March 25, 2024

Ms. Debbie-Anne A. Reese
Acting Secretary Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Via online submission to: http://www/ferc.gov

Subject: **NGO Comments on the Draft Environmental Assessment for the Rumford Falls Project (P-2333-094)**

Dear Acting Secretary Reese:

American Whitewater, Maine Rivers, the Friends of Richardson Lake, Conservation Law Foundation, Appalachian Mountain Club, and Maine Council of Trout Unlimited (collectively "signatories" or "NGOs") submit these comments on the Draft Environmental Assessment ("DEA") for the Rumford Falls Project (P-2333-094, the "Project")) dated February 22, 2024. As set forth in the following comments and proposed corrective actions, the NGOs believe the DEA does not meet certain requirements of the Federal Power Act and its implementing regulations and must be revised accordingly. The changes to Project operations proposed in Brookfield's Final License Application[1] are inadequate and allow the Project to remain unduly dedicated to the production of electricity at the expense of other uses.

Background

With a nameplate capacity of 44.5 megawatts, the Rumford Falls Project represents the third largest electrical generation capacity of any single hydroelectric generation facility in Maine. The hydroelectricity generated by the Project facilities was once key to the profitable operation of a co-located paper mill. The situation has changed markedly over the years with hydro operations no longer tied to mill operations. The mill is now owned by ND Paper, the electricity produced by the Rumford Falls Project is now sold on the grid into wholesale electricity markets. Brookfield has also added a battery storage facility to the Project in part to maximize the economic return on the electricity the Project produces. The Project is located on the site of Maine's largest waterfall – the largest falls in the United States east of Niagara Falls. The Project includes Upper Dam and Middle Dam – currently authorized minimum flows of 1 cfs and 21 cfs respectively – that effectively dewater the falls below the dams for most of the summer months under most flow conditions.

NGO signatories to this filing have timely intervened in the Rumford Falls Relicensing as noted by the DEA. The Maine Counsel of Trout Unlimited ("TU") and American Whitewater ("AW")

[1] Rumford Falls Hydroelectric Project (FERC No. 2333-091) Final License Application dated September 29, 2022.

included substantive protests with their motions to intervene. AW's filing included that additional mitigation measures were needed including: " 1) Increase minimum flows in the Project bypassed reach to support aquatic, recreational, and aesthetic values; 2) Improve access around Project facilities and provide access to the river both above and below whitewater boating features; 3) Provide weekly scheduled whitewater boating flows in the bypassed reach during the recreational boating season whenever sufficient inflows are present; 4) Provide aesthetic flows over the Upper Falls and Middle Dam; and, 5) Provide real-time and advance flow notifications of flows into the Project bypassed reach.[2] Similarly, TU's Motion to Intervene and Protest (incorporated herein by this reference) also included both substantive comments and proposed corrective actions which were expressly supported by AW and Conservation Law Foundation ("CLF"). As the DEA appears to have ignored or dismissed the many of the issues raised and proposed corrective actions, these comments are providing additional information and justification for material changes that need to be made to the DEA.

General Comments

The DEA allows what was once the largest waterfall in the United States east of Niagara to continue to remain dewatered the majority of the time during most summers. As part of this relicensing process, the Commission must determine whether issuing a new license is in the public interest, provided that "equal consideration" be given to power development and non-power uses and public resources of the river, such as fish and wildlife habitat, recreation, and aesthetics.[3] Under most conditions, the upper portion and most scenic portion of the falls are nearly dry with all available flow being directed into penstock and hydro turbines. While some additional water will be required to be released during the summer to provide minimal improvement to the fishery below Middle Falls, the flows provided are a small portion of widely accepted guidelines for minimum flows at hydro operations in the Northeast, as well as a small portion of the total flows. As set forth more fully below, the DEA does not give equal, or even any material consideration to these non-power uses and public resources.

The DEA ignores or minimizes the justification for increased minimum flows provided by both MDIFW and the NGOs. As stated in the DEA itself: "Sections 4(e) and 10(a)(1) of the FPA require the Commission to give equal consideration to the power development purposes and to the purposes of energy conservation; the protection, mitigation of damage to, and enhancement of fish and wildlife; the protection of recreational opportunities; and the preservation of other aspects of environmental quality. Any license issued shall be such as in the Commission's judgment will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for all beneficial public uses."[4] As set forth below, increased minimum flows are necessary and vital to comply with the FPA's non-power requirements here, and the cursory reasoning provided by the Applicant is insufficient with the guidance it has itself cited.

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[2] American Whitewater Motion to Intervene dated August 22, 2023, page 3.
[3] 16 U.S.C. § 797(e).
[4] Rumford Falls Draft Environmental Assessment, page 51.

Directing all flow through the turbines under most of the year and as a result dewatering the upper part of the largest waterfalls east of Niagara in the United States cannot be reasonably construed as giving "equal consideration" to any purpose other than power generation. Neither can the minimal amounts of flow required for the Middle Falls during only part of the year. The DEA's flow regime for the Project is problematic. By maximizing flows diverted through the turbines for power generation, it fails to materially address non-power uses and public resources in multiple ways. As demonstrated below, it is particularly inadequate with respect to maintaining adequate fish and aquatic species habitat and is also recreationally and aesthetically insufficient.

Specific Comments

The NGOs support the bases for protest raised by the Maine Council of Trout Unlimited (TU) as described below. The arguments articulated by FERC Staff in the DEA fail to address the photographic evidence and LIDAR data. They are largely unsupported either because adequate studies were not conducted or clear factual evidence was ignored.

1. **Current and Proposed Project Operations Dewater Rumford Falls with Serious Fisheries and Environmental Consequences.**

TU's Motion to Intervene: "The Upper Reach 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."[5]

Staff Comments: Staff documents many factors seemingly in agreement with this statement and then reverses itself concluding: "However, habitat conditions within the bypassed reach are poor for fish and most aquatic invertebrates at any flow. Increasing minimum flows would not significantly improve habitat conditions for fish because of the high gradient, rapid velocities, turbulence, shallow depths, and limited refuge areas within the bedrock substrate (Figure 6). The only fish that are expected to inhabit the pools within the bypassed reach would be those passing over the dam during spill events… there is no information on the record to suggest that stranding of fish in the pools is common, affecting resident fish species, or affecting downstream eel migration." [6] Staff also had noted: "There is no field data to describe the aquatic habitat in the upper bypassed reach because the reach is too dangerous to allow in situ sampling."[7]

NGO Response: Technical means exist to sample the reach in situ, so the real issue why such sampling was not performed appears to be cost. In the absence of in situ data, the best data available is imagery which can include digital photography and LIDAR. TU provided LIDAR data of the reach below the Upper Falls showing the isolated pools and gradients appropriate for

[5] Maine TU Council Motion to Intervene dated August 4, 2023, page 7.

[6] DEA, page 19.

[7] DEA, page 17.

aquatic organisms. Photographs supplied the data showing that the roughness of the substrates needed to provide aquatic refuge and support aquatic communities.[8] Photo 1 taken from the report shows the roughness present below Upper Dam.

Photo 1 – Upper Rumford Falls taken from the east bank just above the height of the dam. Note the low gradient and rough substrates present. Source: Rumford Falls Trail photo accessed at https://www.mainetrailfinder.com/trails/trail/rumford-falls-trail

The report has since been updated with additional photographs showing low gradients and rough substrates. It is included as Attachment A.

There is no factual basis upon which to describe the habitat as "poor for fish at any flow". The use of the word "poor" in this context is both unscientific and inappropriate. To be sure, if you remove the water from a river system as the Project does most of the year, it is self evident that aquatic habitat is poor to nonexistent – that is the point of having adequate minimum flows. All of Maine's major river systems contain high gradient reaches which can, when they have water in them, support fish and aquatic species and their habitats. Aquatic organisms have evolved to utilize high gradient habits. While having habitat value in their own right, they also add to the drift and contribute to ecosystems downstream. Most of Maine's high gradient riverine systems are now the sites of dams constructed to take advantage of the additional hydraulic head the high gradient provides. Few of these hydroelectric projects have modified the environment as dramatically and ruthlessly as has been done at the Upper Falls by directing all flow through turbines except for leakage. There is no data offered in the DEA to support the statement that such habitat is "poor" when there are sufficient minimum flows. The data NGOs have provided and are supplementing with these comments prove the opposite to be true.

Further, FERC Staff's statement that "the pools are located upstream from the Middle Falls and are unreachable except by those organisms flowing over Upper Dam during periods of higher

[8] TU Motion to Intervene, Evaluation of Aquatic Habitat Potential for the Main Channel of the Androscoggin River Below Rumford Falls Upper Dam.

flows" acknowledges that there would be organisms present, organisms that could be part of community if this river segment were allowed to function as a river, one that did not have all its water diverted to the powerhouses the majority of the time. Staff also states: "Some benthic high-gradient invertebrate specialists could colonize the cascade under higher minimum flows."[9] This supports the notion that the river segment can support aquatic life. Staff states that there is no record of strandings. While there may be no record (perhaps because Applicant has ignored them or simply not looked) a more reasonable assumption, given the presence of the stagnant pools during low to nonexistent flows, and the fact that they are watered during high flow conditions, dewatered during lower flows especially when flashboards have not been installed, is that strandings have and are occurring but are not being recorded when there is a dramatic flow change. The licensee did not conduct stranding studies. Simply put – if you do not look you will not record. Figure 1 illustrates flow changes over the course of a typical year graphically. Given the photography and LIDAR imagery submitted, the burden should be on Brookfield to show that the reach would not cause strandings or provide aquatic habitat if continuously watered.

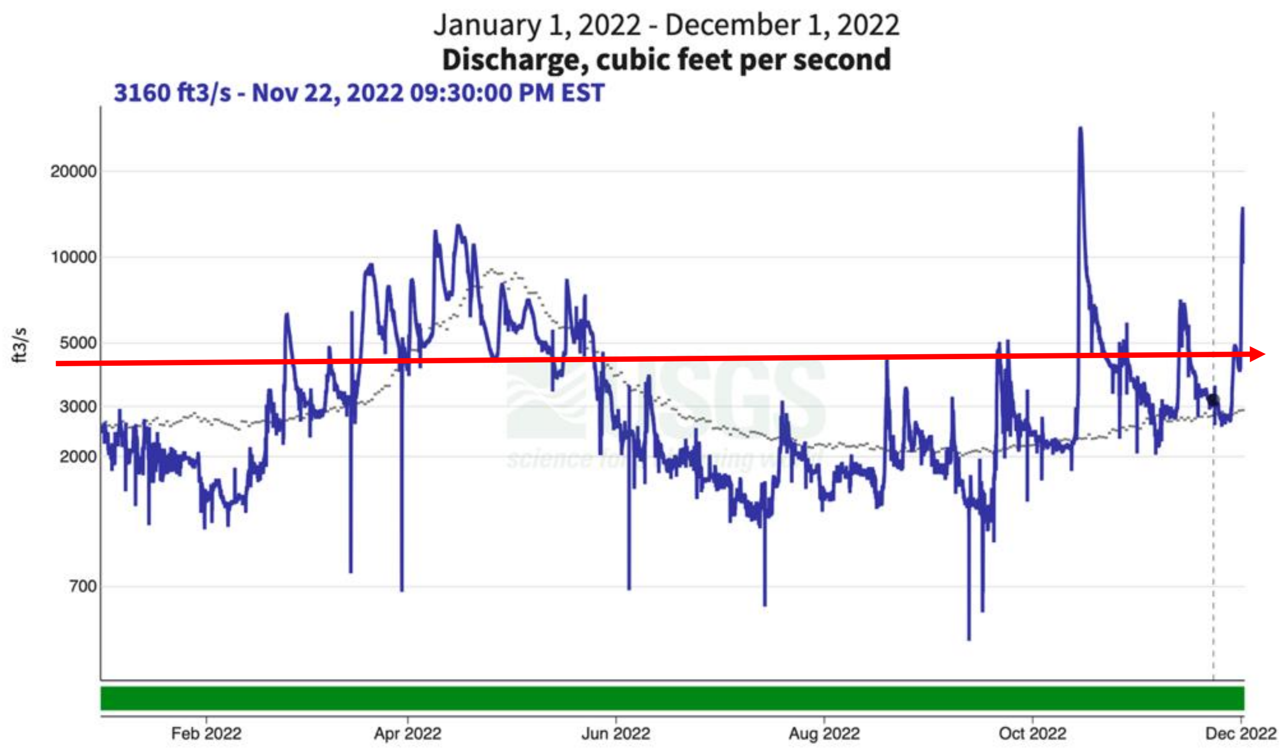

Figure 1 – Flow data from below Middle Dam, Source: USGS accessed at https://waterdata.usgs.gov/monitoring-location/01054500/#parameterCode=00065 period=P7D&showMedian=false. The solid blue line shows flow, the gray line shows median flow, the red line depicts maximum hydraulic capacity of Upper Dam Development, 4550 cfs. Unless generating below capacity, when flows are below the red line, all water except leakage goes through the turbines at Upper Dam.

[9] Ibid.

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

TU's Motion to Intervene: "The EIS issued for those dams recommended minimum flows of 200 cfs to 400 cfs. 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. 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 a project with sufficient minimum flows." [10]

Staff Comments: FERC Staff did not address this point in the DEA. Instead, it proposes to accept what Brookfield offers, improved "Middle Dam bypassed reach of 95 cfs from May 1st to October 31st and 54 cfs from November 1 to April 30"[11]

NGO Response: The **Failure to require reasonable minimum flows at Rumford Falls, shows an inconsistency in the Commission's application of its own standards and practices within the watershed.** The proposed flows remain strikingly lower than those specified by the EIS conducted at the next hydro operations upstream.[12] While the flows proposed by the NGOs and MDIFW are higher than the Upper Androscoggin Basin Projects, they are proportional to base flows. To provide better context for Commission Staff, base flows are computed from widely accepted guidance issued by the USFWS for waters in the Northeast, provided as Attachment B.[13] While this policy is generic for the region, the MDIFW and NGO flow requests are well below those recommended, emphasizing that the flows requested are more than reasonable. The policy prescribes drainage area above the dam in square miles as the default value for August flows in cubic feet per second (cfs). The drainage area for Rumford Falls using the USGS

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[10] Maine TU Council Motion to Intervene dated August 4, 2023, page 7.

[11] DEA, page 20.

[12] 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.

[13] Questions and Answers on Northeast Flow Policy, Vernon long, U. S. Fish and Wildlife Service, Concord, New Hampshire, May 11, 1999.

gauge below Middle Dam as the point of reference is 2068 SQMI. This is the reason that MDIFW states that the flows they propose are only 13-25% of base flows. To compute New Hampshire base flows for comparison, we selected a point on the Androscoggin below Gorham, New Hampshire: Latitude: 44.39160, Longitude: -71.15587. USGS StreamStats[14] indicates a drainage area of 1459.59 SQMI. Thus, base flows at Rumford are computed to be 1.4 times as large as those that are in New Hampshire that the EIS addresses. The resultant values corresponding to 200 cfs and 400 cfs flows in New Hampshire are 283.4 cfs and 566.7 cfs, therefore the proposed 250 cfs to 500 cfs flows are proportional consistent with applicable guidance. The MDIFW proposed flows are well supported and should be applied to the reach below Upper Dam as well. 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 production. Again, we believe additional flow evaluations might help to discover the best, most-balanced value."[15]

The NGOs also note that the Upper Dam is the only large dam where power is produced in Maine where minimum flows are 1 cfs: leakage flows of any amount. Dewatering of main stem river segments is rare in Maine and contrary to applicable State law, which requires that 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."[16] Dewatered riverine reaches are only suited to hydropower generation and there is no data to support the assumption, inherent in the DEA, that 1cfs flows or the minimum flows proposed in the DEA support any of the other state designated uses or FPA non-power uses and public resources.

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

TU's Motion to Intervene: "Additional water quality studies for this riverine reach were requested and not performed. In the absence of requested additional water quality studies, Exhibit 1 [Attachment A in this document] is an Assessment 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 need to be considered here. Maine TU objects to this attempt to "gaslight"

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[14] Accessed at https://streamstats.usgs.gov/ss/.

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

[16] MSRA 38 §465 ¶4A.

the negative fisheries and aquatic impacts the Project has and is proposing to have on this riverine reach."[17]

Staff Comments (a): "Under RFH's [Brookfield's] proposed 1 cfs continuous minimum flow, there would be no change to available aquatic habitat and water quality conditions in the Upper Dam bypassed reach. Flows in the bypassed reach exceed 1 cfs because flows typically exceed the maximum hydraulic capacity (4,550 cfs) of the Upper Development on average 27.8% of the year, from a high of 78.9% during the month of April to a low of 3.9% in September (Table 6). However, flows can drop to 1 cfs almost any time of the year except March, April, and May.

Increasing the minimum flow from 1 cfs year-round to 250 or 500 cfs would increase the wetted area within the bypassed reach, provide a more consistent and higher flow to the pools, may improve water temperatures and DO levels within the pools, and increase habitat connectivity between the pools and downstream habitats. *Some benthic high-gradient invertebrate specialists could colonize the cascade under higher minimum flows."* [18] (italics supplied for emphasis).

