sites to >6000 mm on the western slopes of the Vancouver Island Mountains (A. Chapman, Chapman Geoscience, personal communication). Loose till on steep slopes is susceptible to mass wasting, so bedrock outcrops or consolidated

TABLE 1. Characteristics of 13 study sites and sampling dates. Stream abbreviations were assigned according to area and to number of streams encountered in each area during initial reconnaissance. DB = Deer Bay, MRN = Marion Creek, MTD = Maitland Mountain, NMT = Nahmint Lake, TC = Tofino Creek, and TQ = Toquart Lake. S96 = summer 1996, A96 = autumn 1996, S97 = spring 1997.

Site	Flow regime	Stream abbreviation	Active channel width (m)	Mean channel gradient (%)	Sample date
DB1	Perennial	P1	1.8	25	S96, A96, S97
DB3	Intermittent	I1	2.1	18	A96
DB5	Perennial	P2	2.8	28	S96, A96, S97
DBf	Intermittent	I2	2.5	24	S97
MRN1	Perennial	P3	1.3	30[a]	S96, A96, S97
MRN2	Intermittent[b]	I3	4.9[a]	54	S97
MTD1	Ephemeral	E1	4.2	48	A96
NMT4	Ephemeral	E2	2.0	19	A96
NMT5	Ephemeral	E3	3.4	20	A96
TC1	Intermittent[b]	I4	2.4	42	S96
TC1b	Perennial	P4	2.4	10	S97
TC43	Perennial[b]	P5	3.8	13	S97
TQ1	Perennial	P6	2.7	50	S96, A96, S97

[a] Approximate measure
[b] Flow regime designation based on limited observations

materials were common on hillsides. The steep terrain and seasonally hyperhumid environment of the Clayoquot Sound region caused headwater channels to be frequent, steep, and largely intermittent or ephemeral.

We studied 13 first-order channels. Study reaches were bordered by old-growth forest and were undisturbed by human activity. We did not assess natural upstream disturbance, such as landslide activity, although study channels appeared stable. Active channel widths and mean gradients ranged from 1.3 to 4.9 m and from 10 to 54%, respectively, and flow regimes varied from ephemeral to perennial (Table 1). Ephemeral streams carried storm runoff derived from saturation seepage or from overland flow during and immediately following intense rainstorms, intermittent streams lacked surface flow during the summer dry period, and perennial streams were restricted to those draining depressions or fed by springs.

Predominant channel unit types in the study reaches (Fig. 2) were bedrock cascades, chutes (not shown in Fig. 2), boulder cascades, rapids, riffles, and primary pools (Halwas and Church 2002); lengths of unit types varied with active channel widths. **Bedrock cascades** were rock outcrops free from alluvium, which resulted from high sediment transport capacities associated with steep gradients. **Chutes** also were rock outcrops, but were distinguishable from bedrock cascades by having lower bed slope. **Boulder cascades** consisted of pocket pools interspersed among tightly packed boulders (Fig. 2A). **Rapids** consisted of bed particles organized into steps that crossed the channel and separated secondary pools (Fig. 2B). The secondary pools of rapids were less regularly spaced and larger in area than pocket pools of boulder cascades. Compared to rapids, particles of boulder cascades were larger, more uniformly sized, and less distinctly arranged into steps. **Riffles** consisted of uniformly distributed gravel and cobbles (Fig. 2C). **Primary pools** were channel-spanning topographic depressions with non-uniform substrate (Fig. 2D). Neither pocket pools nor larger (by area) secondary pools were considered morphologically distinctive units because they were <1 channel width in length and usually did not span the channel.

Physical measurements

We measured bed slope and water surface velocity for each channel unit at each stream. We used a clinometer to measure bed slope over the entire channel unit length and also measured velocity by timing a cork floating a known distance downstream. Velocity measurements were both limited and approximate because low dis-

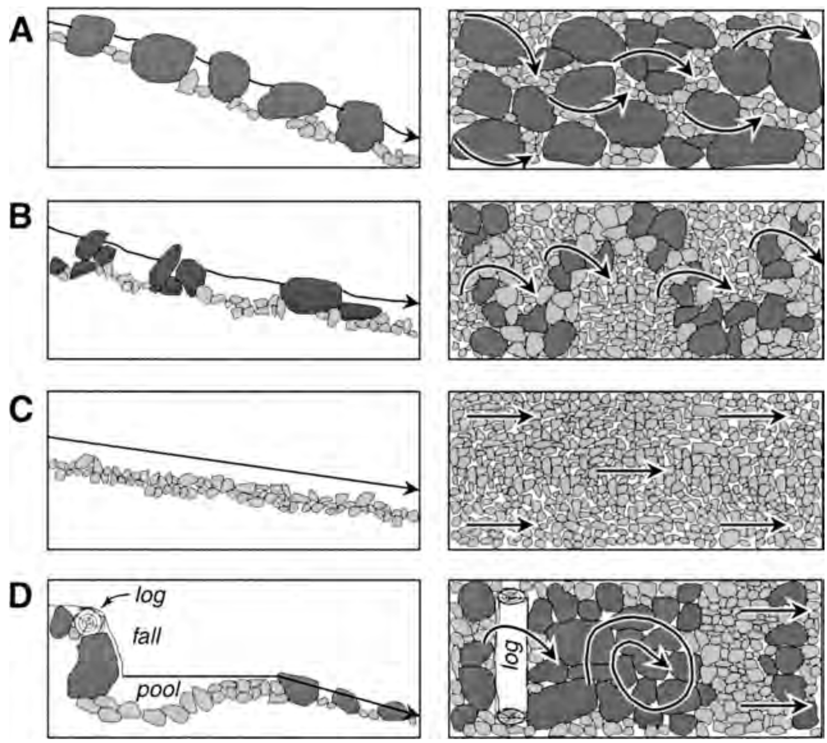

FIG. 2. Longitudinal (left panels) and plan (right panels) view diagrams for channel units defined in the study streams: boulder cascade (A), rapid (B), riffle (C), and fall and pool (D). Bedrock cascades and chutes (not illustrated) are rock outcrops with relatively high and low gradients, respectively. Arrows show direction of flow. (Reprinted from Halwas and Church 2002, with permission from Global Rights Department, Elsevier Scientific Publishing, P.O. Box 800, Oxford, UK 0X5 1DX.)

charge and high bed roughness caused irregular flow through many units. However, velocity measurements were correlated with channel slope (Table 2), so we used flow-independent criteria (i.e., physical criteria other than stream velocity) to classify channel units (Halwas and Church 2002).

At each site, we estimated and classified the dominant riparian shrubs and trees, riparian shading, and dominant channel substrate for inclusion in statistical tests to quantify the expected variability of environmental conditions and invertebrate occurrence among sites. We considered classifications to be site-specific rather than characteristic for any one channel unit type. For shading, we assigned classes of low,

TABLE 2. Mean bed slopes and current velocities of channel unit types in study streams. Velocity measurements taken over 3 seasons (summer 1996, autumn 1996, spring 1997) were averaged to illustrate the relationship between bed slope and velocity.