NGO Response: The first portion of Staff's statement strongly supports TU's contention. Not only is the reach dewatered nearly 75% of the year, water levels can rise and fall dramatically[19] stranding aquatic organisms in the pools that form in most months. We have italicized the second part of Staff's statement for emphasis because it is misleading at best. Much more than benthic high-gradient invertebrates would colonize the habitat. Fisheries habitat suitability is largely a function of substrate roughness and gradient. The Evaluation of Aquatic Habitat Potential included with TU's Motion to Intervene described three reasons to demonstrate that aquatic habitat does exist in the reach below upper falls. 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 includes 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. An updated version of the report is included as Attachment A.[20]

Besides the updated report, we submit the following graphics of the Upper Falls and associated depths. Please also note that Staff comments understate the length of the path water travels over this reach.

[17] Maine TU Council Motion to Intervene dated August 4, 2023, page 7.

[18] DEA, pages 18 and 19.

[19] See Figure 2 on page 4.

[20] 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.

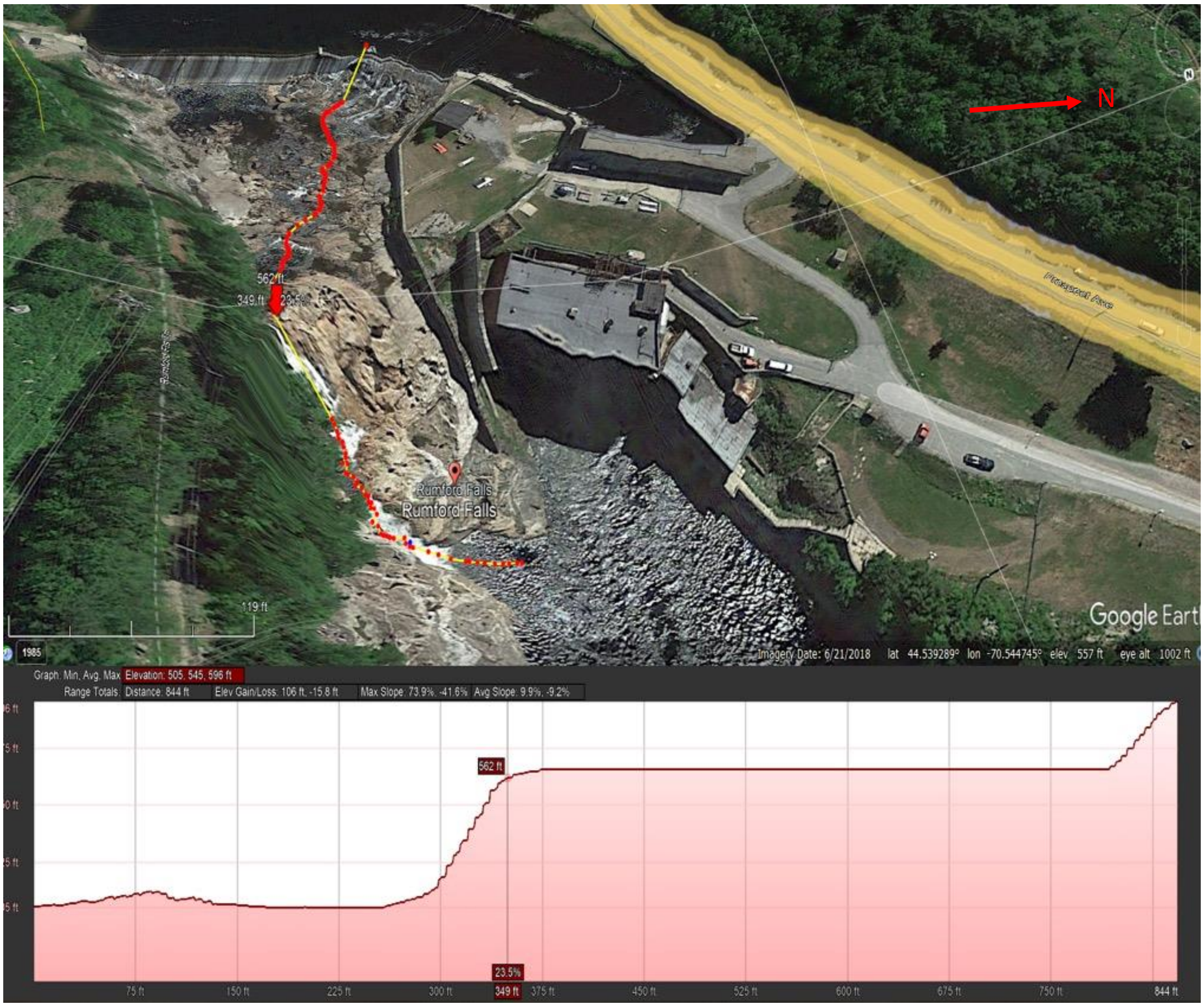

Figure 2. Looking at Rumford Falls upper Dam from the east (looking west). The path starts at the top of the dam and goes to the confluence with the power house outlet. While the overall slope is over 9%, there are long sections that are well within the range of stream gradients used by trout, smallmouth and other riverine fish species.

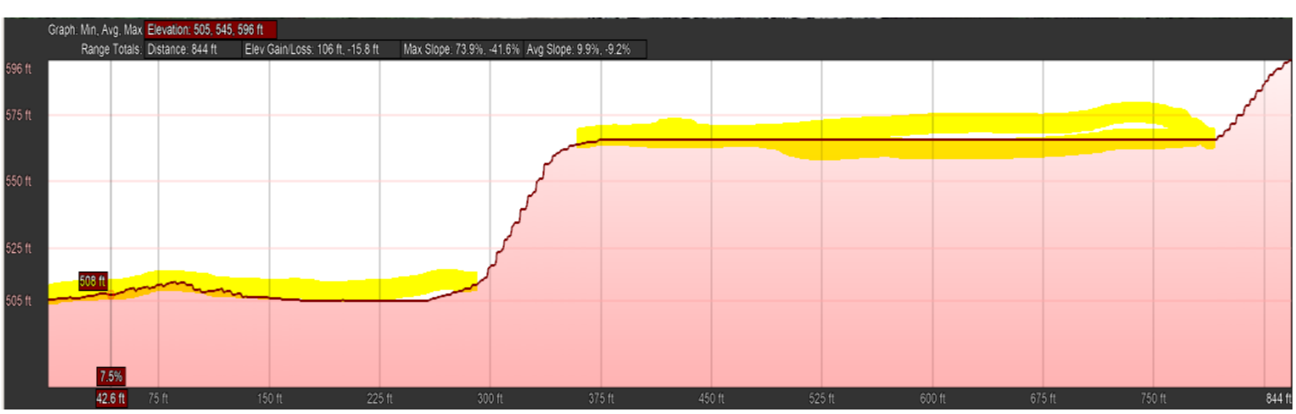

Figure 3 – Highlighted elevation profile of the upper Rumford Falls bypass reach.

While Staff supports the RFH (Brookfield) claim in its DEA that upper reach is not supportive of fish based on the >9% average slope, that is a gross generalization and misrepresentation of the situation. The highlighted stream lengths represent stream sections usable by aquatic species. Of the 844 ft in this bypassed reach, approximately 675 ft of the bypass reach should be capable of being fully supportive of aquatic life and used by riverine fish species. It is immaterial that the source of these fish will be from upstream, not downstream.

Trout would be expected to be actively using stream areas with gradients of 0-4% (Isaak and Hubert, 2011 – included as Attachment C)[21] and occurring in sections with gradients as high as 7-8%. As previously noted in the Evaluation of Habitat Potential, brook trout populations in stream sections with gradients as high as 14%.[22] Bass would prefer lower gradients, but regularly occupy river sections with gradients over 1%. Staff notes that some benthic high-gradient invertebrate specialists may be present. This is correct, another group of species that may not have been considered during EA review are rare freshwater sponges that specialize in occupying steep gradient stream and river areas under waterfalls. Higher gradients are preferred by both stoneflies, Plecoptera, including Giant Stoneflies and Golden Stoneflies, and by caddis flies such as Rhyacophilidae, Green Rock Worms. The habitat below Upper Dam is so rough that eddies and micro-habitat would be present along with a broader diversity of aquatic macro-invertebrates than just these. The macro-invertebrate sampling conducted as part of the Rumford Falls Water Quality Studies showed some Plecoptera with net-spinning caddis, Hydropsyche, and mayflies Hydropsyche predominating as would be expected in the lower flow reaches sampled.[23] A variety of watered gradients and substrates supports a wide variety of macro-invertebrates in a riverine ecosystem.

High flows support aquatic vegetation flora such as Podostemum ceratophyllum that grows on hard bottoms in swiftly flowing rivers and streams. These "plants grow fast and vigorously and provide habitat for many aquatic insects and their larvae, as well as Cnidaria, Turbellaria, Mollusca, Annelida, Hydrachnidia, Cladocera and Copepoda. Small fish feed on the invertebrates and freshwater snails graze on the foliage."[24] Multiple species of the aquatic moss Fontinalis are known to occur in Maine and they are adaptable to a variety of gradients. The mosses in the photos in the West Branch Habit Report[25] in what is normally Class V whitewater are Fontinalis and can be expected to occur in the similar high-energy habitat below the Upper Falls, and to support appropriate macro-invertebrate communities.

"Macroalgae such as Lemanea spp (especially L. fluviatilis), Hydrurus foetidus, and Toumeya spp thrive on rocky ledge (and with aquatic moss as per the above) favor strong currents where they can provide 100% bottom cover. If there is strong plant development, this leads to diverse and abundant invertebrate diversity. Even vertical cascades support large plant and animal

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[21] Isaak, Daniel, and Wayne A. Hubert. 2011. Are Trout Populations Affected by Reach-Scale Stream Slope. Canadian Journal of Fisheries and Aquatic Sciences 57(2):468-477.

[22] 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.

[23] Rumford Falls Initial Study Report dated August 2021, Appendix A, Water Quality Study Report.

[24] Naturalist listing on Threadfoot accessed at https://www.inaturalist.org/taxa/167115-Podostemumceratophyllum. Additional information on Threadfoot can be accessed at https://www.mass.gov/doc/podostemumceratophyllum/download.

[25] TU Motion to Intervene, Evaluation of Aquatic Habitat Potential for the Main Channel of the Androscoggin River Below Rumford Falls Upper Dam.

communities in the splash zone. Even if the stream bottom appears bare, if it is wet then there is a biofilm of microalgae, bacteria and fungi, and detritus that supports a microscopic community. If one is able to think in larger terms than sports fisheries, then one has to include white water and cascades as important contributors to the biodiversity of rivers."[26]

Staff Comments (b): "Maine TU states that the cribworks on the West Branch of the Penobscot River downstream of Ripogenus Dam is a stream reach with similar habitat characteristics to that of the upper bypassed reach at Rumford Falls. Maine TU reasons that since a recent study showed that the West Branch of the Penobscot supported varied and numerous aquatic species, the upper bypassed reach at Rumford Falls should as well with sufficient flow. However, our review of the available information indicates that the West Branch of the Penobscot is not comparable to the Upper Dam bypassed reach because of the difference in stream gradient. The Penobscot reach has an average gradient of 3.6%, much lower than the Upper Dam bypassed reach which averages about 9% near the dam with much steeper sections present in the falls (over 50%). The steeper, high-energy habitat within the Upper Dam bypassed reach limits its utility to aquatic fauna (see elevation profiles in Figures 7 and 8)."[27]

NGO response: The Staff Assessment is incorrect. The two reaches are analogous. Water in that reach of the West Branch is coming from Ripogenus Falls, like Upper Rumford Falls, they too are straddled by a dam below which water travels through a water tunnel so swiftly that a surge tank is required, and exits McKay Station with great force. Under high flow conditions, additional water is released precipitously, normally through the deep gates, at extreme velocities. The areas shown on the West Branch below the Cribworks are Class 5 whitewater.

Both reaches are high-energy habitat and the photos show that the reach below Upper Dam contains rougher substrates. That these are high-energy habitat is not the issue. It is well established that high energy habitat is preferred by both stoneflies, family Perlidae that includes Giant Stoneflies and Golden stoneflies, and by caddis flies such as family Rhyacophilidae, Green Rock Worms - all of which were sampled in the West Branch Stranding Study. One has only to be at McKay Station in mid to late June and look upon the ubiquitous fencing to observe numerous adult Giant Stoneflies despite the high energy habitat in Ripogenus Gorge from which they came. Caddis flies are abundant as well. This is consistent with the works cited: Isaak et al. and Halwas, et al. as previously stated, functional river systems contain a variety of gradients and substrates that support a variety of aquatic species. This adds to biodiversity, a key ecosystem component.

With the exception of noting that mobile aquatic organisms can access the Lower Falls from downstream, the DEA does not dispute that the habitat is similar. Trout are an environmentally sensitive species frequently used in 'canary in the coal mine' comparisons. The DEA does support maintenance of the trout in the reach below the Lower Falls. The DEA ignores effects on habitat while concentrating on recreational aspects of the Project such as the recreational fishery provided below Lower Falls. It treats an environmental assessment as if it were a recreational assessment. **The DEA acknowledges multiple points showing that the reach**

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[26] Statement of Mark Whiting, Ph.D. made March 18, 2024. Statement is based on multiple sources.

[27] DEA, page 19.

below Upper Falls supports aquatic life, but concludes this is unimportant. This conclusion is unsupported by the data, and therefore arbitrary and capricious.

4. There is a high likelihood the reach below Upper Dam will not meet State water quality standards and that minimum flow requirements will need to be modified.

TU's Motion to Intervene: "By law, Brookfield will need to obtain a state of Maine Water Quality Certification in order to have a new FERC license issued. The terms and conditions of that WQC, unless the state of Maine waives its authority to do so, will in turn be incorporated into the new FERC license. There is a high likelihood that the dewatered reaches below Upper Dam as proposed will not meet Maine numeric or narrative water quality standards when there is little to no 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 standards. This issue will ultimately be a matter for the state of Maine to determine but is noted here because the flow regime of the dams in question are both an operational and environmental issue and FERC and Brookfield will need to consider and accommodate minimum flow impacts to state water quality standards. Maine TU preserves its objection for the record here to the minimum flows proposed by Brookfield as potentially in derogation of state water quality standards and further asserts that FERC must require studies and testing early in the process to avoid conflicts with the Maine Water Quality Certification process." [28]

Staff Comments: Staff comments continue to deny requests for additional water quality studies. Staff comments did not directly address the points raised in the expert testimony provided in the Motion to Intervene.[29] The DEA states: "Given the limited aquatic habitat, the benefits of providing a minimum flow of 250 or 500 cfs in the Upper Dam bypass reach are not worth cost."[30]

NGO Response: Overlooked by Staff is that the issue of water quality is mandatory and will be revisited in the context of the required Clean Water Act 401 state Water Quality Certification Process where cost is not the determinative or sole factor. To summarily deny additional water quality studies on vague, undefined costs, is to deny studies that are also applicable to mandatory state water quality standards implemented in part through the state water quality certification process. This is clear error and in fact may jeopardize the Applicant's ability to obtain such certification in which case the Commission will be unable to issue its license. Upper Dam is the only large dam in Maine where power is produced where minimum flows are 1 cfs: leakage flows of any amount. Dewatering of main stem river segments is rare in Maine and contrary to State law. As noted earlier, FERC has mandated minimum flows for other hydro facilities further up the drainage. Failure to require reasonable minimum flows at

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[28] Maine TU Council Motion to Intervene dated August 4, 2023, page 7.

[29] Id, Exhibit 3.

[30] DEA, page F-9.

Rumford Falls, shows an inconsistency in the Agency application of their own standards and practices, and risks Applicant failure under the state's Clean Water Act certification.

5. The License Application as filed does not meet Federal Power Act or NEPA requirements.

TU's Motion to Intervene: The Federal Power Act, and NEPA EA require a "Well Considered" and "Fully Informed" Study. Here, incomplete and inadequate water quality studies are neither "well considered" nor will they "fully inform" the EA that is to be prepared. NEPA demands far more analytical rigor than what has been conducted. It has been shown that lack of complete water quality sampling data in the Environmental Assessment (EA) only serves to form the basis for further administrative and possible resource intensive legal action going forward, a fundamental and unnecessary flaw that is preventable. For example, there is recent precedent that the absence of relevant, contemporary data, and the presence of flawed data and assessment will lead to a license that is doomed by the arbitrary and capricious nature of an EA premised on insufficient data. This means that it is in both the Applicant's and FERC's interests to ensure a hard look is taken at the fisheries and environmental impacts as early in the process as possible to avoid: (1) a failed license because a state WQC cannot issue; and (2) unnecessary administrative and litigation delays that also jeopardize the future license." [31]

Staff Comments: "Based on our review of the license application and agency and public comments, we have not identified any resources that may be cumulatively affected by the proposed operation and maintenance of the Rumford Falls Project."[32]

NGO Response: The photography and LIDAR data provided makes it abundantly clear that with the adoption of Staff Recommendations, the Project is on a path to operations that will continue provide so little water to significant river reaches in the Project area causing profound effects to occur including loss of and continued degradation of riverine habitat and stranding of aquatic organisms. Staff comments are not supported by study data because adequate water quality studies were not performed. Stranding studies were not performed. Sampling sites were apparently chosen on the basis of ease of access, not to sample each distinct reach of this complex Project. Once every 40 years is the only time these study data are collected. Staff overlooks fisheries and aquatic habitat that are and have been severely impacted by the dam's operations and gives short shrift to non-power uses and public aesthetic and recreational resources the Project can provide and to a very limited extent does provide. This is contrary to FPA mandates and a disservice to the stakeholders.