Channel unit type	*n*	Bed slope (%)	Bed slope range (%)	Current velocity (cm/s)	Velocity range (cm/s)
Pool	98	3	−14–20	17	0–90
Riffle	61	9	−3–25	34	3–86
Chute	10	12	2–29	56	10–103
Rapid	55	20	9–35	45	10–100
Boulder cascade	53	45	15–80	95	46–200
Bedrock cascade	33	49	14–80	61	8–200

TABLE 3. Number and proportion of individuals of the 10 most numerically abundant macroinvertebrate taxa within the study streams. Streams, channel unit types, and dates were combined. A total of 20 taxa composed ~95% of invertebrates collected. The 11th most abundant family was Leuctridae (2.4%) followed in descending order of abundance by Tipulidae, Rhyacophilidae, Polycentropodidae, Hydropsychidae, Ameletidae, Brachycentridae, Glossosomatidae, Philopotamidae, and Limnephilidae. Predominant genera are listed in order of decreasing relative abundance.

Taxon	Number of individuals	% of total	Predominant genera
Heptageniidae	2819	21.4	*Epeorus, Ironodes, Cinygma, Cinygmula, Rhithrogena*
Nemouridae	2321	17.6	*Zapada, Podmosta, Visoka, Malenka, Soyedina*
Chironomidae	1490	11.3	
Leptophlebiidae	822	6.2	*Paraleptophlebia*
Enchytraeidae	675	5.1	
Baetidae	552	4.2	*Baetis*
Chloroperlidae	544	4.1	*Sweltsa, Kathroperla*
Tricladida	511	3.9	
Simuliidae	405	3.1	
Lepidostomatidae	350	2.7	*Lepidostoma*
Total	10,489	79.6	

medium, or high determined by height of the riparian canopy and channel width. We accounted for topographic shading and large canopy gaps by increasing or decreasing the assigned class by one, respectively. For substrate type, we visually estimated amount of bedrock, boulders (>256 mm), cobbles (64–256 mm), and gravel (2–64 mm) within each channel unit. Specification of the dominant substrate does not preclude occurrence of other bed material. However, we chose to characterize the substrate visually because 1) accurate description of grain-size distribution requires that no individual stone exceed 0.1% of a sample (Rood and Church 1994), and 2) sampling using this stringent criterion in study reaches would have unavoidably destroyed the channel.

Benthic sampling

We sampled benthic macroinvertebrates on 3 separate occasions (Table 1), and collected samples on each date within 1 wk to minimize temporal variability. We collected stratified random samples from channel units using a kick and sweepnet method. We sampled each of 3 separate channel units of the same unit type (i.e., 3 bedrock cascades, 3 boulder cascades, etc.) within each stream; where ≤3 representatives of a channel unit type occurred, we sampled all of them. We established a 1-m transect within each channel unit parallel to the direction of flow in the channel center, placed a dip net (250-μm mesh) on the streambed at the downstream end of the transect, and then vigorously disturbed the substrate for 2 min. Displaced matter was carried by the current downstream into the trailing net. For units where water velocity was low, such as in deep pools, we moved the net through the water column using a scooping action. We transferred net contents to a plastic jar and preserved them in a buffered 5–10% formalin solution.

Five (DB1, DB5, MRN1, TC1, TQ1) of the 13 streams surveyed in summer 1996 had sufficient water to allow kick sampling. When discharge increased in October and November 1996, we resampled 4 (DB1, DB5, MRN1, TQ1) of the original 5 streams and 4 new streams (DB3, MTD1, NMT4, NMT5). In spring/summer 1997, we sampled 4 additional new streams (DBf, TC1b, TC43, MRN2) as well as the 4 streams (DB1, DB5, MRN1, TQ1) sampled in summer and autumn 1996 (Table 1).

In the laboratory, we washed samples through nested sieves (1 mm and 250 μm) and stored each size fraction in 95% ethanol. We removed invertebrates from the >1-mm portion only, and identified and counted them under a dissecting microscope. We identified insects, decapods, and oligochaetes to the family level. Many families were represented by a single species or genus, and other families often were numerically dominated by single genera (Table 3), so we left identifications at the family level in data analyses. Other authors have concluded that family-level identifications are a reasonable trade-off between cost and discrimination (Bowman and Bailey 1997, Bailey et al. 2001, but see Hawkins et al. 2000), and also may reduce identification error (Bournaud et al. 1996) and seasonal differences caused by phenological variation (Reece et al. 2001).

Data analysis

We estimated relative abundance of the 10 most abundant invertebrate taxa. We log-transformed ($\log_{10}[x+1]$) abundance data and analyzed differences in total macroinvertebrate abundance among channel unit types, streams, and sample dates using a fixed-effects, unbalanced 3-factor ANOVA (SAS 1990, SAS Institute Inc., Cary, North Carolina). Initial analyses showed that the uncharacteristically high macroinvertebrate abundance at TC43 and TQ1 and low macroinvertebrate abundance at TC1 confused rather than clarified patterns in abundance. Therefore, we excluded these abundance data from ANOVA models but not from the data sets analyzed with other statistical methods. We did a posteriori comparisons using the Bonferroni method (Day and Quinn 1989). We used the same method to analyze each of the 10 most abundant taxa.

ANOVA output contained both 2-way and 3-way interactions; however, the number of interactions was small and their patterns were erratic. Furthermore, significance levels of interactions were lower than those of main effects. Accordingly, we focused only on main effects of date, stream, and channel unit on abundances.

We explored major sources of variation within the physical and biological systems using principal components analyses (PCA) based on the correlation matrix of the physical and biotic variables, respectively (Statistica 1994, Statsoft, Inc., Tulsa, Oklahoma) (Barkham and Norris 1970). We excluded rare taxa (≤1% of the total data set, see Zumora-Muñoz and Alba-Tercedor 1996). We calculated mean invertebrate abundance by channel unit type and stream to create a composite data set (Angradi 1996), which was then log-transformed ($\log_{10}[x+1]$) to reduce the numerical dominance of the most abundant taxa. We did not transform physical data. We examined relationships among PCs of the biological system and individual physical variables using correlation analysis (Barkham and Norris 1970).

Unequivocal patterns in data collected from channels often are difficult to obtain because of high variability within and among forest streams (Wood-Smith and Buffington 1996, Trainor and Church 2003). Therefore, we set $\alpha = 0.10$ to detect meaningful differences among groups, to ensure that we did not overlook potentially significant results (i.e., to reduce risk of type II error). However, such results must be recognized as exploratory and, therefore, require stronger confirmation. Thus, we also reported a higher level of significance in post hoc comparisons if it occurred.

Results

Bed slopes and current velocities of channel unit types

The streams were all steep (10–54% mean channel gradient) and narrow, from 1.3 to 4.9 m in active channel width (Table 2). Pools were the most common channel unit in these streams and chutes were the least common channel unit. Riffles, rapids and boulder cascades were similar in frequency (16–18.5% of channel units), and bedrock cascades represented ~10% of all channel units (Table 2).