[31] Id., page 10.

[32] DEA, page 14.

6. FERC's rejection of the request for additional water quality studies below Lower Dam was procedural and without an accurate factual basis.

TU's Motion to Intervene: "FERC rejected the NGOs' arguments that the studies under-sampled the Project below the Lower Station Development. 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 MDEP protocols. Project areas were either not sampled at all or in the wrong locations. 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.

FERC rejected the NGOs arguments that the studies under-sampled the Project saying:

> 'The requested sampling of temperature, DO, and macroinvertebrates directly downstream of the Lower Station development tailrace is also not practicable because there is no location within the free-flowing reach that is not affected by discharges from an adjoining paper mill. Therefore, the sampling sites recommended by the conservation groups would not be representative of the Project discharge.'

This reasoning is also flawed and ignores the fact that the reach in question is the same water and riverine stretch from the impoundment to where the Swift River joins the Androscoggin below the outflow from the lower powerhouse. 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 and submits it is arbitrary and capricious for FERC not to require sampling in this Project area."[33]

Staff Comments: "Maine TU requested that RFH conduct additional water quality and macroinvertebrate sampling in these same areas in response to the filing of RFH's updated study report. Commission staff issued a study plan determination which found that the water quality and benthic macroinvertebrate study required by the Commission's approved study plan and conducted by RFH adequately characterized the water quality in the Project area."[34]

NGO Response: Rumford Falls remains the only Project the NGOs are aware of where no water quality sampling occurred below the last dam in the Project area and where the last sampling site downstream occurred in impounded waters, in this case, impounded by the terminus of the industrial canal. The fact that MDEP did not follow its own protocols when it did not object to Brookfield's proposed water quality studies, does not relieve the Applicant from its obligation to adequately characterize the Project's water quality. It will also not remove this requirement from the state's Water Quality Certification process and conditions that will become part of the license should such certification be obtained.

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[33] Maine TU Council Motion to Intervene dated August 4, 2023, page 11.

[34] DEA, page 24.

7. The whitewater/scenic releases proposed by the Applicant should be accompanied by adequate minimum flows in the bypassed reach to provide natural flow variability below the upper dam and prevent fish strandings

TU's Motion to Intervene: "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 are inadequate to support aquatic habitat and should be accompanied by 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. 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.

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

Maine TU asserts that a minimum flow of 200 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, and (4) improve the views from the Rumford Falls Trail so valued by local residents. A minimum flow range such as proposed by MDIFW of 250 cfs to 500 cfs would do so more effectively and Maine TU supports this minimum flow proposal." [35]

Staff Comments (a): "Continuing to operate the Project in run-of-river mode would minimize fluctuations in the Project impoundment and in the Androscoggin River downstream of the Project. Maintaining stable impoundment levels would continue to protect shoreline habitat and fish and other aquatic organisms that rely on near-shore habitat in the impoundment for spawning, foraging, and cover. Stable impoundment levels would also reduce any erosion of streambanks. Minimizing flow fluctuations downstream of the Project would also continue to protect aquatic habitat and minimize the potential for fish stranding."[36]

NGO Response: This statement acknowledges that the rise and fall of flows that scenic/whitewater flows would entail would not protect aquatic organisms downstream of the releases. The minimum flows proposed by the NGOs would provide more natural flow variability and stabilize habitat for fish and aquatic species.

Staff Comment (b): "The higher flows recommended by Maine TU would prevent stranding because the pools within the bypassed reach would remain wetted allowing for volitional egress to downstream areas. However, there is no information on the record to suggest that

[35] Maine TU Council Motion to Intervene dated August 4, 2023, page 12.

[36] DEA, page 18.

stranding of fish in the pools is common, affecting resident fish species, or affecting downstream eel migration."[37]

NGO Comment: Given the photography presented, which show clear areas of stagnant and disconnected pools, there is every reason to expect strandings have and continue to occur in these areas. There is no record or documentation because no studies were performed in the reach below Upper Dam during relevant flows. Ignoring or dismissing this issue by allowing applicant to ignore it is clear error.

Additional Bases for Objection

The DEA ignores obvious Project harms resulting from routing all Upper Dam flow through the penstock stating under "UNAVOIDABLE EFFECTS": "Impoundment fluctuations associated with Project operation could affect near-shore aquatic habitat; however, RFH's proposal to continue to operate in a run-of-river mode with limited impoundment fluctuations would result in infrequent and minimal disturbances to aquatic and riparian habitat. Project operation would continue to result in some unavoidable injury or mortality to resident fish species entrained through the Project turbines."[38] The Project employs 3-inch trash racks[39] that keep few aquatic organisms from the turbines. Closer spacing would decrease the occurrence of resident species entrainment, diversion of additional water from the penstock would also reduce the frequency of entrainment. All injury cannot be avoided, but these effects could be reduced and neither FERC or Brookfield proposed any measures to reduce mortality.

American eels are a special concern. Commercially important in Maine, they are considered threatened throughout their range, and MDEP reduced Maine's authorized elver harvest in response to this. MDIFW contends that some "minimum flow over the Upper Falls would likely provide an alternate and potentially safer flow path for downstream drift of biota including fish."[40] MDIFW also stated: "RFH appears to have forgotten, overlooked, or dismissed the American eel information provided by MDIFW in our comments on the PAD. MDIFW lake sampling indicates American eel are present in lakes above all of the dams on the lower Androscoggin River below Rumford. In addition, a review of Gerald Cooper's data for waters within our regional boundary indicate the presence of American eel in some lakes above Rumford Falls. Due to MDIFW regional boundaries, our review did not consider all of Cooper's data for the entire drainage above Rumford falls. MDIFW and Cooper's data on American eel should be included in the Final License Application, and some of the statements regarding American eel should be corrected or reworded in light of this information."[41]

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[37] DEA, page 18.

[38] DEA, page 53.

[39] DEA, page 6.

[40] MDIFW Study Requests for the Rumford Falls Hydroelectric Project (FERC No. 2333) dated June 8, 2020, page 5. Also please note that eels are fish.

[41] MDIFW Comments on the Draft License Application for the Rumford Falls Hydroelectric Project FERC No. 2333 July 29, 2022, page 3.

Other species of concern include Maine native brook trout, occurring in the feeder streams both upstream and down with the Swift River known as especially good habitat. While it is acknowledged that Rumford Falls is a natural barrier to upstream fish passage, all the water passing through the turbines except for leaking and high flows forces fish through the turbines minimizing downstream drift and the genetic diversity that accompanies it. It is widely accepted that dams fragment habitat and negatively affect species, even to the point eliminating many riverine populations.[42] The Upper Rumford Falls Dam is a major barrier. Unobstructed downstream passage would allow all riverine fish species to have at least downstream gene flow that is necessary for natural preservation of genetic diversity.

The DEA treats the Project area strictly as a matter of engineering and recreational opportunity rather than as a living part of nature. Minimum flows are more than simple hydraulics. They can be managed in a way to treat the reach like a natural river segment, high flow periods will supply the seasonal flow variability that is needed by riverine habitat to sustain itself. The DEA states: "While extending minimum flows up to the month of December as suggested by Maine DIFW would increase the amount of aquatic habitat available to stocked brook and brown trout, the angler creel survey results indicate that only 2% of the anglers fished in November. Therefore, there would be only a minor benefit of providing additional habitat for the stocked trout through December for the purposes of improving angling opportunities. We find that RFH's proposed flows would provide a substantial enhancement of aquatic habitat at a reasonable cost. However, the additional habitat improvements provided by Maine TU's or Maine DIFW's proposed flows are not worth the cost. Therefore, we recommend RFH provide a minimum flow of 95 cfs from May 1 to October 31 and 54 cfs from November 1 to April 30. Of the alternatives considered, this staff recommended alternative would strike the appropriate balance between flow used for aquatic habitat improvement and flow used for Project generation."[43] It is widely accepted that aquatic communities can only become established in areas that are generally watered with adequate minimum flows. Staff analyses on pages 21 through 24, treat the river like a spigot. **While the Draft <u>Environmental Assessment</u> proposes to support a recreational fishery, it ignores the habitat and does not treat the river like a river - only a potential water source. The statement that "there would be only a minor benefit of providing additional habitat for the stocked trout" is misleading and myopic. Minimum flows benefit the riverine habitat and all the organisms that inhabit it, including trout. The Staff Recommendation shows no respect for the resource and discounts environmental quality as a consideration.**

[42] Fuller, M.R., Doyle, M.W., & David L. Strayer, D.L. 2015. Causes and consequences of habitat fragmentation in river
networks. Annals of the New York Academy of Sciences. August, page 10. "Dams are the most important way humans fragment river networks worldwide because of their large numbers and extensive ecological impacts… Dams vary widely in permeability, from high dams with large impoundments that are nearly complete barriers to fully aquatic organisms and strong barriers even to species with terrestrial or resistant stages, to low dams with small impoundments that pose no barrier to species with terrestrial or resistant stages, and are passable at least during high water even by fully aquatic species. Although most of the world's dams are small, there are enough large dams of very low permeability to fishes and other organisms that they are fragmenting and eliminating many riverine populations (e.g., Refs. 2, 17, and 76), or affecting their genetic structure and connectedness." (e.g., Refs. 77– 80).

[43] DEA, page F-11.

Project Recreational Aspects

The Town of Rumford, FERC Staff and the Maine Bureau of Parks and Lands support development of "a Whitewater Boating and Aesthetic Flow Plan, that includes: "(a) providing whitewater boating flows of 1,200 to 1,500 cfs from 10:00 a.m. to 3:00 p.m to the Middle Dam bypassed reach for ten days (total) per year during the months of June, July, and August (instead of three days total as proposed); (b) providing aesthetic flows of at least 1,200 cfs from 10:00 a.m. to 4:00 p.m to the Upper Dam bypassed reach for ten weekend days (total) in June, July, and August (instead of 3 weekend days); (c) lighting the falls from the Upper Station between evening civil twilight (i.e, sunset) and 12 AM (instead of 8 PM to 12 AM); and (d) developing protocols and a schedule for determining which days boating and aesthetic flows would be released and for communicating the flows to the public." Although this is less frequent than the NGOs had asked for, upon further consideration, the NGOs feel that this is adequate, both in terms of frequency and flow rates. The NGOs appreciate the recommendation to include notifications of flows.

The licensee proposes to improve the access trail behind the Rumford Library on river left to provide recreational access to the natural river channel bypassed reach. We support this access improvement as it will provide public access for boaters, anglers, and other recreational users to the lower bypassed reach below the whitewater features. This trail, however, will not provide access for whitewater boaters seeking to run those rapids further up in the bypassed reach. During the whitewater boating study, participants accessed the river via a steep, rugged, poison ivy-covered goat path on river right behind Rumford Town Hall. The licensee proposes no improvement to the access path on river right. The lack of a suitable access trail on river right is an impediment to whitewater boating in the bypassed reach. We recommend that the Draft Environmental Assessment be revised to require access improvements on river right above the whitewater boating features, either behind town hall or further up in the bypassed reach.

Recreational facilities provided are for the present but may not prove adequate over the 40-year term of the license. We ask that the plan be further conditioned to include periodic reviews to re-evaluate the need for additional recreational facilities. We ask that this be done on ten-year intervals.

The NGOs additionally note that minimum flows requested for Upper Falls would put some amount of water over the reach adjacent to the Rumford Falls Trail making it more of a "Falls Trail" when people are most apt to be using it. This would also provide a distant view of some falls from Eugene Boivin Park. Without this, except during high flow events and scenic releases, the question 'what falls' is logical one.

Conclusions and Requests

The Rumford Falls Project altered the largest waterfalls east of Niagara in ways that would not even be considered today, turning a natural ecological wonder into an industrial process. The flow path taken by most of the water most of the year little resembles their original course.

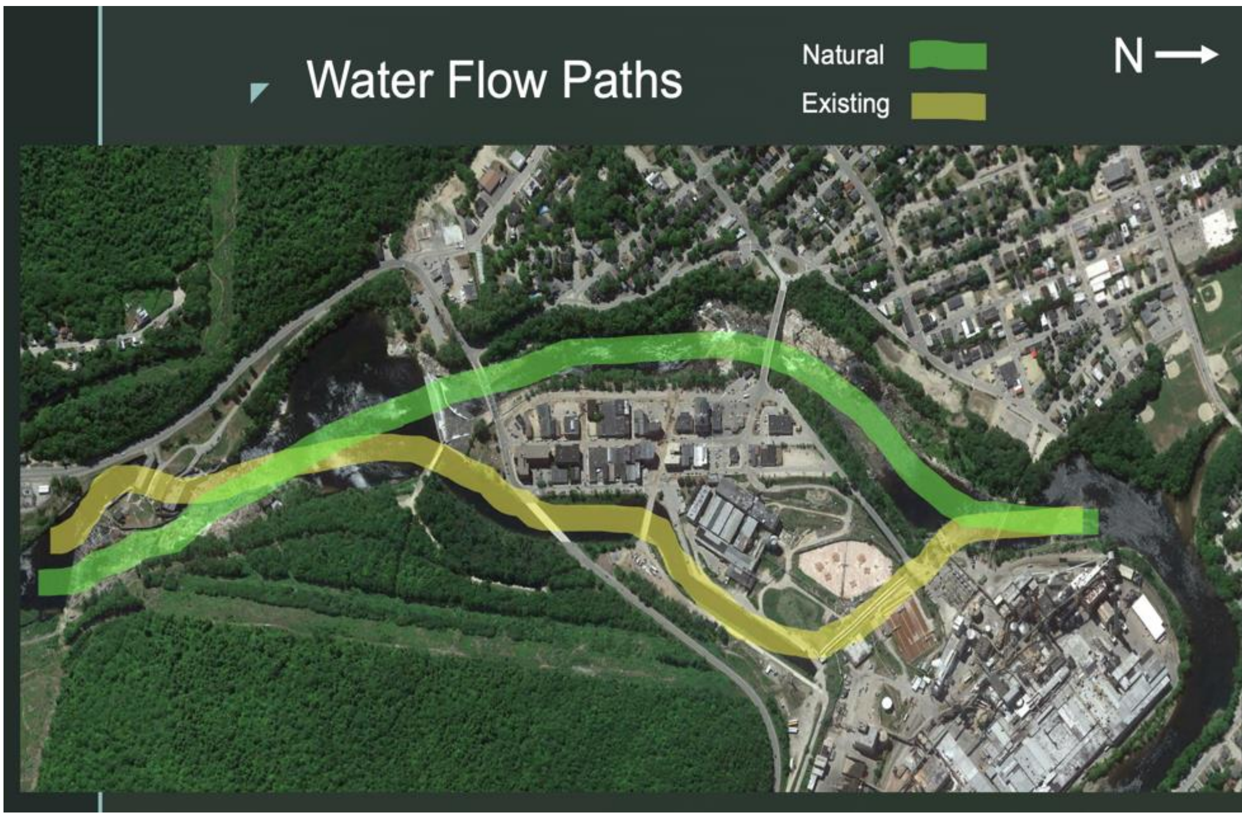


Figure 4. The green path depicts the path of the main flow of the river prior to construction of the Project; the yellow path shows the path most of the water now takes except during high flow periods.

High Flows generally occur only about one fourth of the year – please refer again to figure 1. This has significant effects as most of the water is routed long distances through multiple penstocks and turbines, as well as a canal. We only ask that the Project be operated in such a way that allows this river segment to function like a river segment, one with flora and fauna. As previously demonstrated, the requested minimum flows of 250 cfs to 500 cfs at both Upper Dam and Middle Dam constitute a reasonable request and are less than USGS base flows. Referring again to figure 1, these minimum flows only represent less than 25% of the total flow available, even during the driest part of the year.

Photo 2 - Upper Rumford Falls, October 5, 2023. Photo by John Preble

It is difficult to imagine that the Federal Energy Regulatory Commission is willing to validate the continued wholesale dewatering of the largest waterfall in the United States east of Niagara. While it is acknowledged that the existing installation severely modifies this entire segment of the river, the NGOs assert that Brookfield could operate the Project so as to mitigate the adverse effects of this waterfall turned industrial process and allow the river segment to function as a river.

Accordingly, the NGOs request that the following are included in the DEA to meet the requirements of the Federal Power Act: (1) minimum flows of 250 cfs to 500 cfs at both falls, (2) improvement of the access behind Rumford Town Hall for whitewater access, and (3) review of provided recreational facilities at ten-year intervals.

The signatories appreciate the opportunity to submit these comments on the Rumford Falls Project Draft Environmental Assessment.

Respectfully submitted,

American Whitewater
Bob Nasdor
Northeast Stewardship & Legal Director

Conservation Law Foundation
Sean Mahoney
Vice President, Maine Advocacy Center

Appalachian Mountain Club
Mark Zakutansky
Director of Conservation Policy Engagement

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

Friends of Richardson Lake
John Preble
Treasurer

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

Attachments

A. Rumford Falls Habitat Evaluation Report Revised October 2023
B. Questions and Answers on Northeast Flow Policy, Vernon long, U. S. Fish and Wildlife Service, Concord, New Hampshire, May 11, 1999
C. Isaak, Daniel, and Wayne A. Hubert. 2011. Are Trout Populations Affected by Reach-Scale Stream Slope. Canadian Journal of Fisheries and Aquatic Sciences 57(2):468-477

Attachment A

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.

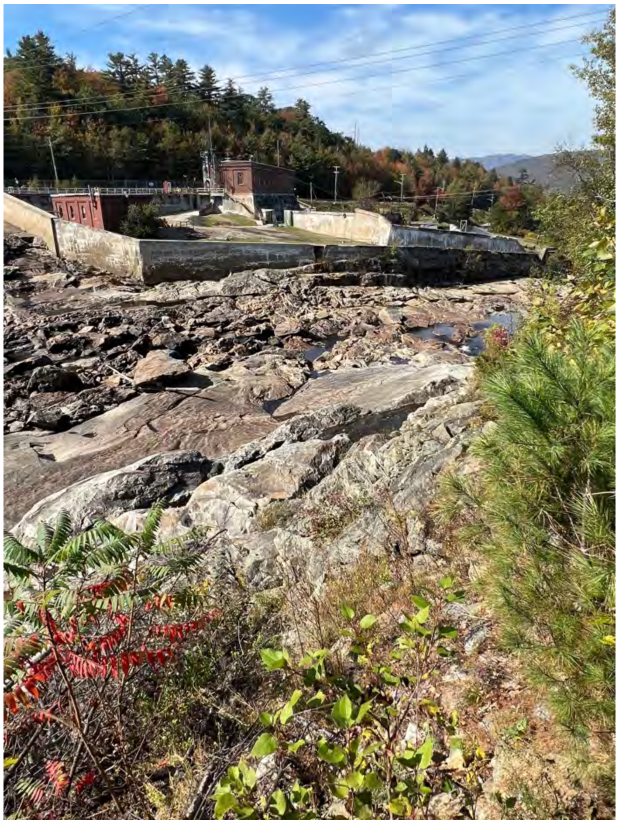
[2] FERC Issuance dated November 21, 2022, Reference: Determination on Requests for Study Modifications for the Rumford Falls Hydroelectric Project.

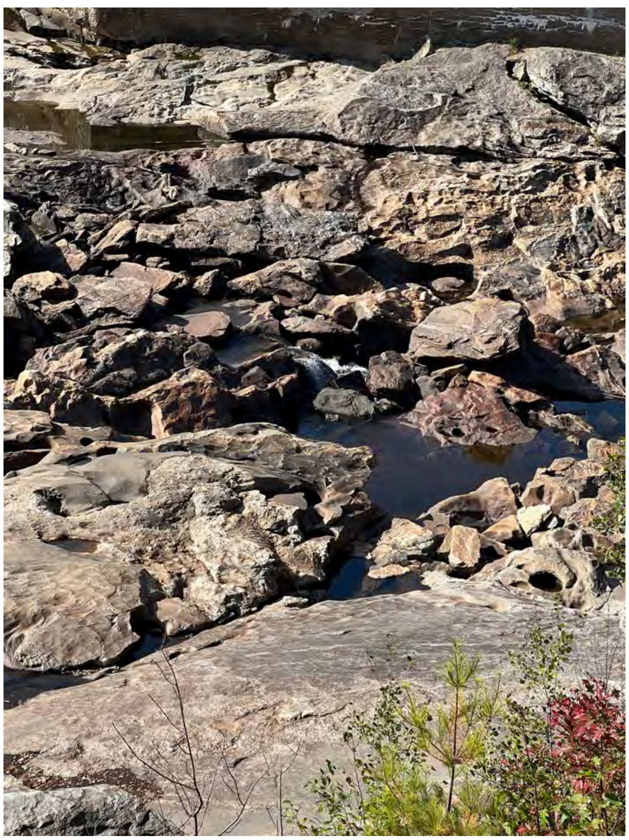
Results.

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]

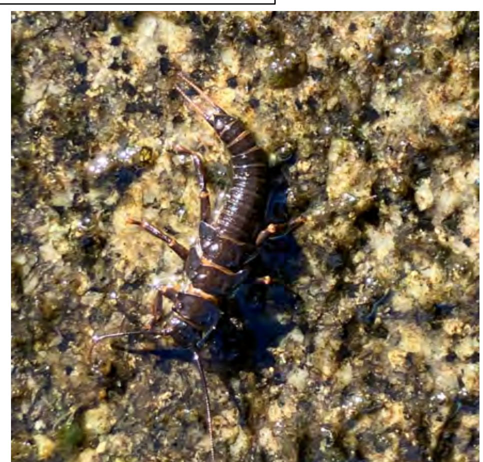
These gradients are similar to gradient at the Cribworks on West Branch of the Penobscot River below Ripogenus Dam.

[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.

Attachment B

Questions and Answers on the New England Flow Policy

An overview of the Interim Regional Policy for New England Stream Flow Recommendations intended for use by lay persons, members of watershed groups, environmental organizations, consultants, public agency staff and others with an interest in instream flow methods and policy.

Prepared by: Vernon Lang

U.S. Fish and Wildlife Service

Concord, New Hampshire

May 11, 1999

Fourth printing with minor revisions 11/12/02

Introduction

The New England Flow Policy has been used extensively since 1980 to establish instream flow levels at water development projects primarily by government agencies and consulting firms. During this time period, a gradual transition in water pollution priorities has occurred with the present focus on non-point source issues, water quantity and watershed initiatives. As a result, many new players have become involved in water issues. With this influx comes a craving for information to help citizens understand how government agencies such as the U.S. Fish and Wildlife Service review water development proposals from a policy perspective, and what methods are used to develop instream flow recommendations. Instream flow is critical to the protection and propagation of stream fishes and related aquatic life because flowing water with certain velocity, depth, substrate, cover and other micro- and macro habitat variables is required to sustain the life cycles of these fluvial life forms.

QUESTIONS AND ANSWERS ON THE NEW ENGLAND FLOW POLICY

1. What is the New England Flow Policy?
The New England Flow Policy is an internal U.S. Fish and Wildlife Service directive that establishes standard procedures for USFWS personnel when reviewing, providing planning advice and commenting on water development projects in New England. A copy of the policy is included in Appendix A.

2. Why was the flow policy developed?
The flow policy was developed to address a number of regional needs including, but not limited to, institutional factors relating to water resource policies both within and outside the Service; a need for instream flow criteria to serve as a water resource planning tool; to provide standardized instream flow assessment procedures; to address regional energy and water supply initiatives; and to address water quality issues.

3. When was the flow policy developed?
The development of the flow policy was initiated in the fall of 1978, and the iterative development process continued until February 13, 1981.

4. What internal review procedures were utilized during the flow policy development phase?
Various iterations of the policy received review at three different levels. The first level of review occurred in the Ecological Services Office in Concord, NH. The second review level included field offices under the New England Area Office. The third level of internal review occurred at the Regional Office in Newton Corner, Massachusetts. The individuals involved included fishery and wildlife biologists, research biologists, hydrologists, engineers and management level staff.

5. Did the flow policy receive interagency review?
Yes, the iteration of the policy issued by the Regional Director, on April 11, 1980 was distributed with a request for comment, to agencies with a known interest in instream flow issues including the New England River Basins Commission, the Federal Energy Regulatory Commission, State Fish and Wildlife Agencies, and the Department of Energy.

6. What does the term Aquatic Base Flow (ABF) mean?
The term Aquatic Base Flow was coined by the Service to describe a set of chemical, physical and biological conditions that represent limiting conditions for aquatic life and wildlife in stream environments. In hydrological terms, it means median August flow as calculated by the Service (see Question 12).

7. How is the flow policy structured?
The flow policy utilizes a bifurcated approach as illustrated in Figure 1 to develop instream flow recommendations. Section C.3. contains the standard setting Aquatic Base Flow (ABF) method, while Section C.6. provides for site-specific studies such as the Instream Flow Incremental Method (IFIM).

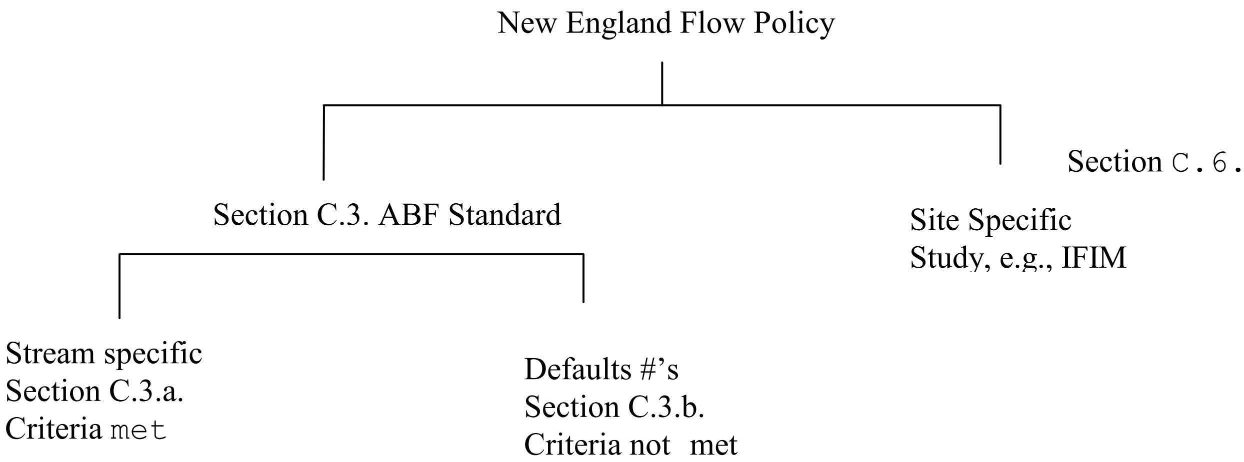


Figure 1.

8. What is a standard setting method and why is it included in the policy?

In regulatory parlance, instream flow standard setting is by definition, a procedure that consistently identifies a flow level that offers a conservative level of protection for aquatic resources without the need to do (or in the absence of) site-specific evaluations. The standard setting ABF method was included in the policy to serve both planning and regulatory needs. Many applicants either do not need or do not have sufficient time or resources to conduct a site-specific instream flow study. The vast majority of projects processed under the flow policy have used the standard setting ABF method.

9. What are the ecological underpinnings of ABF?

The ABF method relies on the natural ecological-hydrological system to serve as a baseline or reference condition from which stream flow conditions suitable for the protection and propagation of aquatic life could be identified. Aquatic life in natural stream systems are subject to an inherently complex array of imperfectly understood relationships and conditions that serve to limit or promote life in lotic environments. The Service concluded that aquatic life in free flowing New England streams have evolved and adapted to naturally occurring chemical, physical and biological conditions, and that if these environmental conditions could be emulated, aquatic life would be sustained at a level commensurate with populations existing under similar natural environmental regimes.

10. Was the limiting factors concept used in the development of the ABF standard setting method?

Yes, the concept was used to identify critical life cycle functions, temporal periods, and chemical and physical parameters that could function as limiting factors on aquatic life. Low flow conditions in August typically represent a natural limiting period because of high stream temperatures and diminished living space, dissolved oxygen and food supply. Over the long term, stream flora and fauna have evolved to survive these adversities without major population changes. The median flow for August was therefore designated as the Aquatic Base Flow.

A similar analysis was used to address other critical functions such as spawning and incubation including access to spawning sites, e.g., migration needs. For fall spawning fish, February was selected as the month with limiting conditions because of low stream flow, cold temperatures and instream ice conditions. In addition to spawning and incubation considerations, the fall-winter criterion is applicable to aquatic life and wildlife that use streams as overwinter or refuge habitat, e.g., turtle hibernacula. For the spring period, the months of April and May were combined to address spawning and incubation requirements for instream and overbank (floodplain/wetland) spawning species and for channel integrity.

11. Was a risk-based analysis used in the development of the ABF standard setting method?
Yes, since the ABF method utilizes critical portions of historic flow patterns to identify levels below which flow cannot be altered in New England streams, the Service concluded that it was a reasonable risk to assume that the aquatic flora and fauna that have evolved and adapted to these conditions would be protected. The risk analysis included an evaluation of different levels of protection such as protecting the complete hydrograph, an intermediate step such as median monthly flows for each month, or the critical periods identified in ABF. The environmental needs of aquatic life were weighed against the realities of administering a more complex standard and the decision was made that it was an acceptable risk to protect those portions of the hydrograph where limiting factors could be identified.

12. What criteria or sideboards are used in the ABF method?
The criteria include a minimum size drainage area of 50 square miles, a period of record for each stream gaging station of at least 25 years, gaging records of good-to-excellent quality, a basically free flowing or unregulated stream and median monthly flow values calculated by taking the median of monthly average flows for the period of record.

13. Why were these specific criteria chosen?
The basic reasons that these criteria or sideboards are used is to help insure that consistent resource protective (conservative) results are achieved and to meet the basic tenets of standard setting.

- The 50-square mile drainage area is intended to insure that a dendritic drainage pattern is included to help smooth out the effects of localized storms, reduce streamflow variability and avoid mass balance issues associated with small drainage systems.
- The 25-year period of record was selected to help insure that the gaging record would include drought and high flow periods and not be unnecessarily skewed by one or the other.
- Stream gaging stations with good to excellent quality records were chosen to insure accuracy in flow measurements. This criterion is occasionally violated at some stations in the winter due to ice conditions.
- The phrases "basically free flowing" or "basically unregulated" are intended to reflect stream flow records that may be more than minimally affected by regulation when viewed in its broadest context. Readers are reminded that few, if any, truly unregulated systems exist in the New England landscape due to past and present land and water uses.
- Median monthly flow values were calculated by taking the median of monthly mean flow. This calculation procedure minimizes the effects of regulation that would be captured,

especially during low flow periods, if medians calculated by taking the median of daily average flow were used. These effects of land use, off-stream water use, diversions and storage/release operation by mills and hydroelectric stations tend to skew the median values downward. The longer time step in the monthly average reduces, but does not eliminate, the effect of the regulation. Monthly average (mean) flow was considered as a criterion but this statistic tends to incorporate the effect of high flow events and skews the monthly flow value upwards. The median of monthly average flow reduces but does not eliminate this skew and provides a reasonable measure of central tendency.

14. Does the flow policy apply only to fish or does it apply more broadly to aquatic life?
The policy is primarily intended to cover aquatic fauna. However, the policy can be used to address aquatic flora since over time, aquatic plants evolved and adapted to stream conditions in a natural selection process similar to faunal resources.

15. What is the ABF reference stream and how is it used?
The ABF reference stream represents monthly streamflow conditions in New England. It was developed from the data compiled on 48 long-term stream gages throughout New England. Appendices B and C contain a hydrograph and monthly flow statistics of the reference stream, respectively, and Appendix D lists the stream gages used in the analysis. The data from the reference stream was used to develop the default ABF values for August, February, and April/May.

16. How do ABF flow values compare with other standard setting methods such as Tenant?
The Tenant method uses percentages of average annual flow (AAF) to describe the suitability of seasonal instream flow conditions for aquatic life, e.g., for summer conditions 10% AAF = poor habitat; 30% AAF = fair habitat; and 50% AAF = excellent habitat. The ABF summer default of 0.5 cfsm is slightly less resource conservative than Tenants' 30 percent average annual flow. The 0.5 cfsm default is about 26 percent of the average annual flow of the ABF reference stream.

17. How does the median August default (0.5 cfsm) compare to optimal flow?
The term optimal flow is a relative term depending on the life cycle requirements and preferences of the species involved. For obligate stream species or life stages such as trout, salmon, dace, and macroinvertebrates such as stoneflies which have an affinity for habitat with moderate water velocities, the optimal flow conditions are frequently in the range of 1.0-1.5 cfsm. These same flow conditions could be expected to provide unsuitable or minimally suitable conditions for typical lacustrine (lake) and some facultative (generalists) species that may attempt to occupy free flowing sections of streams.

18. Under what conditions should standard setting methods be used?
Standard setting methods are most appropriate when: the project is relatively straightforward; the waters are not over-allocated to uses such as water supply, hydropower or irrigation; a single flow recommendation is sufficient; the administrative process is straightforward; time and cost constraints are significant issues; and a goal of the parties involved is to minimize risk and provide certainty during the regulatory process (see Appendix E).

19. When should site-specific studies be undertaken?
Site-specific studies such as the Instream Flow Incremental Method may be appropriate when: complex negotiation processes are involved; the project itself is complex; the waters are allocated or over-allocated; several flow alternatives need to be considered and compared against one or more baselines; complex administrative proceedings are involved; and time and costs are not major constraints (see Appendix E).

20. Does the Service have criteria or sideboards for site-specific studies?
Yes, Appendix F contains eight specific considerations that should be evaluated when contemplating a site-specific study.

21. Why was a fall instream flow criterion not included in the ABF method?
A fall instream flow criterion was considered to address migration, spawning and hydrograph protection. However, a fall criterion was not included for several reasons. The Service concluded that the most probable limiting conditions for fall spawners and overwintering aquatic life occurred during February due to low stream temperatures, low stream flow and instream ice conditions. The Service was also concerned about adding additional complexity to the method and the ability of agencies and the regulated public to administer these additional flow criteria.

22. How does the flow policy fit within the Clean Water Act framework?
The Service view is that the ABF method provides flow criteria and streamflow recommendations that achieve the interim goal of the Act. However, like other water quality criteria, compliance with the antidegradation policy could be problematic in cases involving high quality waters. In addition, the designated uses and criteria for some water classifications in state water quality standards may be more stringent than ABF criteria. It is important to recognize that the flow policy is not structured to provide stream flow recommendations that achieve the full restoration objective of the Act. Appendix G contains a more thorough discussion of these issues.