Macroinvertebrate abundance

Interchannel unit variation.—Abundance of the numerically dominant taxa Heptageniidae, Nemouridae, Leptophlebiidae, Enchytraeidae, Chloroperlidae, and Simuliidae (Table 3), and total macroinvertebrate abundance were significantly different among channel unit types ($p \leq 0.01$, Table 4). Chironomidae and Lepidostomatidae also differed ($p \leq 0.10$) among unit types. In contrast, abundance of Baetidae and Tricladida did not significantly differ among unit types (Table 4). Mean total abundance was higher in riffles and rapids than in other unit types (Fig. 3A). All taxa were most abundant either in riffles or rapids, except for Baetidae and Simuliidae, which were most abundant on bedrock and chutes (Tables 5, 6, respectively) where total abundances were low (Fig. 3A). Most taxa except Simuliidae, Baetidae, and Chironomidae were absent from bedrock. In general, pools

TABLE 4. ANOVA results for the effects of date, stream, channel unit type, and interactions on macroinvertebrate abundances in study streams. Individual taxa are listed in descending order of abundance. * = $p \leq 0.10$, ** = $p \leq 0.05$, and *** = $p \leq 0.01$.

Dependent variable	Date (df = 2)	Stream (df = 9)	Channel unit (df = 5)	Stream × Channel unit (df = 25)	Stream × Date (df = 4)	Channel unit × Date (df = 8)	Stream × Channel unit × Date (df = 9)
Heptageniidae	4.19**	4.60***	5.61***	1.90**	1.44	0.39	1.03
Nemouridae	2.53*	4.89***	5.07***	1.28	0.63	0.64	1.95*
Chironomidae	5.45***	1.83*	2.16*	1.36	2.75**	0.61	1.14
Leptophlebiidae	1.61	8.27***	5.28***	1.08	2.02*	0.66	1.66
Enchytraeidae	0.26	5.82***	3.41***	1.79**	1.76	0.40	0.54
Baetidae	5.71***	2.55**	1.90	0.60	1.95	0.53	0.68
Chloroperlidae	5.82***	3.77***	5.35***	1.02	0.84	0.94	1.05
Tricladida	0.11	3.40***	1.07	0.95	1.26	0.69	0.39
Simuliidae	3.38**	2.57**	5.55***	1.10	0.89	1.11	0.75
Lepidostomatidae	1.16	2.44**	2.28*	1.56*	1.75	2.51**	1.22
Total abundance	2.31	1.65	4.86***	1.40	1.51	0.54	0.85

supported an intermediate number of animals, although Baetidae, Simuliidae, and Tricladida were underrepresented in pools (Tables 5, 6). Mean total abundance in boulder cascades exceeded that of both bedrock cascades and chutes (Fig. 3A). However, Bonferroni tests indicated that total abundance was lower in boulder cascades than in any other channel unit type (Tables 5, 6). This discrepancy resulted from the elimination of TQ1 data from ANOVA models.

Interstream variation.—Benthic invertebrate total abundance was not significantly different among streams (Table 4). All taxa were more abundant in perennial streams than in ephemeral or intermittent streams except for Enchytraeidae, which was most abundant in ephemeral streams (Tables 5, 7). Mean total abundance per sample was lower in the 3 ephemeral streams (MTD1, NMT4, and NMT5) than in the perennial or intermittent streams (Fig. 3B, Table 5).

Temporal variation.—Abundance of 5 abundant insect families (Heptageniidae, Chironomidae, Baetidae, Chloroperlidae, Simuliidae) significantly varied among dates ($p \leq 0.05$, Table 4); abundance of Nemouridae also differed among dates when $p \leq 0.10$. Total abundance and abundance of Leptophlebiidae, Lepidostomatidae, and both non-insect groups (Enchytraeidae and Tricladida) did not vary significantly among dates (Table 4).

Macroinvertebrate assemblage structure

Physical system.—Ordination of the 4 environmental variables (streambed slope, current velocity, substrate, shade) using PCA revealed 2 groups: 1) bedrock (chutes and bedrock cascades), and 2) rapids (Fig. 4). The close grouping of chutes and bedrock cascades suggested similar physical conditions within these channel unit types. In contrast, the spread of factor scores for pools, riffles, and boulder cascades throughout the ordination indicated that physical characteristics of these unit types were highly variable. The somewhat open group of factor scores for rapids in ordination space (Fig. 4) indicated that physical conditions within this unit type were more uniform than those within pools, riffles, and boulder cascades, but were less so than those within bedrock cascades and chutes.

Both mean streambed slope and current velocity were positively related to PC_1 ($r = 0.79$ and 0.73, respectively, $p \leq 0.01$), whereas substrate size was negatively related to PC_1 ($r = -0.65$, $p \leq 0.01$; Fig. 4). PC_1 separated channel unit types along a gradient from depositional and alluvial (pools and riffles) to erosional and nonalluvial (cascades). Shade was significantly correlated with PC_2 ($r = 0.96$, $p \leq 0.01$; Fig. 4), but was not associated with any 1 stream or habitat type.

Biological system.—Ordination of the compos-

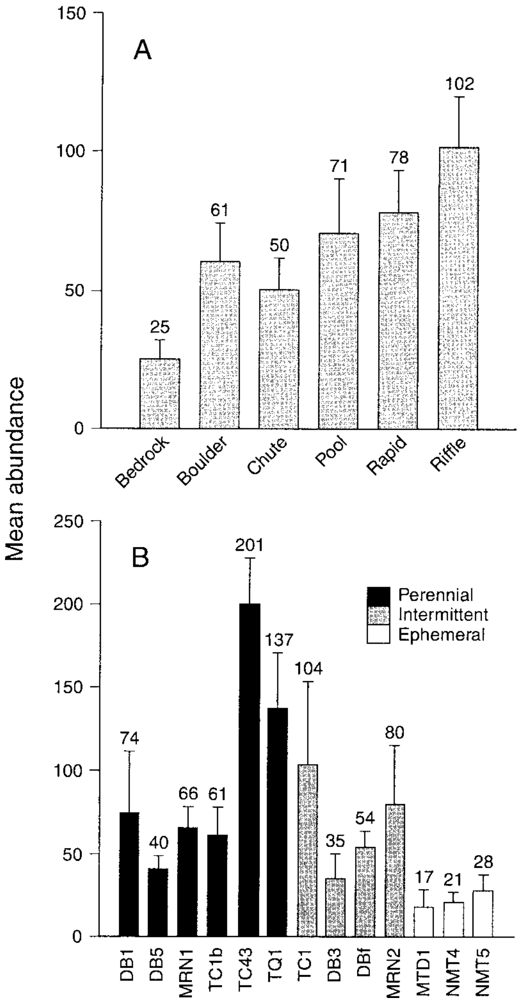

FIG. 3. Mean (+ SE) invertebrate abundance expressed as animals per sample for each habitat type pooled across streams and dates (A), and animals per sample for each study stream pooled across habitat types and dates (B). Sample size noted above bars.

ite macroinvertebrate data using PCA revealed 3 habitat groups: 1) TC43, 2) bedrock cascades and chutes, and 3) ephemeral channels (Fig. 5). To assess which taxa had a strong influence on the ordination, we correlated abundance of each taxon with PC_1 and PC_2, and showed taxa with significant correlations ($p \leq 0.05$) in Fig. 5. The TC43 and ephemeral channel groups were most dissimilar, whereas the bedrock group was neither exclusive to only bedrock cascades and chutes nor close in ordination space, suggesting high within-group variability and some similarities with other channel unit types. Taxa in several sites within intermittent channels grouped within those of ephemeral channels (Fig. 5).

Biotic–physical relationships.—To explain invertebrate distributions displayed in Fig. 5 in relation to the physical system, we correlated the 4 original environmental variables with biological PC_1 and PC_2 scores. Correlations with individual variables showed clear relationships, e.g., bed slope was negatively related to PC_1 ($r = -0.26$, $p < 0.05$), whereas PC_2 corresponded to a gradient in flow velocity ($r = 0.29$, $p < 0.01$) and bed slope ($r = 0.18$, $p < 0.05$). These results suggested that biological PC_1 separated sites along a gradient from steep slopes and high current velocity to the left of the origin, and to lower slopes and current velocities to the right of the origin (Fig. 5). Based on significant correlation ($p \leq 0.01$) with biological PC_1, Chloroperlidae showed the strongest influence on the ordination of macroinvertebrate abundance data (Fig. 5); their abundance was higher in sites with lower bed slopes and lower current velocities. Sites were ordered along biological PC_2 (Fig. 5) according to a gradient in velocity, decreasing from top to bottom of Fig. 5, although this trend was not strongly associated with most channel unit types. Rather, the larger perennial channels with more water, hence higher current velocities, occurred near the top of the ordination biplot, whereas smaller intermittent and ephemeral channels occurred near the bottom of the ordination space (Fig. 5). Based on significant correlation ($p \leq 0.01$) with biological PC_2, Baetidae had the strongest influence on the ordination of macroinvertebrate abundance data (Fig. 5), reflecting an increased abundance of this family in sites with steeper bed slopes and higher current velocities.

Discussion

Interchannel unit variation in assemblages

The goal of our study was to elucidate differences in habitat characteristics among channel unit types in high-gradient streams by examining physical and biological variation among unit types. Total macroinvertebrate abundance was higher in riffles and rapids than in the other 4 channel unit types. Interstitial conditions within coarse gravel, characteristic of riffles and rapids, are ideal for many benthic species (Stan-

TABLE 5. Rank order (Bonferroni post hoc test after ANOVA) of 6 channel unit types and 10 streams (4 perennial, 3 intermittent, and 3 ephermeral) based on mean abundance data. Channel unit types and streams are listed in descending order from left to right. Two perennial streams (TC43 and TQ1) and 1 intermittent stream (TC1) were excluded because of abnormally high and low invertebrate counts, respectively. Definitions for stream abbreviations as in Table 1.

Taxon	Channel unit types	Streams
Heptageniidae	Riffle, Chute, Rapid, Pool Bedrock cascade, Boulder cascade	I3, P2, P4, P1, I2, P3, E3, E2, E1, I1
Nemouridae	Riffle, Chute, Rapid, Boulder cascade, Pool, Bedrock cascade	P3, I2, I3, P2, I1, P4, P1, E3, E2, E1
Chironomidae	Riffle, Rapid, Bedrock cascade, Chute, Pool, Boulder cascade	I2, P4, P3, I3, E3, P1, P2, I1, E1, E2
Leptophlebiidae	Riffle, Pool, Rapid, Boulder cascade, Chute, Bedrock cascade	P3, P4, P2, I2, P1, I3, E3, E2, I1, E1
Enchytraeidae	Rapid, Riffle, Boulder cascade, Chute, Pool, Bedrock cascade	E2, I1, E3, E1, I2, I3, P2, P4, P3, P1
Baetidae	Bedrock cascade, Chute, Riffle, Rapid, Boulder cascade, Pool	I3, I2, P4, P2, P1, P3, E2, E1, E3, I1
Chloroperlidae	Riffle, Pool, Rapid, Chute, Bedrock Cascade, Boulder cascade	P3, P1, P4, I1, P2, I2, I3, E3, E1, E2
Tricladida	Rapid, Riffle, Boulder cascade, Chute, Bedrock cascade, Pool	P3, E3, I3, P1, I2, P4, I1, E2, P2, E1
Simuliidae	Chute, Bedrock cascade, Rapid, Riffle, Boulder cascade, Pool	P4, I2, P2, I3, P1, P3, I1, E1, E3, E2
Lepidostomatidae	Riffle, Pool, Chute, Rapid, Boulder cascade, Bedrock cascade	P1, P4, I3, P3, I2, E3, I1, P2, E1, E2
Total abundance	Riffle, Rapid, Chute, Pool, Bedrock cascade, Boulder cascade	P3, P4, I3, I2, P1, P2, I1, E3, E2, E1

ford and Ward 1983, Minshall 1984), with the greatest proportion of interstitial space (i.e., having dimensions neither too small nor large for activity of most organisms) occurring within coarse gravel (Pennak and Van Gerpen 1947). In our study, total macroinvertebrate abundance was lower in bedrock and boulder cascades, and chutes, than in the other channel unit types, supporting earlier conclusions that intermediate-sized particles support more invertebrates than relatively smaller or larger particles, or bedrock (Pennak and Van Gerpen 1947, Minshall 1984, Brown and Brussock 1991, Bourassa and Morin 1995). Bedrock cascades have virtually no alluvial material on their surfaces because of high transport capacity, so these units provide little protection from current. Bed slope and associated transport capacity of chutes are less severe than cascades, reducing the flushing of alluvium, and thus provide comparatively more refugia and microhabitat diversity. However, contrary to the ANOVA results, PCA did not show distinct differences in assemblage structure among channel unit types, except for bedrock cascades. Within the ANOVA models, macroinvertebrate data were associated with discrete channel units, whereas in PCA macroinvertebrate distributions were associated with substrate, bed slope, and velocity (continual measures). Taken together, our results suggest that these channel unit types are not as distinct in terms of benthic habitat as previously assumed (e.g., Hawkins et al. 1993), at least in the steep-channeled streams we studied.

Low total abundance in boulder cascades may have resulted from less interstitial space between the fewer, larger particles in this unit type, which may not afford free movement of organisms or sufficient retention of organic matter as food. Also, lower stone surface area in boulder cascades compared with units containing smaller, less-compact particles, also may promote low invertebrate abundance (Resh 1979). Exposed surfaces of boulders may appear much like bedrock (Minshall 1984), but water often flows around (vs over) boulders, so boulder surfaces would be uninhabitable to most organisms. It is important to note, however, that

TABLE 6. Multiple pairwise comparisons (Bonferroni post hoc test after ANOVA) among 6 channel unit types based on mean macroinvertebrate abundance. Taxa in the upper right half of the matrix indicate significant differences between channel units when $p \leq 0.05$. Bold text indicates $p \leq 0.01$. Taxa in the lower left half of the matrix indicate significant differences between channel units when $p \leq 0.1$. hep = Heptageniidae, nem = Nemouridae, lepto = Leptophlebiidae, ench = Enchytraeidae, baet = Baetidae, chlo = Chloroperlidae, sim = Simuliidae, – = nonsignificant.