23. What do the terms csm/cfsm mean?
The terms csm and cfsm are simply abbreviations for cubic feet per second per square mile of drainage area. The terms convert discharge in cubic feet per second and drainage area in square miles into a universal expression or unitized value.

24. What is a default flow?
A default flow is simply a generic flow criterion applicable to a stream that does not meet the minimum ABF criteria, e.g., 25 years of records, etc, as discussed in Question 11. The default flows are developed from the flow statistics from 48 stream gages in New England. This same data set is used to develop the ABF reference stream.

25. What basic information is needed to develop a flow recommendation from the ABF method?
This question has two possible answers. If the project is on an ungaged stream or does not meet minimum ABF criteria, then the defaults apply. To use the defaults, you need to know the size of the drainage area above the project (dam, diversion, out take, etc) in square miles. The drainage area is

then multiplied by the defaults to obtain the streamflow values in cfs that apply at the project site. If fall spawning fish occur in the stream, or if other critical aquatic needs are identified (winter fish refuge, hibernacula for turtles etc), then both the fall/winter and spring spawning and incubation flow criteria need to be met.

For projects on streams that meet ABF criteria (25 years of records, etc, see Question 8 and 9), the same process is used except that the median monthly flow for that specific stream is used instead of default numbers for August, February, and April/May.

26. What significance attaches to the term Interim above the title on the flow policy?
The reason that the word Interim was inserted above the title related to the pending change from the Carter to Reagan Administrations in early 1981. The policy was developed under the Carter Administration and, since implementation would occur in the new Reagan Administration, the word Interim was inserted to allow implementation to continue while discussion with policy level staff in the new Administration occurred. Under Secretary of the Interior Donald Hodel was briefed on the policy and determined that it was not contrary to Administration goals or policy.

27. Can the flow policy be used in nonregulatory administrative settings, e.g., in a stand-alone mode?
Yes, the most frequent example of this scenario is the use of ABF defaults in a planning mode. In the regulatory mode, the flow policy is used in conjunction with other administrative processes such as §401 Certifications, §402 and §404 permits, FERC exemptions and licenses, special use permits, NEPA, and alternatives analyses associated with one or more of the above.

28. Does ABF provide adequate hydrograph protection?
The ABF method is designed to protect low and moderate flow segments of the hydrograph where critical life cycle functions of aquatic life occur. This results in a constriction and flattening of the hydrograph and leaves significant portions unprotected. This condition is ameliorated at some water projects because they lack the capacity to materially affect the hydrograph above flow levels of 1.0 csm or greater. However, for large impoundments or large capacity water withdrawals, hydrograph protection may be problematic. For these reasons, additional hydrograph protection such as ramping rates (rate-of-change limits) percent diminishment limitations or other features may be advisable.

29. If site-specific study results and ABF standard setting values are both available, which method is used for determining flow recommendations?
Generally speaking, if site-specific studies have been properly coordinated, scoped, conducted and reviewed, the tendency should be to use site-specific over standard setting (ABF) data. Simply conducting a site-specific study, however, does not and should not lead to an automatic acceptance of study results. Site-specific studies such as IFIM are subject to a number of variables that can significantly affect study results such as species selection, transect placement, hydrologic baseline, negotiation technique, and the level of sophistication of participants.

30. How do IFIM results compare to ABF values?

The results of an IFIM study are expressed in graphical form depicting the relationships between weighted useable area (habitat) and streamflow. Flow values are negotiated from these graphs by the parties involved in the study. In contrast, the ABF standard setting method yields one answer and no negotiation. Generally speaking, flow recommendations negotiated from IFIM studies tend to be lower than ABF values.

31. Is it appropriate to use long-term gaging records from an unregulated stream to develop simulated unregulated flow records for a nearby ungaged stream, data from a stream with short-term records or a regulated stream for the purpose of developing stream specific ABF flow values?

No. The standard setting (ABF) section of the policy is designed to be prescriptive in nature. Unless the data and stream characteristics meet the basic criteria for the ABF method, e.g., 25 years of record, basically unregulated etc, the default flow values apply. However, under Section 6 of the policy, an applicant could propose a study to develop flow data and values for the situations described above. Caution is advised because under normal circumstances, the Service currently views the Instream Flow Incremental Method as the method of choice for site-specific flow studies. Where site-specific flow studies are done, applicants are frequently required to develop simulated flow records due to the absence of stream gage data or regulation. In these situations, the median of monthly average flow or monthly mean flow may be the preferred statistics rather than a median value based on average daily flows for the reasons described in Question 12.

32. Approximately how many times has the New England Flow Policy been applied?

A complete count of the total number of applications is not possible because no estimates are available for those situations where the policy has been used by agencies or parties other than the Service. The Service has used the policy on over 350 projects, predominately hydroelectric projects but also including public water supply, agricultural irrigation, snowmaking and power plant cooling water applications.

33. After reading the questions and answers, I still don't understand the New England Flow Policy. Whom can I talk to?

Call Vernon Lang at 603-223-2541, or e-mail Vernon_Lang@fws.gov

Appendix A

INTERIM
REGIONAL POLICY
FOR NEW ENGLAND STREAMS FLOW RECOMMENDATIONS

A. Purpose

The U.S. Fish and Wildlife Service (USFWS) recognizes that immediate development of alternative energy supplies is a high national priority. We further recognize that hydroelectric developments are among the most practical near-term alternatives and that environmental reviews may have delayed expeditious licensing of some environmentally sound projects. A purpose of this policy is to identify those projects that do not threaten nationally important aquatic resources so that permits or licenses for those projects can be expeditiously issued without expensive, protracted environmental investigations.

This directive establishes Northeast Regional (Regional 5) policy regarding USFWS flow recommendations at water projects in the New England Area. The policy is primarily for application to new or renewal hydroelectric projects but should also be used for water supply, flood control and other water development projects. The intent of this policy is to encourage releases that perpetuate indigenous aquatic organisms.

B. Background

The USFWS has used historical flow records for New England to describe stream flow conditions that will sustain and perpetuate indigenous aquatic fauna. Low flow conditions occurring in August typically result in the most metabolic stress to aquatic organisms, due to high water temperatures and diminished living space, dissolved oxygen, and food supply. Over the long term, stream flora and fauna have evolved to survive these periodic adversities without major populations changes. The USFWS has therefore designated the median flow for August as the Aquatic Base Flow (ABF)1/. The USFWS has assumed that the ABF will be adequate throughout the year, unless additional flow releases are necessary for fish spawning and incubation. We have determined that flow releases equivalent to historical median flows during the spawning and incubation periods will protect critical reproductive functions.

C. Directive

1. USFWS personnel shall use this standard procedure when reviewing procedure, providing planning advice for and/or commenting on water development projects in New England Area.

1/Aquatic Base Flow as used here should not be confused with the hydrologic base flow, which usually refers to the minimum discharge over a specified period.

2. USFWS personnel shall encourage applicants, project developers and action agencies to independently assess the flow releases needed by indigenous organisms on a case-by-case basis, and to present project-specific recommendations to the USFWS as early in the planning process as possible.

3. USFWS personnel shall recommend that the instantaneous flow releases for each water development project be sufficient to sustain indigenous aquatic organisms throughout the year. USFWS flow recommendations are to be based on historical stream gaging records as described below, unless Section 6 herein applies.

   a. Where a minimum of 25 years of U.S. Geological Survey (USGS) gaging records exist at or near a project site on a river that is basically free-flowing, the USFWS shall recommend that the ABF release for all times of the year be equivalent to the median August flow for the period of record unless superceded by spawning and incubation flow recommendations. The USFWS shall recommend flow releases equivalent to the historical median stream flow throughout the applicable spawning and incubations periods.

   b. For rivers where inadequate flow records exist or for rivers regulated by dams or upstream diversions, the USFWS shall recommend that the aquatic base flow (ABF) release be 0.5 cubic feet per second per square mile of drainage (cfsm), as derived from the average of the median August monthly records for representative New England streams.2/ This 0.5 cfsm recommendation shall apply to all times of the year, unless superceded by spawning and incubation flow recommendations. The USFWS shall recommend flow releases of 1.0 cfsm in the fall/winter and 4.0 cfsm in the spring for the entire applicable spawning and incubation periods.

4. The USFWS shall recommend that when inflow immediately upstream of a project falls below the flow release prescribed for that period, the outflow be made no less than the inflow, unless Section 6 herein applies.

5. The USFWS shall recommend that the prescribed instantaneous ABF be maintained at the base of the dam in the natural river channel, unless Section 6 herein applies.

2/ The ABF criterion of 0.5 cfsm and the spawning and incubation flow criteria of 1.0 and 4.0 cfsm were derived from studies of 48 USGS gaging stations on basically unregulated rivers throughout New England. Each gaging station had a drainage area of at least 50 square miles, negligible effects from regulation, and a minimum of 25 years of good to excellent flow records. On the basis of 2,245 years of record, 0.5 cfsm was determined to be the average median August monthly flow. The flows of 1.0 and 4.0 cfsm represent the average of the median monthly flows during the fall-winter and spring spawning and incubation periods.

6. The USFWS shall review alternative proposals for the flow release locations, schedules and supplies, provided such proposals are supported by biological justification. If such proposals are found by USFWS to afford adequate protection to aquatic biota, USFWS personnel may incorporate all or part of such proposals into their recommendations.

7. USFWS personnel shall forward their recommendations to the Regional Director for concurrence (prior to release) whenever such recommendations would differ from the median historical flow(s) otherwise computed in accordance with Sections 3a and 3b above. For projects with lengthy headraces, trailraces, penstocks, canals or other diversions, Regional Director's concurrence need not be obtained on flow recommendations applicable to the river segment between the dam and downstream point of confluence of the discharge with the initial watercourse.

D. Exemptions

On projects where the USFWS has written agreements citing 0.2 cfsm as a minimum flow, the USFWS shall not recommend greater flows during the lifetime of the current project license. Three hydro-electric projects at Vernon, Bellow Falls and Wilder, Vermont, currently qualify in this regard.

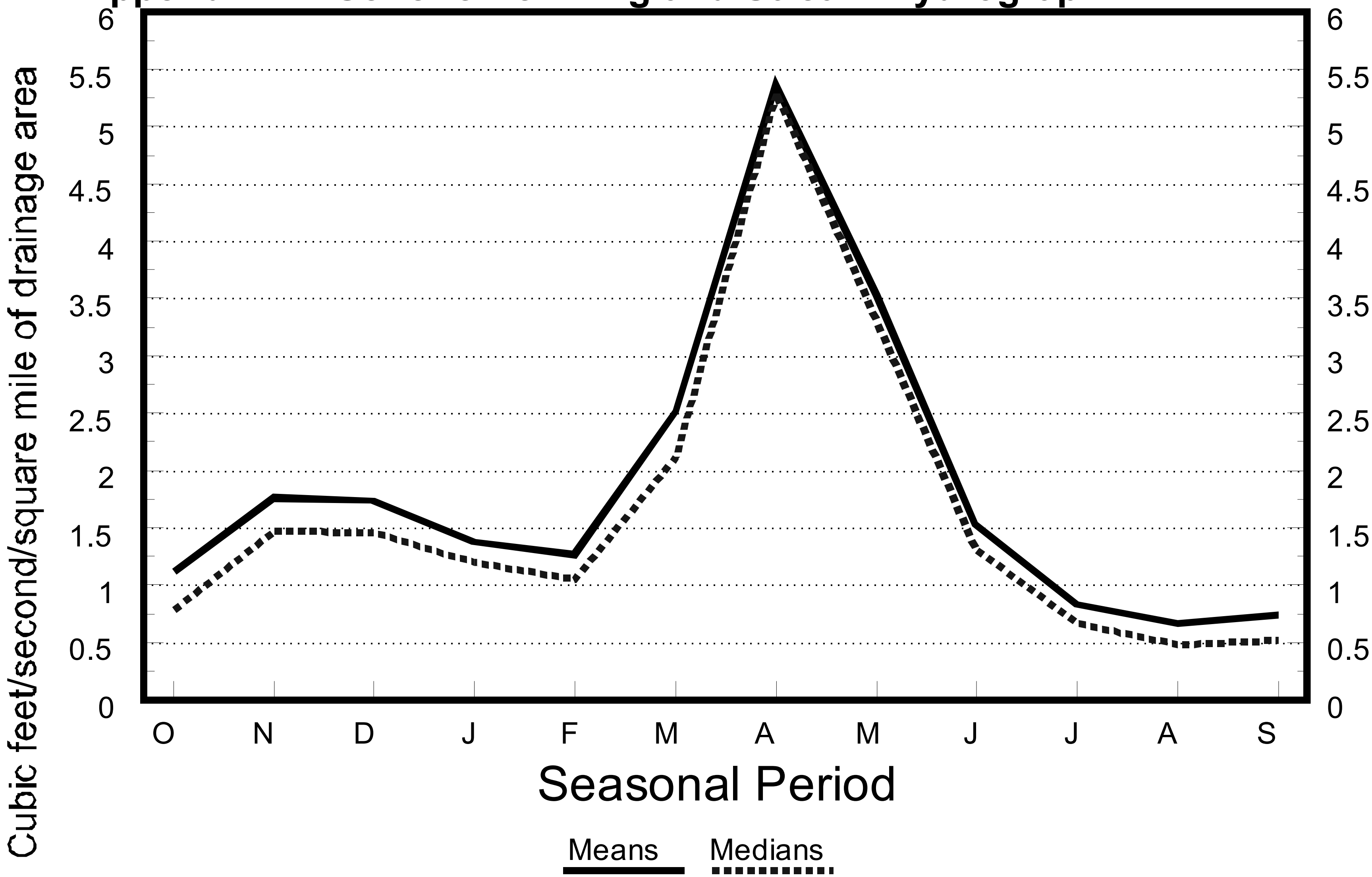
E. Previous Directives

The Regional Director's memorandum dated April 11, 1980 and attached New England Area Flow Regulation Policy are hereby rescinded.

Dated: 2/13/81

Signed: Howard N. Larsen,
Regional Director

Appendix B. Generic New England Stream Hydrograph



Appendix C

New England Stream Flow Patterns

Monthly flows in cfsm based on 48 streams with 2,245 years of USGS records.

	Oct.	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sept.**
Means	1.11	1.76	1.73	1.37	1.27	2.50	5.38	3.53	1.53	.83	.66	.74
Medians	.78	1.47	1.46	1.20	1.06	2.12	5.30	3.31	1.32	.67	.48	.52

Winter and summer low flow period
Spring and fall high flow period

Average annual flow ≈ 1.89 cfsm
.6 cfsm ≈ 30% average annual flow
.5 cfsm ≈ 26% average annual flow

Southern and Coastal spring peaks are attenuated by winter precipitation in the form of rain
Interior streams have lower winter lows and higher spring peaks than coastal streams because of snow pack
Stream flow decline in July, August, and September due largely to evapotranspiration
Stream flow increase in October due partly to evapotranspiration decline after killing frost

Appendix D

LIST OF STREAM GAGES USED IN ABF

STATION	GAGE #	DRAINAGE AREA	PERIOD OF RECORD*
Ten Mile (CT/NY)	01200000	203	62 Years (1931-1993)
Salmon (CT)	01193500	102	65 Years (1929-1993)
Batten Kill (VT)	10329000	152	56 Years (1929-1984)
Walloomsac (VT)	01334000	111	63 Years (1931-1993)
Otter Creek (VT)	04282500	628	80 Years (1903-1993)
N.Br.Winooski (VT)	04285500	69.2	60 Years (1934-1993)
Dog River (VT)	04287000	76.1	59 Years (1935-1993)
Mad River (VT)	04288000	139	65 Years (1929-1993)
Lamoille (VT)	04292000	310	71 Years (1910-1993)
Missisquoi (VT)	04293500	479	74 Years (1915-1993)
Black (VT)	04296000	122	42 Years (1952-1993)
Halls Stream (Que/NH)	01129300	85	31 Years (1963-1993)
W.Br.Farmington (MA)	01185500	92	81 Years (1913-1993)
Housatonic (MA)	01197500	280	81 Years (1913-1993)
Hoosic (MA)	01332500	132	54 Years (1940-1993)
Diamond (NH)	01052500	153	53 Years (1941-1993)
Saco (NH)	01064500	386	72 Years (1904-1993)
Pemigewasset (NH)	01075000	193	40 Years (1940-1993)
Baker (NH)	01076000	143	50 Years (1929-1993)
Smith (NH)	01078000	85.8	76 Years (1918-1993)
Contoocook (NH)	01082000	68.1	38 Years (1945-1993)
Warner (NH)	01086000	146	39 Years (1940-1978)
Blackwater (NH)	01087000	129	70 Years (1918-1993)
S.Br.Piscataquog (NH)	01091000	104	41 Years (1940-1989)
Ammonoosuc (NH)	01137500	87.6	55 Years (1939-1993)
Mascoma (NH)	01145000	80.5	40 Years (1939-1978)
Wood (RI)	01118000	72.4	53 Years (1941-1993)
E.Br.Passumpsic (VT)	01133000	53.8	39 Years (1939-1979)
Moose (VT)	01134500	75.2	47 Years (1947-1993)
White (VT)	01144000	690	78 Years (1915-1993)
Williams (VT)	01153500	103	48 Years (1940-1992)
Allagash (ME)	01011000	1250	63 Years (1931-1993)
Fish (ME)	01013500	871	71 Years (1903-1993)

STATION	GAGE #	DRAINAGE AREA	PERIOD OF RECORD*
St. John (ME)	01014000	5690	67 Years (1927-1993)
Meduxnegeag (ME)	01018000	175	43 Years (1941-1983)
Machias (ME)	01021500	457	65 Years (1906-1977)
Narraguagus	01022500	232	46 Years (1948-1993)
W.Br.Union (ME)	01023000	148	61 Years (1910-1979)
Mattawamkeag (ME)	01030500	1418	59 Years (1935-1993)
Passadumkeag (ME)	01035000	299	64 Years (1916-1979)
Sandy (ME)	01048000	514	58 Years (1929-1993)
Swift (ME)	01055000	95.8	64 Years (1930-1993)
Nezinscot (ME)	01055500	171	52 Years (1942-1993)
L.Androscoggin (ME)	01057000	76.2	73 Years (1914-1993)
Millers (MA)	01162000	83	78 Years (1916-1993)
North (MA)	01169000	88.4	54 Years (1940-1993)
Mill (MA)	01171500	54	55 Years (1939-1993)
W.Br.Westfield (MA)	01181000	93.7	59 Years (1935-1993)

* Years in period of record may vary slightly due to whether data was recorded using calender year date of gage or by water years. Some gages have inactive periods during period of record which reduces the number of years of records.