	Bedrock cascade	Boulder cascade	Rapid	Chute	Riffle	Pool
Bedrock cascade		**baet**	nem, **lepto, ench, baet**	–	total, **nem, lepto,** ench, **baet, chlo**	**lepto,** ench, **baet,** sim
Boulder cascade	baet		–	hep, **sim**	**total, hep,** nem, **chlo**	–
Rapid	nem, lepto, ench, baet	total, hep		–	**chlo**	nem, **ench**
Chute	–	hep, sim	ench, sim		**lepto,** chlo, sim	lepto, **sim**
Riffle	total, hep, nem, lepto, ench, baet, chlo	total, hep, nem, chlo	chlo	lepto, chlo, sim		**total**, hep, **nem**, ench, **chlo**
Pool	lepto, ench, baet, sim	–	total, nem, ench, sim	lepto, sim	total, hep, nem, ench, chlo	

TABLE 7. Multiple pairwise comparisons (Bonferroni post hoc test after ANOVA) among 10 streams (4 perennial, 3 intermittent, and 3 ephemeral) based on mean invertebrate abundance data. Two perennial streams (TC43 and TQ1) and 1 intermittent stream (TC1) were excluded because of abnormally high and low invertebrate counts, respectively. Taxa in the upper right half of the matrix indicate significant differences in stream types when $p \leq 0.05$. Bold text indicates $p \leq 0.01$. Taxa in the lower left half of the matrix indicate significant differences in stream types when $p \leq 0.1$. hep = Heptageniidae, nem = Nemouridae, chir = Chironomidae, lepto = Leptophlebiidae, ench = Enchytraeidae, baet = Baetidae, chlo = Chloroperlidae, triclad = Tricladida, sim = Simuliidae, lepid = Lepidostomatidae. – = no significant difference. Definitions for stream abbreviations as in Table 1.

	P1	P2	P3	P4	I1	I2	I3	E1	E2	E3
P1		**lepid**	**nem, lepto,** triclad	sim	**hep, ench**	ench	baet	**total, hep, ench,** chlo, **lepid**	**hep, ench,** chlo, lepid	**hep, ench**
P2	lepid		hep, **lepto,** baet, **triclad**	–	**hep,** ench, **baet**	chir	baet	total, **hep, nem,** baet	**hep, nem, ench**	**hep, ench** baet
P3	nem, lepto, triclad	hep, lepto, baet, triclad		**lepto, sim**	**lepto, ench,** triclad	**lepto,** baet, triclad, sim	**hep, lepto, baet**	**total, nem, lepto, chlo, triclad**	**nem, lepto, ench, chlo,** triclad	nem, **lepto, ench**
P4	sim	–	lepto, triclad, sim		**hep, ench,** sim	–	–	**total, hep, sim**	hep, **ench,** sim	hep, ench, sim
I1	hep, ench, baet	hep, ench, baet	lepto, ench, triclad	hep, ench, sim		hep, **baet**	**hep, ench, baet**	–	–	–
I2	nem, ench	chir	lepto, baet, triclad, sim	–	hep, baet, sim		–	**total, hep, nem, chir, baet,** sim	hep, **nem, chir,** baet	hep, baet
I3	baet	baet	hep, lepto, baet	–	hep, ench, baet	–		**total, hep, nem, baet**	**hep, nem, ench, baet**	**hep, baet**
E1	total, hep, ench, baet, chlo, lepid	total, hep, nem, lepto, baet	total, nem, chir, lepto, ench, chlo, triclad	total, hep, sim	–	total, hep, nem, chir, baet, sim	total, hep, nem, baet		–	–
E2	hep, ench, chlo, lepid	hep, nem, ench, baet	nem, chir, lepto, ench, chlo, triclad	hep, chir, ench, sim	–	hep, nem, chir, baet, sim	hep, nem, ench, baet	–		–
E3	hep, ench	hep, ench, baet	nem, lepto, ench, chlo	hep, ench, sim	–	hep, baet, sim	hep, ench, baet	–	–	

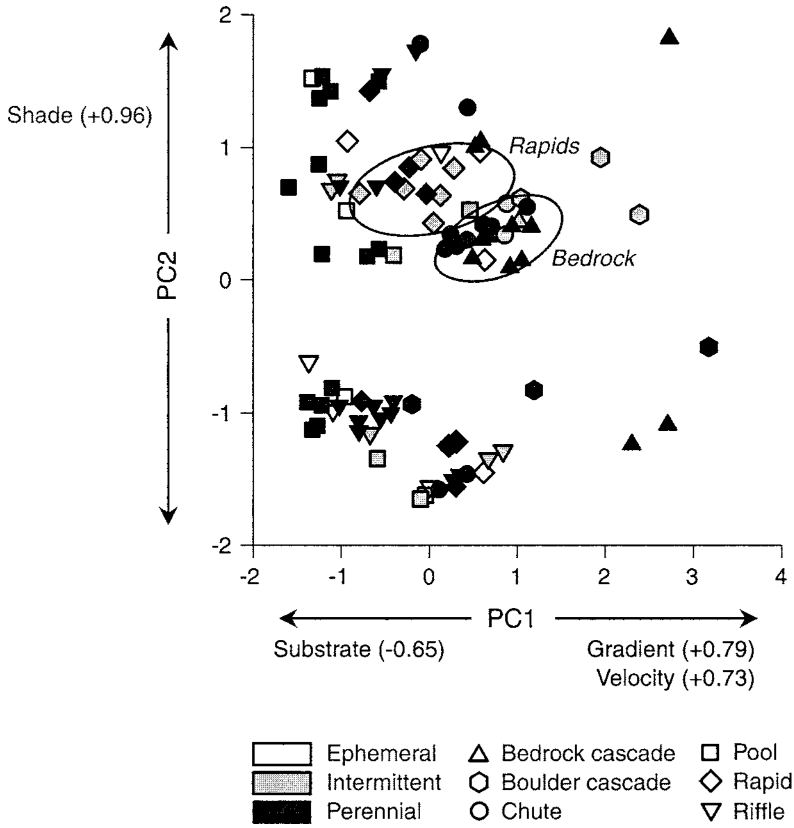

FIG. 4. Principal components analysis (PCA) scatterplot for 95 stream channel units by 4 environmental variables (shade, substrate size, gradient, current velocity). Symbols represent the 6 channel unit types and fills represent the 3 types of streams. Ellipses were placed manually around dense clusters of habitat types. Environmental variables significantly correlated ($p \leq 0.01$) with the first 2 PC are shown outside the plot. PC axes 1 and 2 explained 40 and 25% of the variation in the data matrix, respectively.

tightly packed and largely immovable boulders may have reduced our sampling efficiency, and low total abundance in boulder cascades may be attributable, in part, to sampling error.