UNITED STATES GOVERNMENT
MEMORANDUM U.S. FISH AND WILDLIFE SERVICE

NEW ENGLAND FIELD OFFICE
22 BRIDGE STREET - UNIT # 1
CONCORD, NEW HAMPSHIRE 03301-4986

TO: Instream Flow Group, Region 5 September 13, 1994

FROM: Vern Lang

SUBJECT: Considerations for Instream Flow Studies

In recent years, agencies and the general public have placed greater emphasis on watershed management and protection. Streams and rivers represent one of our most extensively utilized and unfortunately, most stressed ecosystems. A low risk or conservative method of approaching watershed management and protection on rivers and streams is to emulate the spatial and temporal patterns of the natural environment. This may not always be achievable due to man's developments within each watershed. However, to insure that stream flow recommendations reflect an ecosystem perspective, the following should be considered:

1. When selecting species for use as evaluation species in IFIM and related studies of water development projects, obligate stream (lotic) species or life stages should be utilized or recommended. Facultative species and/or life stages should be carefully considered or, in some cases, avoided as evaluation elements. For instance, facultative or other generalists could be included as study elements, but not evaluation elements, when parties want to know how they would be affected by various stream flow regimes. Staff should focus their review and evaluation on the habitat specialists within the stream system such as members of the riffle/run community and on critical life cycle processes such as instream or overbank spawning, incubation, or winter survival. The guilding process is an effective way to identify appropriate habitat specialists. The intent is to insure that flow recommendations for habitat specialists are not compromised by data from species or lifestages of habitat generalists and facultative species. These latter species or lifestages should not form the basis for, nor unduly influence how staff prescribe or recommend stream flow regulation for habitat specialists.

2. Under normal circumstances, habitat suitability criteria (HSC) for aquatic life should be tested for transferability to the study site and be utilized, by preference, in the following order: (1) site (stream) specific curves based on empirical data; (2) category III preference curves; (3) category II utilization curves; and (4) category I or Delphi curves. The intent is to provide staff with discretion and guidance when determining which of the available suitability criteria bases would best emulate the spatial and temporal habitat conditions at a specific project.

3. Instream flow studies for impact assessment purposes need considerable attention at the "front end" or scoping phase. The species and habitat used as evaluation elements must be directly affected by changes in stream flow and the effects must be measurable. This seemingly obvious relationship is necessary to insure that the results are meaningful, that they demonstrate a streamflow-habitat relationship, and achieve the impact assessment purpose of the study.

4. Under normal circumstances, hydraulic simulations should be restricted to the ice free period.

5. Under normal circumstances, the habitat-flow relationship derived using habitat suitability criteria should be restricted to the temporal period of the data points contained therein.

6. Flow recommendations based on instream flow studies should consider optimum temporal and spatial conditions for the range of habitat specialists contained within the waterbody. This should expressly include overbank species or life stages. When natural flow conditions provide less than optimum habitat conditions, consider adopting the natural flow pattern until inflow exceeds the optimum level. The difference between optimum flow conditions for obligate stream species and conditions provided by natural low flow periods may be significant and represents an impact that should be considered along with water project impacts.

7. Staff are advised to use one of the standard setting methods (ABF or Tennant) as a reality check when scoping instream flow studies and for evaluating study results. In highly impacted streams and those without streamflow data, the ABF reference stream can be used as a baseline from which scoping and evaluation decisions are made.

8. When utilizing and/or evaluating time series analyses, staff should insure that the time steps are related to stream hydrologic characteristics. This includes response to short-term episodic events (rise and fall after storms) as well as longer-term events such as summer/winter low flows and fall/spring high flows. In addition to stream hydrology, various ecological factors such as biological time clocks, photoperiod, biological homogeneity-heterogeneity periods and species-specific life cycle processes need to be considered in time series analyses.

Staff should recognize that the ecological relationships of aquatic life in flowing waters are inherently complex. This guidance mentions only a few of the issues that have recently generated attention. Because instream flow studies rely on a small number of evaluation species to generate data for instream flow proposals, staff need to be more cognizant of the habitat specialists. Scientists will probably never be able to fully unravel the complex life history and environmental requirements of all aquatic life. Consequently, whenever possible, we should strive to emulate natural stream flow patterns as the least risk alternative for aquatic life.

Questions should be directed to me at 603-225-1411.

Appendix F

When to Apply

<u>Standard Setting Method</u>	**<u>Site Specific Method</u>**
Standards Settings Process	**Negotiation Process**
Relatively straightforward project	**Complex project**
Water resource not over-allocated	**Water allocated or over-allocated**
Only need single flow recommendation	**Need many potential flow alternatives**
Administrative process straightforward	**Complex administrative process**
Time and cost constraints	**Time and cost not major constraints**

RELATIONSHIP OF FLOW POLICY TO CLEAN WATER ACT

National Objective -	**Restore and maintain the chemical, physical, and biological integrity of the Nations' waters 33 U.S.C. 1251(a)**
Interim goal -	**Water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water 33 U.S.C. 1251(a)(2)**
Flow policy objective -	**Stream flow conditions that will sustain and perpetuate indigenous aquatic fauna**
Service view - (Interim Goal)	**Flow policy is providing recommendations that achieve the interim goal** **Antidegradation compliance could be problematic where high quality waters are involved 40 CFR 131.12(a)(2) and (3)** **Compliance with designated uses and criteria in some water classifications in state water quality standards could be problematic, e.g., some Class AA and A waters**
(National Objective)	**Restoration objective could be attained by:** **(a) prescribing median monthly flows for all months** **(b) prescribing run-of-river operation** **(c) prescribing optimum biological flows**

 Attachment C

Are trout populations affected by reach-scale stream slope?

Daniel J. Isaak And Wayne A. Hubert

Abstract: Reach-scale stream slope and the structure of associated physical habitats are thought to affect trout populations, yet previous studies confound the effect of stream slope with other factors that influence trout populations. We isolated the effect of stream slope on trout populations by sampling reaches immediately upstream and downstream of 23 marked changes in stream slope on 18 streams across Wyoming and Idaho. No effect of stream slope on areal trout density was observed, but when trout density was expressed volumetrically to control for differences in channel cross sections among reaches in different slope classes, the highest densities of trout occurred in medium-slope reaches, intermediate densities occurred in high-slope reaches, and the lowest densities occurred in low-slope reaches. The relative abundance of large trout was reciprocal to the pattern in volumetric trout density. Trout biomass and species composition were not affected by stream slope. Our results suggest that an assumption made by many fish-habitat models, that populations are affected by the structure of physical habitats, is at times untenable for trout populations in Rocky Mountain streams and is contingent upon the spatial scale of investigation and the population metric(s) used to describe populations.

Résumé : On pense que la pente des cours d'eau à l'échelle des tronçons et la structure des habitats physiques associés influent sur les populations de truites, mais des études antérieures ont confondu l'effet de la pente avec d'autres facteurs qui influent sur ces populations. Nous avons isolé l'effet de la pente sur les populations de truites en prélevant des échantillons immédiatement en amont et en aval de 23 changements marqués de la pente dans 18 cours d'eau du Wyoming et de l'Idaho. On n'a observé aucun effet de la pente sur la densité des truites par unité de superficie, mais, quand la densité des truites était exprimée par unité de volume pour tenir compte des différences entre les sections transversales des chenaux des tronçons de différentes classes de pente, les plus fortes densités de truites se trouvaient dans les tronçons de pente moyenne, les densités intermédiaires dans les tronçons à forte pente et les plus faibles densités dans les tronçons à faible pente. L'abondance relative des truites de grande taille suivait le profil des densités volumétriques de truites. La pente n'avait pas d'effet sur la biomasse de truites et la composition par espèces. Nos résultats laissent penser que l'hypothèse introduite dans de nombreux modèles d'habitat du poisson suivant laquelle les populations sont affectées par la structure des habitats physiques est dans certains cas non valides pour les populations de truites des cours d'eau des Rocheuses, et qu'on doit prendre en considération dans l'application de cette hypothèse les paramètres utilisés pour décrire les populations.

[Traduit par la Rédaction]

Introduction

A stream reach is a 10 to several hundred metre length of stream that exhibits consistent slope (Frissell et al. 1986). Reach-scale stream slope and the energy that it helps to generate exert a dominant influence on the structure of physical habitat in streams (Hubert and Kozel 1993), and reaches of specific slopes contain characteristic assortments of smaller-scale habitats (i.e., channel units, subunits, substrate particles; Kershner et al. 1992). If fish populations are influenced by the structure of physical habitat, as many models assume (Fausch et al. 1988), change in reach-scale stream slope should elicit change in fish populations.

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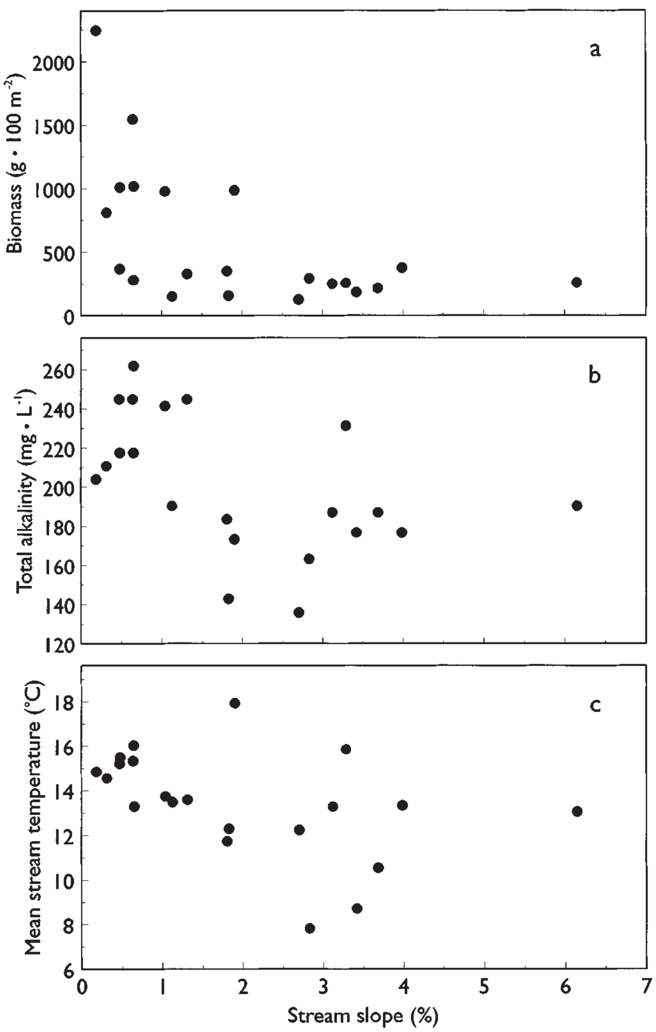
Researchers working with trout have collected data that seem to support the preceding logic, and most work has focused on four population metrics: biomass, species composition, density, and length structure. Several investigators have described a negative relationship between trout biomass and stream slope (Fig. 1*a*) (MacPhee 1966; Chisholm and Hubert 1986; Kozel et al. 1989), with the explanation often being a habitat-based hypothesis that asserts that optimal living conditions are associated with the undercut banks, overhanging vegetation, and the amount of pool habitat found in reaches with low stream slopes. Alternatively, Wilzbach and Hall (1985) have formulated a food-based hypothesis that suggests that macroinvertebrates preferred by trout will be more abundant and easier to obtain due to higher light levels in low-slope reaches that often occur with open canopy riparian zones dominated by willows (*Salix* spp.), alders (*Alnus* spp.), or sedges (*Carex* spp.) It has also been common for researchers to document changes in species composition as a function of stream slope (Moore et al. 1985; Fausch 1989; Bozek and Hubert 1991). Proposed mecha-

Fig. 1. Correlations among stream habitat variables and trout biomass. (*a*) Inverse relationship often reported between trout biomass and stream slope and concurrent relationships between stream slope and either (*b*) total alkalinity or (*c*) temperature. Data are from our own unpublished surveys and were collected using a longitudinal sampling design on five streams draining two physiographically similar mountain ranges in southeastern Idaho.



nisms are either that one trout species is competitively excluding another from optimal habitats or that individual trout species prefer the types of physical habitats associated with particular stream slopes.

The relationship between reach-scale stream slope and trout density has not been clearly defined. Hermansen and Krog (1984) described a positive relationship between stream slope and the density of hatchery trout longer than 15 cm but gave no explanation for their findings. Conversely, Kennedy and Strange (1982) and Moore and Gregory (1989) documented negative relationships between stream slope and densities of age-1 and older (age-1+) trout. These researchers concluded that changes in trout densities resulted from the preference of age-1+ trout for the deeper water habitats that occurred at low stream slopes. Less work has described the influence of stream slope on population length structure, but a study by Larscheid and Hubert (1992) indicated that larger trout composed a greater proportion of populations at lower stream slopes. Proposed mechanisms included competitive exclusion of smaller trout by larger trout and a habitat-based hypothesis suggesting that conditions for growth and survival of larger fish were better in reaches with low stream slopes.

Despite the existing body of evidence, we contend that a causal link has yet to be established between reach-scale stream slope and trout populations. All studies addressing this issue have used sampling designs wherein data were collected either in a longitudinal upstream progression or from stream reaches distributed across space and time. Both sampling designs make it impossible to separate the effect of stream slope from other factors that affect trout populations. Causal inference from longitudinal sampling designs is negated by intercorrelations among many habitat variables that result from the concavity of stream slope profiles and environmental gradients that occur over the length of streams (Figs. 1*b* and 1*c*). Distributed sampling designs are limited by similar problems due to the universal concavity of stream slope profiles and similarities among streams draining a physiographic region. However, inference from distributed sampling designs is further weakened by inclusion of interstream differences and temporal variation in trout populations if samples are collected over extended periods of time.

For the above reasons, we believe that much of the thought regarding how reach-scale stream slope and associated physical habitats affect trout populations has been poorly substantiated. Our goal was to determine whether stream slope had a causal effect on any of several trout population metrics by conducting a study that isolated the effect of stream slope. To accomplish this goal, we eliminated the effects of confounding variables by sampling trout populations immediately upstream and downstream of marked, reach-scale changes in stream slope and describe the responses that we observed in trout biomass, density, species composition, and length structure. We also linked the observed changes in trout populations to changes in physical habitat characteristics and discuss how patterns manifest in trout populations at the reach scale may be affected by mechanisms operating at other spatial scales.

Materials and methods

Sample sites

Potential sample sites were initially identified as marked changes in stream slope on 1:24 000 scale U.S. Geological Survey topographic maps. Sites were then located in the field to ensure that a large change in stream slope existed (as inferred from the amount of supercritical flow, channel patterns, array of channel units, and substrate types) and that reaches at least 100 m long with consistent slope occurred both upstream and downstream of the marked change in stream slope. Sites with beaver (*Castor canadensis*) dam complexes, severe habitat degradation, angler harvest, or recent stocking were avoided. Forty-six reaches at 23 sites on 18 streams met these selection criteria and were sampled on U.S. Forest Service land. Stream slopes of the two reaches at each site were measured with an Abney level following procedures described in Isaak et al. (1999) and differed on average by 2.4%. Steeper-sloped reaches were located upstream from lower-sloped reaches 70% of the time. Reaches averaged 183 m in length and

Table 1. Summary of study reach attributes by stream slope class.

Stream slope class	Reaches	Stream slope range (%)	Wetted width range (m)	Channel unit composition (%)[a]	Substrate composition (%)[b]	Channel pattern	Riparian vegetation
Low	17	0.2–1.8	1.9–7.0	28:5:0:41:25:0:0:1	1:2:39:49:4:5	Sinuous	Willows and sedges
Medium	18	1.8–4.3	1.6–7.2	19:34:2:32:6:3:3:1	5:8:61:22:2:2	Straight	Mixed conifers
High	11	4.0–7.2	1.7–7.0	16:34:14:16:1:8:6:5	15:12:50:20:2:1	Straight	Mixed conifers

[a]Channel unit types are ordered as follows: riffle, rapid, cascade, run, lateral scour pool, trench pool, plunge pool, dam pool.
[b]Substrate types are ordered as follows: large boulder, small boulder, cobble, gravel, large fines, small fines.

were of three general types corresponding to Rosgen (1994), A, B, and C channels, that, for clarity, we hereafter term high slope, medium slope, and low slope, respectively. Additional attributes of the study reaches are given in Table 1.

The majority of sites (17 of 23) were sampled during late-summer baseflow conditions in 1996 and 1997 on streams draining the Caribou and Webster ranges in southeastern Idaho and streams draining the Salt River Range in western Wyoming. Allopatric cutthroat trout (*Oncorhynchus clarki*) populations existed at most sites, but brook trout (*Salvelinus fontinalis*) were sympatric with cutthroat trout at one site, and another site contained allopatric brown trout (*Salmo trutta*). The only nonsalmonid fish species occasionally present was Paiute sculpin (*Cottus beldingi*). Additional data were collected from streams draining the Medicine Bow Mountains in southeastern Wyoming and consisted of two sites that we sampled during late summer in 1998 and four sites sampled in late summer by Kozel (1987) that met our site selection criteria and used similar fish sampling methods. Species composition at sites in the Medicine Bow Mountains consisted of allopatric populations of brown trout or brook trout or mixtures of these species. Hydrographs of all study streams were typical for the Rocky Mountain region, with peak discharges driven by snowmelt in May or June, followed by baseflows from July to February.

Data collection

Trout populations in the reaches downstream from abrupt changes in stream slope were sampled first at the sample sites and trout populations in upstream reaches were sampled within 2 days on average. Trout populations were sampled by deploying a block net at the downstream end of a reach and then collecting trout using a backpack electrofisher (model 15-C, Smith-Root,[3] Vancouver, Wash.) and multiple removal efforts within the stream reach (Zippin 1958). Each removal effort consisted of a single electrofishing pass through a reach in an upstream direction. An effort was made to capture 35 age-1+ trout during the initial pass through a reach (average total number of age-1+ trout collected per reach was 119), but this was not always possible when trout densities were low. In these cases, we stopped sampling once stream slope began to change or 300–400 m of stream had been sampled. When trout were abundant, at least 100 m of stream were sampled so that habitat could later be characterized accurately. Because the endpoint of a reach was not predetermined, the second block net was not set until a criterion for stopping was met. Electrofishing was then conducted up to a natural barrier or the block net was set a short distance upstream and the remainder of the reach electrofished. Trout captured during a pass were identified to species and measured to the nearest millimetre total length (TL) before being released downstream of the reach. Trout weights were later estimated from species-specific length–weight regressions that had r^2 values ranging from 0.96 to 0.99 and were developed from trout sampled within the study areas.

Additional electrofishing passes (one to four) were made until the width of the confidence interval (CI) associated with the population estimate for trout longer than 135 mm TL was less than 30% of the size of the population estimate (average widths of CIs were 16% of the population estimate). Only trout longer than 135 mm were considered when calculating the approximate precision of population estimates in the field because these fish composed the majority of fish biomass in a reach, and, for reasons described below, separate population estimates were calculated for trout shorter and longer than 135 mm. Population estimate precision was estimated after the second and subsequent electrofishing passes using a graph from MicroFish 3.0 (Van Deventer and Platts 1989) in conjunction with rough estimates of population size and electrofishing efficiency derived from the following equations:

$$(1) \qquad S = x_1/(1 - (x_2/x_1))$$

$$(2) \qquad E = (x_1 - x_2)/x_1$$

where S is population size, E is electrofishing efficiency, x_1 is the number of trout longer than 135 mm captured during the first removal effort, and x_2 is the number of trout longer than 135 mm captured during the second removal effort.

Electrofishing effort was standardized by thoroughly searching all habitat during each pass and having the same person, accompanied by one netter, run the electrofisher. We minimized electrofishing- and temperature-related changes in fish behavior that would violate the assumption of constant catchability employed by closed-population removal estimators (Zippin 1958) by leaving reaches undisturbed for 1 h between electrofishing passes and electrofishing only when water temperatures exceeded 7°C.

After completion of electrofishing activities, habitat variables were measured using a transect methodology. Transects were spaced every 10 m and wetted width was measured to the nearest centimetre along each transect. Water depths were recorded to the nearest centimetre at one quarter, one half, and three quarters of the wetted width. A water velocity index was estimated from the height of water displacement (estimated to the nearest centimetre) on the upstream side of the depth staff at each depth measurement. Mean depths and water velocities were calculated for each transect as the sum of these measurements divided by 4 before the calculation of reach averages. Dominant substrate was visually estimated for a 0.3-m^2 area surrounding each point where water depth was measured using substrate categories defined in Platts et al. (1983). Unobstructed sun-arc was measured at the stream's surface at the midpoint of every third transect using a clinometer and procedures described in Platts et al. (1983). Trout cover as defined by Wesche (1980) was measured within an area extending 1 m upstream and 1 m downstream from each transect and was converted to a percentage of reach surface area. The longitudinal lengths of channel units were measured with a tape, and channel units were visually classified as trench pools, plunge pools, dam pools, lateral scour pools, runs, riffles, rapids, or cascades following definitions in Bisson et al. (1982). Additional criteria used to identify fast-water habitats such as amount of supercritical flow, presence–absence of

[3]Mention of trade names does not imply endorsement by the University of Wyoming.

transverse bars, and stream slope were obtained from Grant et al. (1990).

Data processing and analysis

Population estimates for age-1+ trout were calculated using the maximum likelihood estimator in MicroFish 3.0 (Van Deventer and Platts 1989). Age-0 trout were removed from consideration based on the timing of appearance in study streams and breaks in length–frequency histograms. Based on our own empirical observations and work by Anderson (1995), we calculated separate population estimates for trout shorter and longer than 135 mm in an effort to reduce length-related differences in catchability that would otherwise decrease the accuracy of population estimates. Areal and volumetric density estimates for a reach were obtained by adding population estimates for both length categories and dividing the total by either the surface area or the volume of the reach. Biomass estimates were calculated by multiplying the population estimate for a length category by the mean weight of trout in that length category, adding biomass estimates for both length categories, and dividing the total by either the surface area or the volume of the reach.

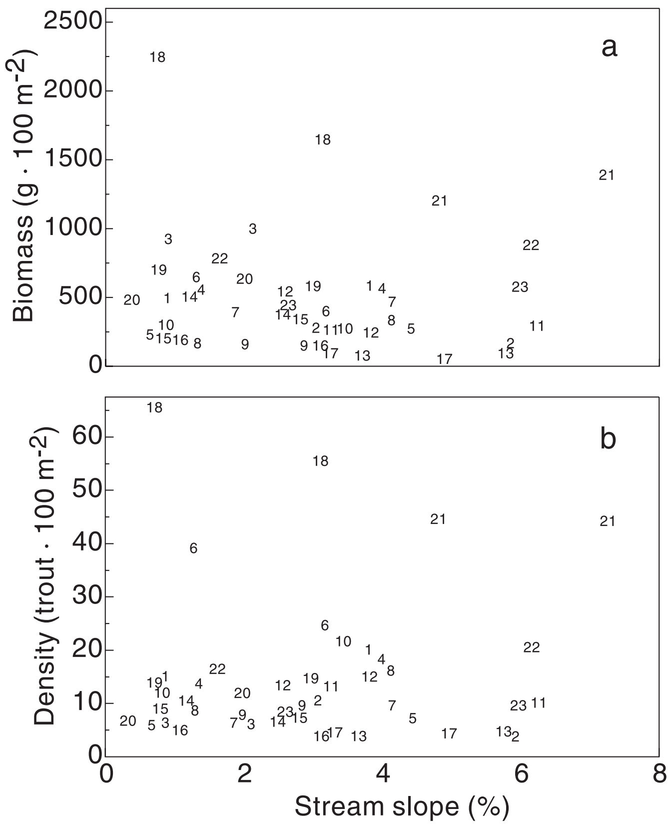
Population length structure for age-1+ trout was summarized by calculating the proportion of trout from each reach that were shorter or longer than the respective mean trout length at a site (one pair of reaches). Length structure was also summarized using the length of the shortest trout in the group of largest trout (those comprising 50% of the biomass) sampled from a site to delineate length categories. For sites with sympatric trout populations, species composition was enumerated by number and weight for age-1+ trout.

The effect of stream slope on population metrics or habitat attributes was assessed by testing whether the change in a variable between the reaches at a site differed from zero. Each site provided one sample and the variance among these samples was used to calculate 95% CI around the average amount of change in a variable. If zero was excluded from or occurred in the extremity of a CI, it was concluded that stream slope affected the variable. When sample sizes permitted, CIs for continuous variables such as density, biomass, or habitat attributes were constructed using bootstrapping techniques and were corrected for bias after Dixon (1993). Confidence intervals were constructed using standard normal theory techniques when sample sizes limited the utility of bootstrapping techniques ($N < 5$). Confidence intervals for population length structure were constructed using a technique suitable for categorical data (DerSimonian and Laird 1986), and Cochran's Q statistic was used to test for homogeneity among changes in length structure across sites. Small numbers of sites with sympatric trout populations precluded a similar approach to statistical testing, so chi square tests were used to assess changes in species composition by number at each sympatric site.

Results

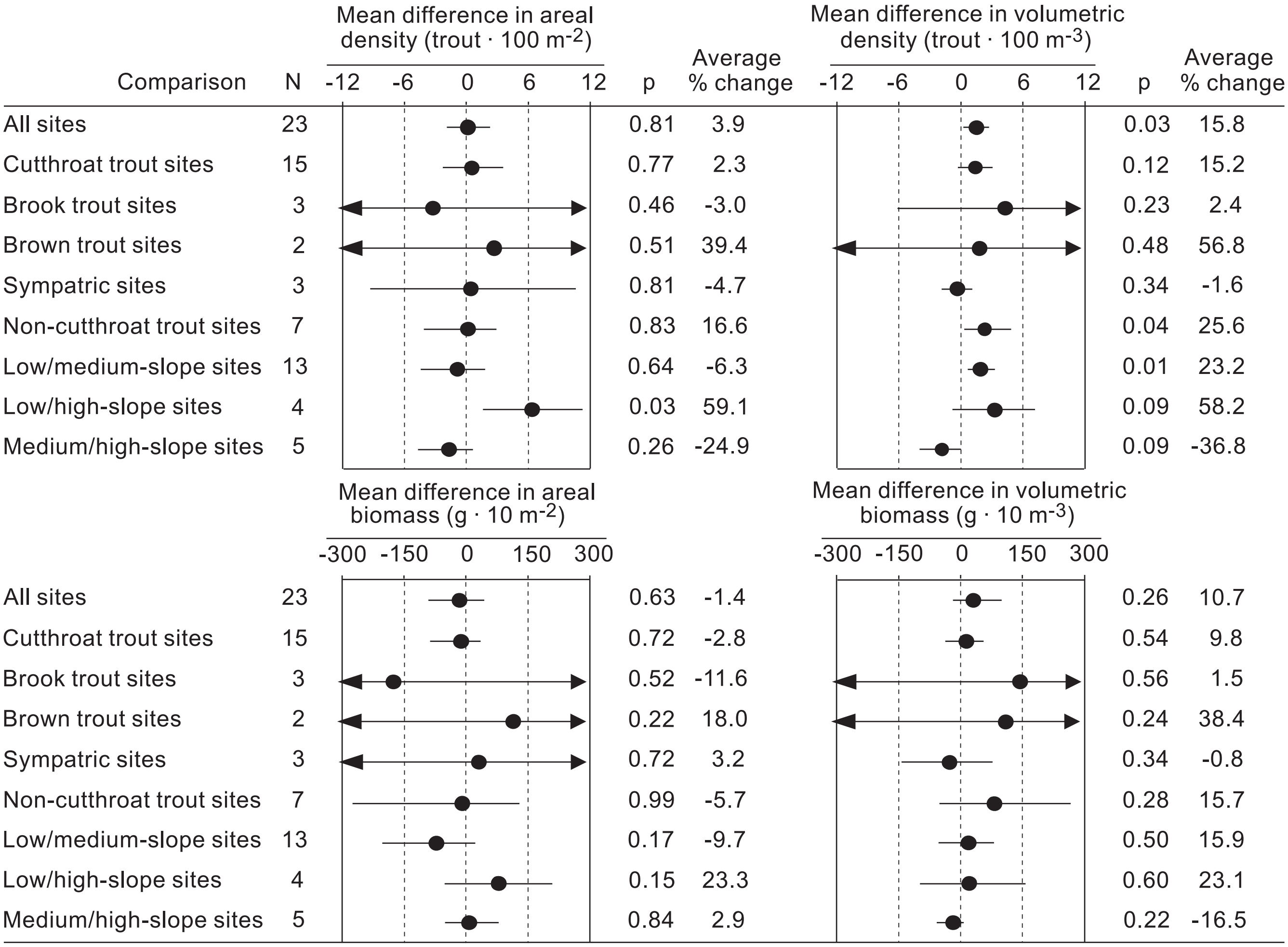
In contrast with the negative relationship often reported between trout biomass and stream slope, scatter plots of our trout biomass and density estimates obtained using a paired-reach sampling design gave no indication that increased stream slope negatively affected trout populations (Fig. 2). Additionally, some of the data collected with the paired-reach design were obtained from streams where, using a longitudinal sampling design, we had observed a negative relationship between stream slope and biomass (Fig. 1*a*). These results suggest that the previously documented negative relationship between trout biomass and stream slope was largely an artifact of sampling design.

Fig. 2. Scatter plots of stream slope versus the areal trout (*a*) biomass and (*b*) density data sets used in this study. Data were obtained using a paired-reach sampling design at 23 sites on 18 streams draining four mountain ranges in Idaho and Wyoming. Data points with the same number represent the two reaches sampled at a site.



Statistical tests based on the paired data structure indicated that stream slope did not affect areal trout density across the 23 sample sites (average change = 3.9%; $p = 0.81$, $N = 23$). This result was consistent for areal densities across most of the comparisons based on subsets of the 23 sites that had similar trout species or stream slope classes (Fig. 3). The only exception was the greater trout densities that occurred in high-slope reaches relative to low-slope reaches (average change = 59.1%; $p = 0.03$, $N = 4$). Statistically improbable patterns were common, however, when changes in channel cross sections among reaches in different slope classes were corrected for by expressing trout density volumetrically. Volumetric trout density across the 23 sample sites increased as stream slope increased (average change = 15.8%; $p = 0.03$, $N = 23$) as did volumetric densities in the majority of more specific comparisons based on trout species (Fig. 3). Sites with cutthroat trout comprised the majority of the data set, but changes in volumetric density at non-cutthroat trout sites (average change = 25.6%; $p = 0.04$, $N = 7$) were similar to changes observed at cutthroat trout sites (average change = 15.2%; $p = 0.12$, $N = 15$). In comparisons based on stream slope classes, volumetric densities increased from low-slope reaches to either medium- (average change = 23.2%; $p = 0.01$; $N = 13$) or high-slope reaches (average change = 58.2%; $p = 0.09$, $N = 4$) but decreased from

Fig. 3. Effect of reach-scale stream slope on trout density and biomass. Error bars are 95% CIs that encompass the average difference in a population metric among sites. One site was eliminated from comparisons based on stream slope classes because both reaches were in the high-slope category.



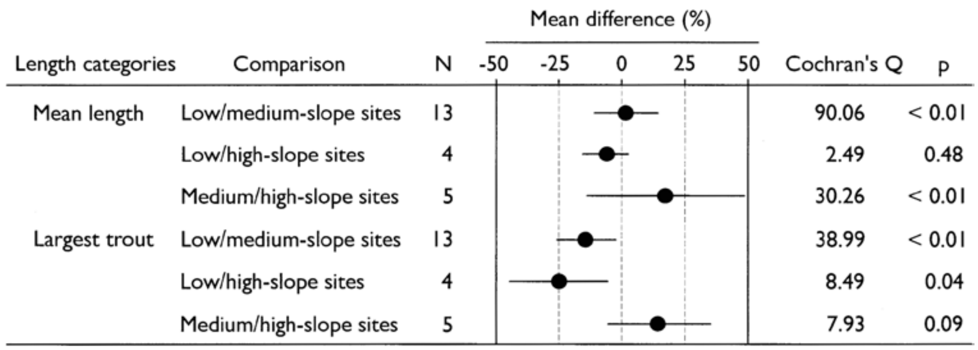
medium- to high-slope reaches (average change = –36.8%; p = 0.09, N = 5).

Results of statistical tests involving areal and volumetric expressions of trout biomass were similar. Increases in stream slope did not affect either areal (average change = –1.4%; p = 0.63, N = 23) or volumetric (average change = 10.7%; p = 0.26, N = 23) trout biomass across the 23 sample sites, and a similar trend held for more specific comparisons based on subsets of the 23 sites with similar trout species or stream slope classes (Fig. 3). The width of CIs associated with some comparisons suggested that statistical power was occasionally low, but changes in biomass were not observed even when precise estimates were obtained (e.g., average change in volumetric biomasses at cutthroat trout sites or medium/high-slope sites).