Differences in macroinvertebrate abundance between pools and other channel unit types were not apparent in our study. Pools are usually depositional areas with accumulations of fine sediment and detritus, at least during base flow (Keller 1971, Lisle 1979). In steep headwater reaches, however, little deposition occurs in pools, even during periods of low to normal flow. Thus, the pool assemblages and habitats we examined appeared somewhat atypical of those in lower-gradient reaches.

Differences in abundance among channel unit types can be further explained by examining the dominant taxa within unit types individually, and by considering known habitat preferences of associated taxa. We found highly significant differences in individual abundances of Heptageniidae, Nemouridae, Leptophlebiidae, Enchytraeidae, Chloroperlidae, and Simuliidae among channel units. Heptageniid, nemourid, leptophlebiid, and chloroperlid abundances were highest in riffles, habitats with both swift currents and many interstitial spaces. Simuliid larvae were most abundant in fast-flowing, highly stable chutes and bedrock cascades, likely because they have holdfast structures (Minshall and Minshall 1977, Logan and Brooker 1983, Grubaugh et al. 1996, Hauer and Resh 1996). PCA also revealed that assemblages in units with predominantly bedrock substrata were distinguishable from others, probably because of the numerical dominance of Simuliidae and

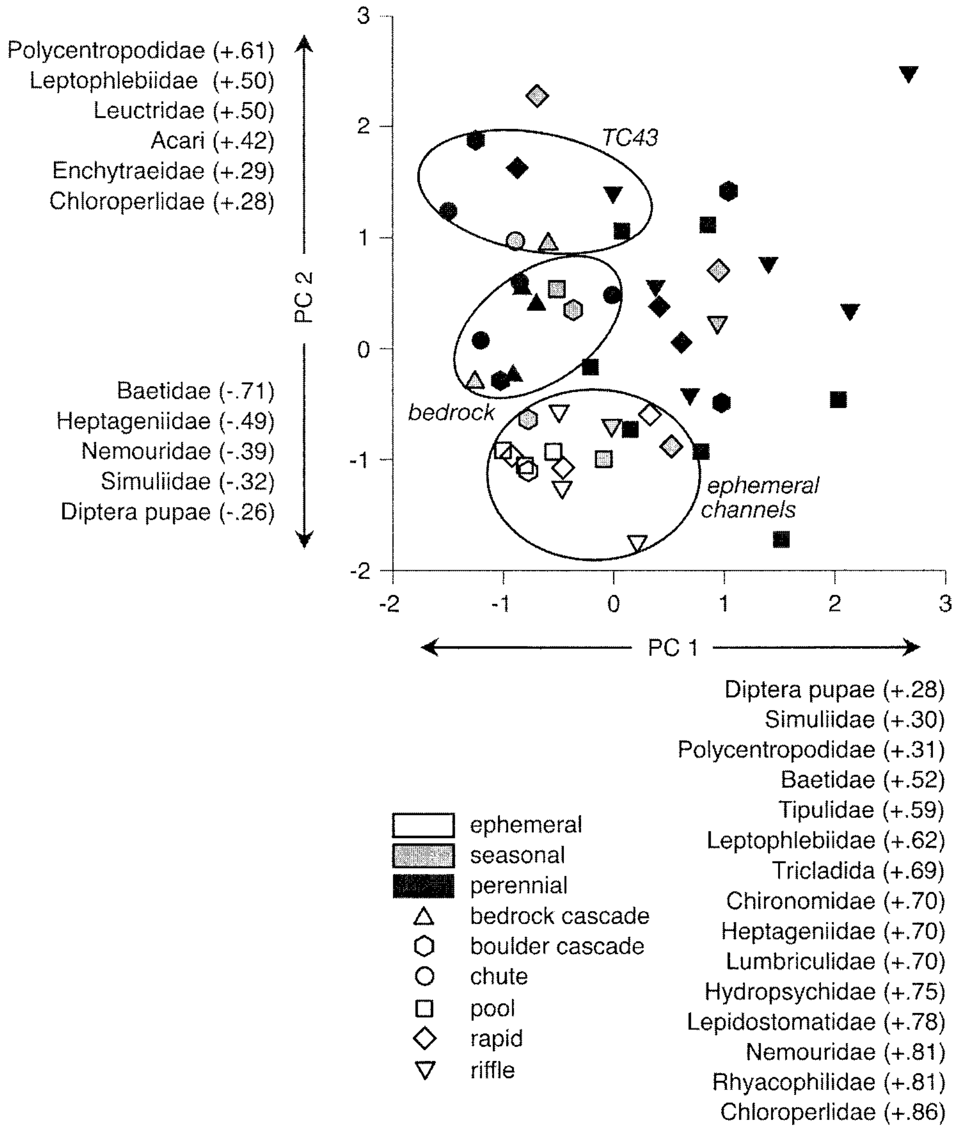

FIG. 5. Principal components analysis (PCA) scatterplot for 52 channel units by 18 taxa (composite data set, invertebrate abundance for each channel unit type in each stream). Symbols represent the 6 channel unit types and fills represent the 3 types of streams. Ellipses were placed manually around groups revealed by PCA. Taxa significantly correlated ($p \leq 0.05$) with the first 2 PC are shown outside the plot. PC axes 1 and 2 explained 39 and 13% of the variation in the data matrix, respectively.

Baetidae. Habitat associations among genera for these 2 groups are typically conservative at the family level (Bowman and Bailey 1997, Bailey et al. 2001), so our coarse level of taxonomic resolution was unlikely to bias family-wide patterns in abundance.

Although significant, differences in chironomid and lepidostomatid abundances among channel unit types were not as strong as the differences shown in the above families, and differences in baetid or triclad abundances among channel units were nonsignificant. Low among-unit differences in chironomid and baetid abundances may have resulted because of the ubiquitous distributions (Hynes 1970, Abell 1984, Clifford 1991) of species in both taxa, showing limited substrate and/or microhabitat preference (Williams 1978, Brown and Brussock 1991). Many Baetidae also are good swimmers found in fast currents (Peckarsky 1996), which in our study could account for higher baetid abundance in bedrock cascades and chutes than in pools. Strong distinctions among habitats, based on family-level identifications, would not be provided by families with broad ecological tolerances (e.g., Bailey et al. 2001).

Interstream variation in assemblages

Considering interstream variation in invertebrate assemblages, the most prominent finding of our study was that all taxonomic groups were more abundant in perennial than ephemeral or intermittent streams, except for Enchytraeidae, which were most abundant in ephemeral streams. Enchytraeids are mainly terrestrial oligochaetes common in semiaquatic habitats (Rosario and Resh 2000). Similar to our study, Rosario and Resh (2000) also reported that intermittent streams had lower total densities than perennial streams. A second notable finding of our study was that community structure of ephemeral, as well as some intermittent, streams was distinctive from perennial streams. Another study conducted in headwater streams on western slopes of the Vancouver Island Mountains found that richness of aquatic insects was similar between perennial and intermittent streams, and lower in ephemeral streams (Price et al. 2003). Williams (1987) claimed that certain taxa dominate the temporary water assemblage; Williams and Hynes (1977) and Wright et al. (1984) suggested that low faunal overlap occurs between temporary and permanent habitats; and Wright et al. (1984) and Williams (1996) reported that temporary waters (i.e., intermittent streams) do not support as diverse an insect fauna as is found in permanent waters (i.e., perennial streams).