No patterns in population length structure relative to stream slope class were apparent when mean trout length at a site was used to delineate length categories (Fig. 4). Length structure changed less than 6.3% for two of three comparisons, and Cochran's Q statistic indicated that the amount of change in length structure between reaches at a site was often heterogeneous among sites. Patterns in length structure were discerned, however, when length categories were delineated based on the shortest trout length in the group of largest trout (those comprising 50% of the biomass) sampled at a site (Fig. 4). Changes in length structure were reciprocal to changes in volumetric trout densities among stream slope classes, and disproportionately small numbers of the largest trout occurred in medium- (average change = –14.1%; N = 13) and high-slope reaches (average change = –25.0%; N = 4) relative to low-slope reaches and greater numbers of large trout occurred in high-slope reaches relative to medium-slope reaches (average change = 14.4%; N = 5).

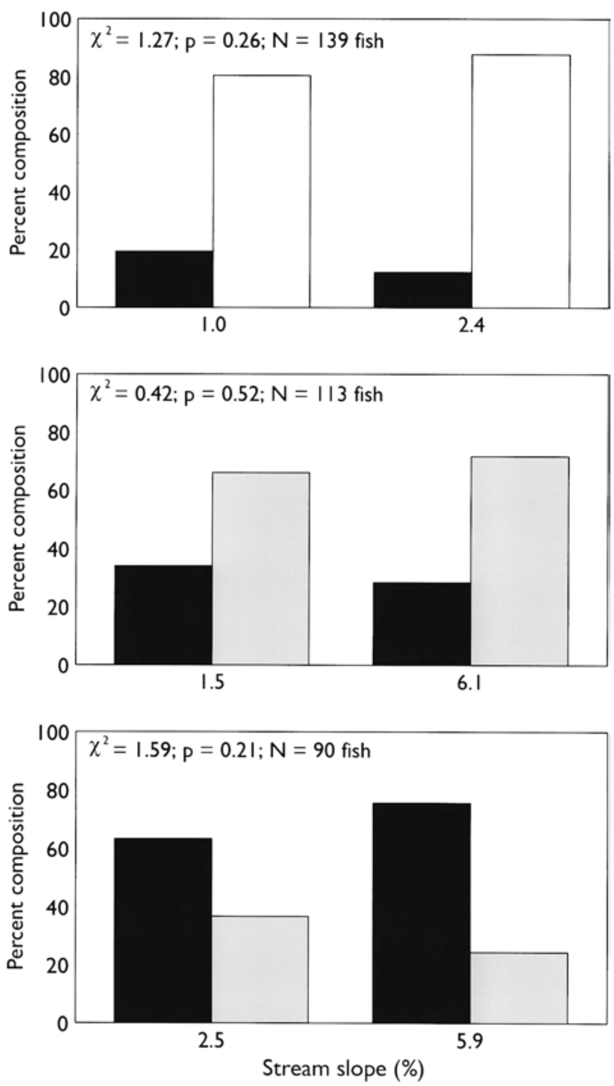
Stream slope had no effect on species composition (Fig. 5). At one site with brook trout and cutthroat trout, the numerical abundance of brook trout decreased by 7.2% as stream slope increased, but this change was not statistically improbable (χ^2 = 1.27, p = 0.26, N = 139). A similar trend was observed when change in species composition was calculated by weight and brook trout abundance decreased by 4.3%. The change in stream slope between the two reaches at this site was small (1.0–2.4%) but involved a marked change in channel characteristics from a low-slope reach with a sinuous channel pattern and channel units composed of lateral scour pools, riffles, and runs to a medium-slope reach with a straight channel pattern and riffles, rapids, and

Fig. 4. Effect of reach-scale stream slope on population length structure. Error bars are 95% CIs that encompass the average difference in a population metric among sites. One site was eliminated from comparisons based on stream slope classes because both reaches were in the high-slope category.



Length categories	Comparison	N	Cochran's Q	p
Mean length	Low/medium-slope sites	13	90.06	< 0.01
	Low/high-slope sites	4	2.49	0.48
	Medium/high-slope sites	5	30.26	< 0.01
Largest trout	Low/medium-slope sites	13	38.99	< 0.01
	Low/high-slope sites	4	8.49	0.04
	Medium/high-slope sites	5	7.93	0.09

Fig. 5. Effect of reach-scale stream slope on species composition by number for sites with sympatric trout populations. Cutthroat trout are represented by open bars, brook trout by solid bars, and brown trout by shaded bars. Patterns in species composition by weight were similar and are not shown.



trench pools. At two sites with brook trout and brown trout, changes in species composition were inconsistent. Numerical brook trout abundance decreased by 5.7% at site 1 ($\chi^2 = 0.42$, $p = 0.52$, $N = 113$) but increased by 12.3% at site 2 ($\chi^2 = 1.59$, $p = 0.21$, $N = 90$) as stream slope increased. Changes in species composition by weight mirrored changes in number, and brook trout abundance by weight decreased by 6.6% at site 1 and increased by 10.5% at site 2.

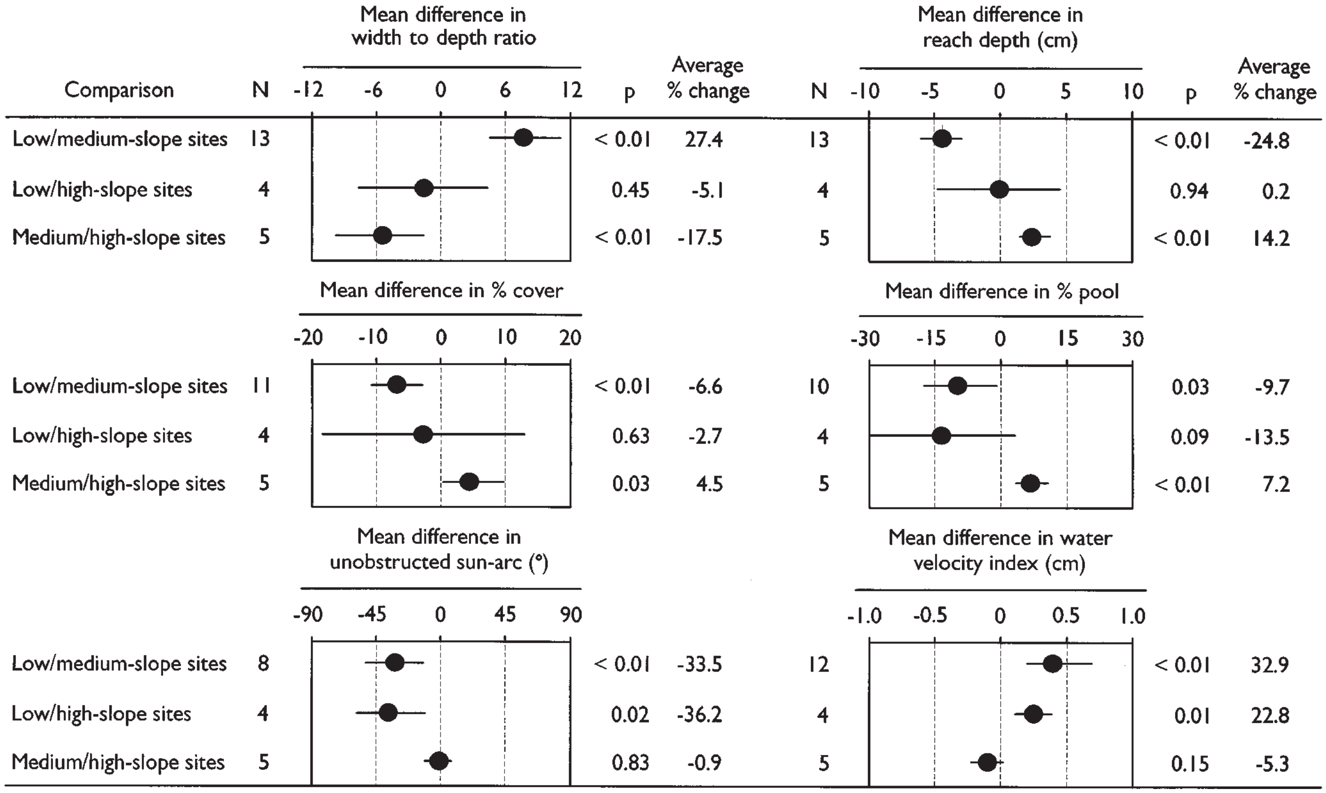
Most habitat attributes differed among the three stream slope classes (Fig. 6). Medium-slope reaches had the greatest width to depth ratios, some of the fastest water velocities, and the smallest amounts of trout cover and pool habitat. Low-slope reaches had the greatest amount of pool habitat, the most open canopies, and the slowest water velocities. High- and low-slope reaches had similar width to depth ratios (average change = –5.1%; $p = 0.45$, $N = 4$), mean depths (average change = 0.2%; $p = 0.94$, $N = 4$), and amount of trout cover (average change = –2.7%; $p = 0.63$, $N = 4$).

Discussion

Patterns in trout populations

Numerous studies have suggested that trout biomass is negatively related to stream slope (e.g., MacPhee 1966; Chisholm and Hubert 1986; Kozel et al. 1989), but these studies used data sets in which many factors were confounded with stream slope. After sampling in a manner that eliminated the effects of confounding factors, we observed no effect of stream slope on trout biomass. Our results were unexpected, given differences in the amount of pool habitat among stream slope classes and the well-documented preference of trout for pools. However, Riley and Fausch (1995) have indicated that pools serve to concentrate trout from adjacent areas. If this "concentration effect" affected trout more strongly in habitats adjacent to pools than in distant habitats, trout distributions would be more patchy in reaches with more pool habitat and these reaches would not necessarily support greater trout biomass. Our results were also unexpected, given that changes in trout biomass did not track available cover, despite the documented relationship between trout biomass and cover (Wesche et al. 1987; Kozel and Hubert 1989). However, many systems for rating trout habitat (e.g., Binns and Eiserman 1979; Platts et al. 1983), including the one that we used (Wesche 1980), comprise

Fig. 6. Effect of reach-scale stream slope on habitat attributes among stream slope classes. Error bars are 95% CIs that encompass the average difference in a habitat attribute among sites. Sample sizes vary among comparisons because all habitat attributes were not measured at each site.



several cover types of which overhead cover and deepwater cover are major constituents. Many habitat rating systems may therefore be predisposed towards providing better ratings in downstream areas where streams are deeper and the sinuous channel patterns associated with low-slope reaches generate overhead bank and vegetative cover. As such, better cover ratings will coincide with factors not related to the structure of physical habitat (e.g., water temperature, macroinvertebrate abundance) but that favor the production of trout in downstream areas. This hypothesis may explain why the physical habitat in low-slope reaches is often erroneously perceived as optimal trout habitat.

A pattern in population length structure was detected when we focused on the largest trout sampled from our sites. Large trout were most abundant in low-slope reaches, of intermediate abundance in high-slope reaches, and least abundant in medium-slope reaches. This ordering concurred with the availability of deepwater habitats (as inferred from channel cross sections and pool abundance) across slope classes and, when combined with the reciprocal changes in trout density that we observed, suggested that a competitive mechanism may have been at work whereby large trout were excluding smaller trout from certain habitats. Reciprocity between density and large trout abundance was likely enhanced by the preference of smaller fish for shallow-water habitats (Kennedy and Strange 1982; Moore and Gregory 1988) that were most available in medium-slope reaches. Reciprocal patterns in density and large fish abundance also explain how biomass remained constant across stream slope classes despite changes in large fish abundance.

Our results regarding the effect of reach-scale stream slope on species composition do not agree with the findings of previous investigators. In the most comprehensive treatment of the subject, Fausch (1989) concluded that stream slope was an important determinant of species composition in sympatric cutthroat trout and brook trout populations, and similar conclusions have been reached for different combinations of trout species (Moore et al. 1985; Bozek and Hubert 1991). However, the changes in species composition that we observed at sympatric sites were small and not statistically improbable. The direction of these changes at sites with brook trout and brown trout was also inconsistent, despite studies that suggest that brown trout outcompete brook trout (Fausch and White 1981; Waters 1983) and should, therefore, have always been most abundant in reaches with low slopes. Similar competitive mechanisms or the perceived preference of cutthroat trout for higher slopes (e.g., Griffith 1988) could be invoked to argue that the small decrease in cutthroat trout relative to brook trout in the low-slope reach where these species were sympatric supported previous understanding, but this change was so small (7.2% by number, 4.3% by weight) that it likely had little biological relevance. Unfortunately, our data set contained few sites with sympatric trout populations, which precluded us from making stronger inferences regarding specific combinations of trout species or stream slope classes. Despite this limitation, our results, in combination with the nature of previous sampling designs that precluded drawing strong causal inference, call into question the belief that stream slope affects trout species composition.

Spatial scale considerations

The scale at which studies are conducted influences the patterns that are discerned and the mechanisms responsible for effecting these patterns (Levin 1992). Our study is a case in point, as our data suggest that the strong patterns in species composition (Griffith 1972; Fausch and White 1981) and trout biomass (Saffel and Scarnecchia 1995; Herger et al. 1996) that have been observed at channel unit and smaller scales do not translate to patterns at the reach scale. In the case of trout biomass, this implies that stream-scale gradients in the quality and quantity of materials moving through a reach (e.g., allocthonous materials, water temperature, discharge, macroinvertebrate drift) may ultimately determine the amount of trout biomass that occurs within a reach. Similarly, a stream-scale gradient in water temperature seems the most logical variable capable of effecting change in species composition at larger scales based on mechanisms related to the physiology of individual fish species. Once stream-scale gradients have set biomass levels and species composition within a reach, mechanisms intrinsic to trout (i.e., competitive tendencies or affinities for particular habitats) further structure trout populations and lead to the patterns observed at channel unit and subunit scales.

In contrast with species composition and biomass, trout density and length structure were affected by reach-scale stream slope. Because it is likely that many of the mechanisms operating at stream and subreach scales that we implicated above also influence density and length structure, these population metrics are influenced by mechanisms operating at a minimum of three spatial scales. When all possible interactions among scales are considered, the issue of how density and length structure are regulated becomes complex and makes it difficult to speculate about the various roles played by stream system components to regulate these population metrics. However, we view formulation and empirical testing of such hypotheses as challenging avenues for future research.

Regional differences

The paired-reach sampling design that we used eliminated the effects of most confounding variables, but it was impossible to control for differences in riparian vegetation and the amount of solar insolation among stream slope classes. Low-slope reaches occurred in wider, alluviated valleys, where streams had riparian canopies composed of sedges and willows that provided less shade than the mixed conifer stands adjacent to steeper-sloped reaches. The food-based hypothesis proposed by Wilzbach and Hall (1985) suggests that open canopies will facilitate increased primary productivity, which ultimately translates to greater macroinvertebrate and trout abundance. Paired-reach studies conducted in the Pacific Northwest have supported this hypothesis by describing increases in trout abundance associated with canopy removal (Murphy and Hall 1981; Hawkins et al. 1983). If the food-based hypothesis held true in our study streams, the greatest trout densities and biomass should have occurred in low-slope reaches. Instead, low-slope reaches had the lowest trout densities, and biomass levels were similar to those in steeper-sloped reaches, possibly suggesting that differences in macroinvertebrate abundance among our stream slope classes were minor.

Support for the explanation that macroinvertebrate differences among stream slope classes were minor can be inferred from the decreased density of timbered stream canopies in the Rocky Mountain region relative to the Pacific Northwest region (Johnson et al. 1986; Platts and Nelson 1989). Decreased tree shading, in combination with the greater shading that our low-slope reaches received relative to the clearcut streams studied in the Pacific Northwest (Hawkins et al. 1983), should have decreased differences in insolation and macroinvertebrate abundance between low- and steeper-sloped reaches. Alternatively, trout populations in Rocky Mountain streams may not be strongly regulated by macroinvertebrate abundance. Average trout biomasses that are nearly four times greater than biomasses in Pacific Northwest streams (Platts and McHenry 1988) and studies demonstrating strong food limitations (Warren et al. 1964; Mason 1976) in streams of the Pacific Northwest suggest that this may be the case. Without additional data, both explanations appear plausible.

In conclusion, our study took a detailed and synthetic look at how stream slope affected several trout population metrics and stream habitat by focusing on marked, reach-scale changes in stream slope. Some of our results call into question or contravene existing thought and suggest that patterns between stream slope and trout population metrics observed in previous research were correlative in nature and arose from the effects of many stream habitat variables acting simultaneously rather than a causal effect of stream slope. Contrary to previous research, our study suggests that trout biomass and species composition are unaffected by reach-scale stream slope. Trout density and population length structure, however, are affected by stream slope, and these metrics appear to change in reciprocal fashion such that available biomass is structured to make efficient use of the habitat within a reach. Our results have implications for fish habitat modeling because many models have been developed predicated on the assumption of a causal link between the structure of instream physical habitats and the characteristics of fish populations. Previously, however, this supposition had not been rigorously tested. It now appears that this assumption is at times untenable for trout populations in Rocky Mountain streams and is dependent on the population metric(s) used to describe populations and the spatial scale(s) at which studies are conducted. This leads us to believe that full understanding of the factors regulating trout populations will only be gained once studies are conducted that address the multimetric response of trout populations across multiple scales of inquiry.

Acknowledgments

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