However, conclusions of other studies comparing invertebrate communities of temporary and permanent waters disagreed with our findings. For example, Abell (1984), Boulton and Suter (1986), Delucchi (1988), Feminella (1996), and Dieterich and Anderson (2000) suggested that fauna are taxonomically similar between intermittent and perennial streams. However, among other abiotic and biotic factors, variation in site permanence or length of the hydroperiod among studies may have produced unaccountable variation in the data. Feminella (1996) rated magnitude of stream intermittence according to a multipoint scale based on flow- and habitat-related criteria, and found this system useful in describing relationships between water permanence and invertebrate assemblages. In our study, better separation of perennial and intermittent stream faunas may have been possible had we quantified hydroperiod more exactly or had taxa we found been widespread, habitat generalists.

The fauna of intermittent streams probably is influenced by the onset of channel bed drying and length of the dry period, as well as by other environmental factors. For example, aquatic insect populations undergo drastic changes in spatial distribution in response to spates as a result not only of mortality but also of retreat into the hyporheic zone (Resh 1979). We collected many of our autumn samples amidst heavy rain storms (which are characteristic of this environment), so discharge may have strongly influenced abundance estimates (see Resh 1979), and thus concealed potential differences among intermittent and perennial flow regimes. Despite this additional source of variation, intermittent and perennial flow regimes showed some distinctiveness. However, overlap among some of the channel units might be explained by the highly variable flow and the ability of these taxa to move among habitat types as flow conditions change.

Seasonal variation in assemblages

Significant variation in abundance of heptageniids, chironomids, baetids, chloroperlids, and simuliids among dates suggests seasonal responses of these taxa to changes in environmental conditions, such as temperature, photoperiod, discharge, or food abundance. In contrast, low variation in leptophlebiid, lepidostomatid, nemourid, enchytraeid, and triclad abundance among dates suggests that phenology of one taxon in each group is balanced by others. Mackay and Kalff (1969) and Waters (1979) both suggested that representation of some stream insect families occurs throughout the year because of staggered life histories of inclusive species. However, many families in our study were represented in all seasons by only one species or genus. Nonetheless, season was included as a variable in ANOVA models to control for temporal variability across channel units and streams. Further, through our use of the family level (cf. genus or species level), temporal variation was reduced (see Reece et al. 2001). However, it is important to point out that we excluded specimens <1 mm in length and only sampled once in summer, autumn, and spring, so that taxa sampled only as early instars may have been excluded, thus potentially increasing seasonal variation in abundance (Pennak and Van Gerpen 1947).

In conclusion, stream ecologists are beginning to realize that descriptions of physical habitat must be specific enough to be both geomorphologically and ecologically meaningful, yet not so rigorous that classification is impracticable (see Thomson et al. 2001). Easily diagnosed variables such as substrate particle size and bed slope, are systematically associated with the various channel unit types in steep channels on the west coast of Vancouver Island (Halwas 1998, Halwas and Church 2002). In turn, the channel unit types described here provide reasonable stratification of physical habitat variables such as bed slope, current velocity, and substrate character that are useful in classifying benthic invertebrate assemblages. Other studies (e.g., Angradi 1996, Grubaugh et al. 1996) also have shown that these same variables provide an ecologically meaningful description of biological variation in habitat types within small, high-gradient montane channels. Hence, the channel units represent an easily observed surrogate measure of macroinvertebrate habitat in these streams. Discrimination of macroinvertebrate assemblages afforded by channel unit types remains imperfect; however, this limitation should not be too surprising given the intrinsically high environmental variation to which animals must adapt.

Approaches to assessing streams at the habitat scale for management purposes should be consistent with evaluation of channel unit types at a larger scale (Thomson et al. 2001). For example, the reach scale is a more pragmatic level of spatial resolution than channel units upon which to manage with limited resources. Established theory in fluvial geomorphology holds that channel units repeat every 5 to 7 channel widths in relatively large channels with low to moderate gradients (Leopold et al. 1964), and every 3 to 4 channel widths in relatively small, steep channels (Church 1992). Increased awareness of the dynamics within channel units, together with application of theory, may allow more accurate extrapolation from habitat to larger spatial scales.

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Exhibit 5

September 28, 2022

Kyle Olcott
Hydropower Coordinator
Maine Department of Environmental Protection
17 State House Station
Augusta, ME 04333-0017

Transmitted via email

Subject: **NGO Request for Reconsideration of Required Water Quality Studies for the Rumford Falls Project**

Dear Mr. Olcott:

Inland Woods and Trails, the Appalachian Mountain Club, Maine Rivers, the Friends of Richardson Lake, American Whitewater and Maine Council of Trout Unlimited (NGOs) submit this request as a result of information that we became aware of during the study phase of the relicensing phase of the Rumford Falls Project, Federal Energy Regulatory Commission (FERC) project P-2333.

Background

The NGOs provided comments on the Rumford Falls Project Draft License Application and Updated Study Report in their August 31 filing to the FERC docket. These included:

> "The NGOs request additional Water Quality Studies to meet MDEP protocols and the requirements of Maine water quality statutes, and will initiate a request to this effect to MDEP by separate correspondence.
>
> Temperature and DO studies in the area below Upper Dam
>
> Macro-invertebrate studies in the area below Upper Dam, especially the large pools immediately below the dam as well as any other pools
>
> Impoundment Trophic State Study of the canal area below Middle Dam."

This letter further explains our rationale for these comments and refines our request for additional sampling locations.

Discussion

MDEP policy and protocols are stated in Methods for Biological Sampling and Analysis of Maine's Rivers and Streams, Susan P. Davies and Leonidas Tsomides, Revised April, 2014; DEP

Sampling Protocol for Hydropower Studies, September 2019. Page 3 of the latter: "Sampling should also occur in any bypassed segment of the river created by the project."

The DO and macroinvertebrate studies did not include the reach below Upper Dam. The Middle Dam Canal is a construction that is physically separated from the Middle Dam impoundment. Its character is different from that of the Middle Dam impoundment that occurs on the main stem of the river. A separate Impoundment trophic state study should have been conducted.

No studies were conducted in the reach below the Upper Dam even though this reach is actually the main stem of the Androscoggin River, it is described as a "bypass" because it is dewatered most of the year. Minimum flows at 1 cfs – all available water in the river is run through the turbines most of the year. "A Cross-Section Flow Study is required that measures width and depth at various flows to determine the flow at which at least 75% of the bank full cross-sectional area of the river or stream is continuously watered. At least three cross sections representative of the river or stream must be measured."[1] This is obviously not the case for the reach below Upper Dam. While there may be some short stretches of dewatered area that may be considered of inconsequential habitat value, this approach makes little sense with Rumford Falls, the largest waterfall in the U. S. east of Niagara. As the NGOs stated in our earlier filing: "Reference to Google Maps shows the location of two large pools immediately below Upper Dam that persist for most of the summer months.[2] As there is only leakage flow feeding these pools, one must assume that they would entrap fish and other aquatic organisms and that the stagnant water they contain would not sustain their lives."[3] We have included the annotated image in a large scale as Attachment A for your convenience.

The Updated Study Report (USR) for the Rumford Falls Project Brookfield filed dated August 2022 contained the Flow Study for Aquatic Habitat Evaluation and Outlet Aquatic Habitat Study. The transects used for the studies were below Middle Dam.[4] These studies showed conclusively that increased flows above the 21 cfs minimum flows provided additional habitat for both trout and macro-invertebrates. The only real issue there is what flows balance gains in habitat with the power generation lost by watering the main stem of the Androscoggin.

It can be assumed that additional habitat may also be gained in the reach below Upper Dam. The topography is similar - the locations are relatively close. The U. S. Fish and Wildlife Service has provided LIDAR information that we have included as Attachment B. The imagery shows an additional pool in this reach. While the gradient of the entire reach is 12 percent, there are flatter sections in the upper and middle parts of the reach where three large pools are apparent. Velocities in these areas would be lower, but even the 12 percent slope does provide

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[1] DEP Sampling Protocol for Hydropower Studies, September 2019, page 4.

[2] Imagery of the area below Upper Dam accessed at https://www.google.com/maps/place/Rumford,+ME+04276/@44.5381696,-70.5440009,210m/data=!3m1!1e3!4m5!3m4!1s0x4cb17d61fb89f9f9:0xbf89e1a4e6304e23!8m2!3d44.5536606!4d-70.5508829

[3] Inland Woods and Trails, the Appalachian Mountain Club, Maine Rivers, the Friends of Richardson Lake, and Maine Council of Trout Unlimited letter dated August 31, 2022, Subject: NGO Comments on the Draft License Application (DLA) and Updated Study Report (USR) for the Rumford Falls Hydroelectric Project (FERC No. 2333). Page

[4] USR, page B-7, Figure 2.

habitat for most stonefly species, mayflies, and both net-building and free-living caddis. Numerous species have been documented in assemblage studies of high gradient waters.[5] Consideration should also be given to indigenous aquatic vertebrates: American eels and brook trout. The historic range of American eels in statewide and American eels have been documented in the watershed by Maine DIFW in East Richardson Pond far upstream from the project.[6] Closer to the project: "Joes Pond does indeed flow into the Androscoggin River a short distance above Rumford Falls. And, during a resurvey of the pond in 2001, an eel ring was observed in the gillnet set to evaluate the status of the pond's fish populations. Eel rings are usually all we have to go by to determine their presence in a lentic water as they are almost always able to slip through the net's mesh, leaving behind a telltale slim ring."[7] More water through the dewatered reach would improve American eels' chances of making it upstream beyond Upper Dam. While the high gradient area is likely not passable by salmonids, brook trout and other indigenous species are undoubtedly washed downstream over the Upper Dam during periods of high flows and entrapped in the pools that, with no required effective minimum flow, are bound to become stagnant. Appropriate minimum flows over the dam would correct this condition. This reach has habitat value.

Conclusion and Requests

That MDEP staff revisit and reconsider the water quality study decisions made by its predecessors some years ago that failed to adequately consider the complexity of the project. Attachments C,[8] D,[9] and E[10] are supplied to show the deployment for water quality studies. Please note that the macroinvertebrate sampling station shown in Attachment E is apparently co-located with the Middle Dam bypass reach continuous water temperature and DO monitoring station. Please note that the project has two "bypass" reaches (actually the main stem of the Androscoggin River) and that only one was sampled. Please also note that the terminus of the industrial canal functions as a third dam.

That based on that reconsideration, MDEP submit study requests to FERC to expand the sampling locations as stated below by the October 6 due date, or support the requests that the NGOs submit. Attachment F is supplied to indicate nominal locations for sensor deployment for additional studies needed for conformance with established MDEP protocols. Locations shown are nominal, and would be subject to consultation with MDEP.

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[5] Benthic assemblage variation among channel units in high-gradient streams on Vancouver Island, British Columbia, Karen L. Halwas, Michael Church, and John S. Richardson, Journal of the North American Benthological Society, Volume 24, Number 3.

[6] Fish Collections Summary Report, Region D, Water name: l. East Richardson Pond, Date last sampled 7/2/79; Fish Collections Summary Report, Region D, Water name: l. East Richardson Pond, Date sampled 7/2-/10.

[7] Email from David Howatt, MDIFW to Casey Clark, MDEP dated April 1, 2020, RE: Eels at Rumford Falls.

[8] Rumford Falls Initial Study Report, page A-3, Figure 1.

[9] Id., page A-3, Figure 2.

[10] Id., page A-3, Figure 3.

Temperature and DO studies in the area below Upper Dam, especially the large pools immediately below the dam as well as any other pools, and below the discharge of the Lower Station Development.

Macro-invertebrate studies in the area below Upper Dam, especially the large pools immediately below the dam as well as any other pools, and below the discharge of the Lower Station Development.

Impoundment Trophic State Study of the industrial canal.

It was also noted when preparing this letter that the location of the Middle Dam Canal DO Sampling Station does not conform to MDEP protocols and thus should repeated and conducted in accordance with the established standards.[11] The sampling location was apparently chosen for ease of access.

Sincerely and respectfully,

Inland Woods and Trails
Karen Wilson
At-Large Member of Board of Directors

Appalachian Mountain Club
Mark Zakutansky
Director of Conservation Policy Engagement

Maine Council of Trout Unlimited
Stephen G. Heinz
Maine TU Council FERC Coordinator

American Whitewater
Robert Nasdor
Northeast Stewardship & Legal Director

Friends of Richardson Lake
John Preble
Treasurer

Maine Rivers
Charles Owen Verrill, Jr., Esq.
President, Board of Directors

ATTACHMENTS:

A – Google Map imagery of the area below Upper Dam

B – LIDAR Study of Upper Rumford Falls Project

C – Map of Tropic State Sampling Stations

D – Map of Continuous Water Temperature and DO Monitoring Stations

E – Map of Location of Macroinvertebrate Sampling Station

F – Map of nominal proposed additional water quality study sites

[11] DEP Sampling Protocol for Hydropower Studies dates December 2017, page 3: “Sampling shall occur in the tailwater downstream from the turbine/gate outlet or dam at a location representative of downstream flow as agreed by DEP on a case by case basis.”

ATTACHMENT A

ATTACHMENT B

high gradient area

additional pool

lower gradient areas

ATTACHMENT C

ATTACHMENT D

ATTACHMENT E

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ATTACHMENT F

Additional sampling sites requested by NGOs, locations nominal